Contents

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UNIT 10

SIMPLE HARMONIC MOTION AND WAVES

10.1 SIMPLE HARMONIC MOTION (SHM)

LONG QUESTIONS

Q.1 Define SHM. Also prove that motion of mass attached with spring have simple harmonic motion. **(K.B + U.B + A.B)**
(LHR-G1),(SGD-G2),(DGK-G2),(RWP-G1),(GRW-G2)-2015 / (MTN-G1)-2016 / (SGD-G1), (SWL-G1),(FSD-G1),(RWP-G1),(DGK-G1)-2017

Ans: **SIMPLE HARMONIC MOTION**

Definition:

"Simple Harmonic Motion occurs when the **net force** is **directly proportional** to the **displacement** from the mean position and is always directed towards the mean position**"**.

Mathematical Expression: $\mathbf{F \propto -x}$

OR

Definition:

"The **acceleration** of a body executing **SHM** is **directly proportional** to the **displacement** of the body from the mean position and is always directed towards the mean position**"**.

Mathematical Expression: $\mathbf{a \propto -x}$

Where **'a'** is an acceleration. It is always directed towards the mean position and **'x'** is displacement from mean position.

MOTION OF MASS ATTACHED TO A SPRING

One of the simplest types of oscillatory motion is that of horizontal mass-spring system (as shown in figure). If the spring is stretched or compressed through a small displacement **x** from its mean position due to external force '$\mathbf{F_{ext.}}$' on the mass.

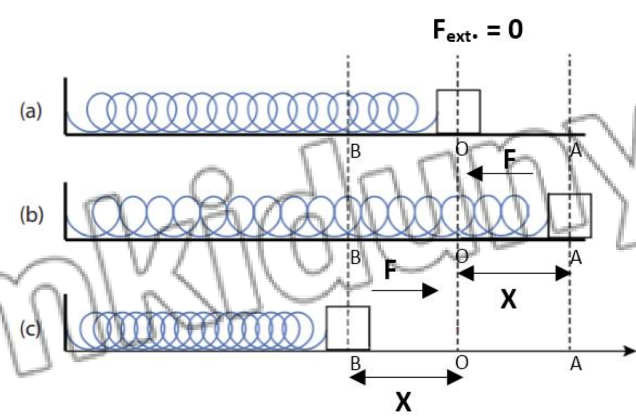


Figure: SHM of Mass-Spring System

According to Hooke's law this force is directly proportional to the change in length x of the spring within the elastic limit.

$$F_{ext.} \propto x$$

$$F_{ext.} = kx \ldots (i)$$

Where x is the displacement of the mass from its mean position O, and k is a constant called the **Spring Constant**.

$$k = \frac{F}{x} \quad ...(ii)$$

The value of k is a measure of the stiffness of the spring. Stiff springs have large k values, and soft springs have small k values. It is measured in **Nm^{-1}**.

When external force removed from mass attached to the spring then restoring force exert on the body and move it towards its mean position. This restoring force is exerted by spring on the mass

Restoring Force:

"A restoring force always pushes or pulls the object of performing oscillatory motion towards the mean position."

$$F = -F_{ext.}$$

Putting value of F_{ext}. from equation (i)

Therefore,

$$F = -kx \quad ....(iii)$$

According to Newton's 2^{nd} Law of Motion

$$F = ma \qquad \text{Putting the value of 'F' in eq. ....(iii)}$$

$$ma = -kx$$

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

or $$a = -\text{constant } x \qquad \left(\text{Where } \frac{k}{m} = \text{constant}\right)$$

$$\Rightarrow \quad a \propto -x$$

It means acceleration of mass attached to a spring is directly proportional to its displacement from the mean position. Hence, the horizontal motion of a mass-spring system is an example of simple harmonic motion.

The **negative sign** in **eq. (iii)** shows that the force exerted by the spring is always directed opposite to the displacement of the mass.

At Mean Position 'O':

Initially the mass m is at rest in mean position O and the resultant force on the mass is zero. Hence at this position **P.E = 0, K.E = 0, V = 0 and a = 0**

From Position 'O' to 'A':

Suppose the mass is pulled through a **distance** x up to extreme position A at this position **P.E** is **maximum**, **K.E** is **minimum**, **Velocity** is **minimum** and **Acceleration** is **maximum.** Then the body released from exchange position and the restoring force exerted by the spring on the mass will pull it towards mean position O. Due to restoring force the mass moves back, towards the mean position O.

At Mean Position 'O':

The magnitude of restoring force decreases with the distance from the mean position and becomes zero at O. However, the mass gains speed as it moves towards the mean position and its speed becomes maximum at mean position O, **K.E** is also **maximum**, **P.E** is **minimum** and **Acceleration** is **zero** because **displacement** "X" is equal to **zero**. Due to inertia the mass does not stop at mean position O but continues its motion and reaches the extreme position B.

From Position 'O' to 'B':

As the mass moves from the mean position O to the extreme position B, the restoring force acting on it towards the mean position steadily increases in strength. At position B, **P.E** is **maximum K.E** is **minimum**, Velocity become is **minimum** and **Acceleration** is **maximum** because **displacement** is **maximum** at this position.

Effect on Speed:
The speed of the mass decreases as it moves towards the extreme position B. The mass finally comes briefly to rest at extreme position B as shown in Figure-(c). Ultimately the mass returns to the mean position O due to the restoring force.

Conclusion:

> **This process is repeated, and the mass continues to oscillate back and forth about the mean position O. Such motion of a mass attached to a spring on a horizontal frictionless surface is known as "Simple Harmonic Motion" (SHM).**

Time Period (T):
The time period T of the simple harmonic motion of a mass m attached to a spring is given by the followi

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

Q.2 Prove that motion of ball placed in a bowl executing simple harmonic motion when displaced from its mean position. **(K.B + A.B)**
(BWP-G1),(DGK-G1),(GRW-G1)-2016 / (SWL-G1),(LHR-G2)-2017

Ans:

BALL AND BOWL SYSTEM
SIMPLE HARMONIC MOTION

Definition:
"Simple Harmonic Motion occurs when the **net force** is **directly proportional** to the **displacement** from the mean position and is always directed towards the mean position".

Mathematical Expression: $\mathbf{F \propto -x}$

The motion of a ball placed in a bowl is another example of simple harmonic motion as shown in Figure.

When ball is at rest (At mean position O):
When the ball is at the mean position O, that is, at the center of the bowl, net force acting on the ball is zero. In this position weight of the ball acts downward and is equal to the upward normal force of the surface of the bowl. Hence there is no motion.

At Extreme Position A:
Now if we bring the ball to position A and then release it, the ball will start moving towards the mean position O due to the restoring force caused by its weight.

At Mean Position O:
At position O the ball gets maximum speed and due to inertia it moves towards the extreme position B while going towards the position B, the speed of the ball decreases due to the restoring force which acts towards the mean position.

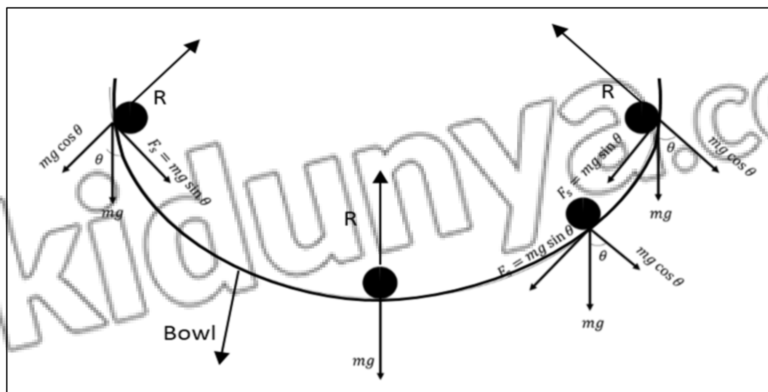


Figure: When a ball is gently displaced from the centre of a bowl it starts oscillating about the centre due to force of gravity which acts as a restoring force

At Extreme Position B:
At the position **B**, the ball stops for a while and then again moves towards the mean position O under the action of the restoring force. This to and fro motion of the ball continues about the mean position O till all its energy is lost due to friction.

Conclusion:

> **Thus the to and fro motion of the ball about a mean position placed in a bowl is an example of simple harmonic motion.**

Q3. Prove that motion of simple pendulum is simple harmonic. (K.B + U.B+A.B)
(LHR-G1),(MTN-G2),(GRW-G2),(BWP-G1)(SGD-G2),(SWL-G2)-2014 / (BWP-G1),(DGK-G2),(MTN-G2), (SWL-G1/G2)-2015 / (BWP-G1),(DGK-G1),(GRW-G1)-2016 / (SWL-G1),(LHR-G2)-2017

Ans:

MOTION OF A SIMPLE PENDULUM
SIMPLE HARMONIC MOTION

Definition:

"Simple Harmonic Motion occurs when the **net force** is **directly proportional** to the **displacement** from the mean position and is always directed towards the mean position**"**.

Mathematical Expression: $\mathbf{F \propto -x}$

A simple pendulum also exhibits **SHM**. It consists of a small bob of **mass** 'm' suspended from a light string of **length** 'ℓ' fixed at the upper end.

In Equilibrium Position O (at mean position O):

In the equilibrium position O, the net force on the bob is zero and bob is stationary.

Weight = Tension

At Extreme Position A:

Now if we bring the bob to extreme position **A**, the net force is not zero as shown in figure. There is no force acting along the string as the tension in the string cancels the component of the weight mg cosθ.

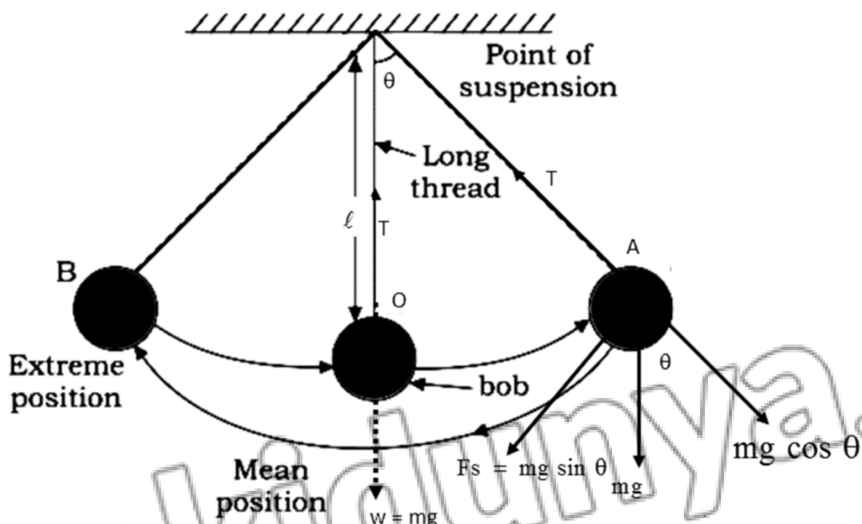


Figure: Forces acting on a displaced pendulum. The restoring force that causes the pendulum to undergo simple harmonic motion is the component of gravitational force mg sinθ tangent to the path of motion

Hence there is no motion along this direction. The component of the weight mg sinθ is directed towards the mean position and acts as a restoring force. Due to this force the bob starts moving towards the mean position **O**.

$$T = mg\cos\theta,\ Fs = mg\sin\theta$$

At Mean Position O:

At O the bob has got the maximum velocity and due to inertia it does not stop at O rather it continues to move towards the extreme position B during its motion towards point B, the velocity of the bob decreases due to restoring force.

At Extreme Position B:

The velocity of the bob becomes zero as it reaches the point B, the restoring force mg sinθ still acts towards the mean position O and due to this force the bob again starts moving towards the mean position O. In this way, the bob continues its to and fro motion about the mean position O.

Speed of bob Between Position A&B:

It is clear from the above discussion that the speed of the bob increases while moving from point A to O due to the restoring force which acts towards O. Similarly, when the bob moves from O to B, its speed decreases due to restoring force which again acts towards O.

Conclusion:

It follows that the acceleration of the bob is always directed towards the mean position O. Hence the motion of a simple pendulum is SHM.

Time Period (T):

We have the following formula for the time period of simple pendulum

$$\boxed{T = 2\pi\sqrt{\frac{\ell}{g}}}$$

Q.4 Write down important features of Simple Harmonic Motion. ***(K.B)***

(LHR-G1),(MTN-G2),(GRW-G2),(BWP-G1)(SGD-G2),(SWL-G2)-2014 / (BWP-G1),(DGK-G2),(MTN-G2), (SWL-G1/G2)-2015 / (DGK-G1),(GRW-G1)-2016 / (SWL-G1),(LHR-G2)-2017

Ans: **IMPORTANT FEATURES OF SHM**

Important features of SHM are summarized as:

- A body executing SHM always vibrates about a fixed position.
- Its acceleration is always directed towards the mean position.
- The magnitude of acceleration is always directly proportional to its displacement from the mean position i.e. acceleration will be zero at the mean position while it will be maximum at the extreme positions.

  Mathematical Expression: $\mathbf{a \propto -x}$
- Its velocity is maximum at the mean position and zero at the extreme positions.

Q.5 Define following terms which characterize simple harmonic motion. ***(K.B)***

- **Vibration**
- **Time period**
- **Frequency**
- **Amplitude**
- **Displacement**

(GRW-G1) (DGK-G2)-2014 / (RWP-G1) (BWP-G1) (SGD-2) (LHR-G1)-2016 / (LHR-G1)-2016 / (RWP-G2) (SGD-G1) (DGK-G1) (LHR-G1) MTN-G1)-2017

Ans: **VIBRATION**

Definition:

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

TIME PERIOD

Definition:

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

Symbol: Time period is represented by 'T'.

Unit: SI unit of time period is second (s).

Formula: Time period is reciprocal of frequency i.e. $T = \frac{1}{f}$

FREQUENCY

Definition:

"The number of vibrations or cycles of a vibrating body in one second is called its frequency**"**.

Symbol: Frequency is represented by 'f'.

Unit: SI unit of frequency is Hertz (Hz).

Formula: frequency is reciprocal of time period i.e. $f = \frac{1}{T}$

AMPLITUDE

Definition:

"The maximum displacement of a vibrating body on either side from its mean position is called its amplitude**"**.

Symbol: Amplitude is represented by 'A'.

Unit: SI unit of amplitude is meter (m).

DISPLACEMENT

Definition:

"Distance of a vibrating body from its mean position at any instant during the vibration**"**.

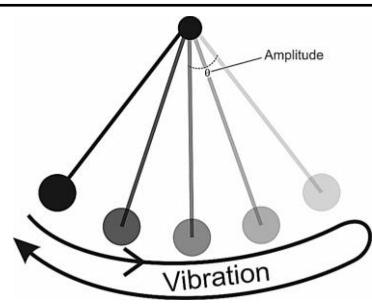


Figure: SHM of Simple Pendulum

10.1 SHORT QUESTIONS

Q.1 What do you know about restoring force? OR Define restoring force. *(K.B)*
(MTN-G1)-2014, (FSD-G2)-2015, (SGD-G1/G2),(RWP-G1),(DGK-G2),(BWP-G2)-2016 / (SGD-G2),(RWP-G1),(BWP-G1)-2017

Ans: **RESTORING FORCE**

Definition:

"A restoring force always pushes or pulls the object performing oscillatory motion towards the mean position."

$$F = -F_{ext.}$$
$$F = -kx$$

The negative sign in above equation shows that the force exerted by the spring is always directed opposite to the displacement of the mass. Because the spring force always acts toward the mean position, it is sometimes called a restoring force. The unit of restoring force Newton (N).

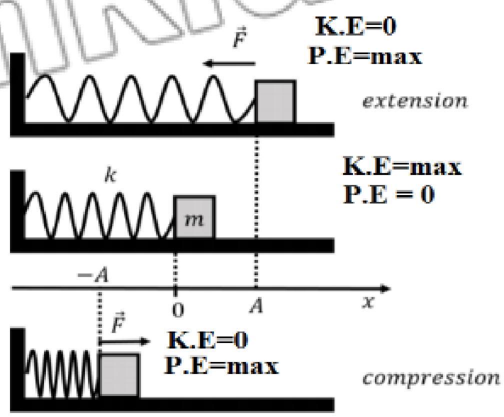
Q.2 How a spider detects its prey? *(A.B)*

Ans: **A SPIDER DETECTS ITS PREY**

A spider detects its prey due to the vibration produced in the web.

Q.3 Draw a figure to show the Kinetic and Potential energy at different positions in a mass-spring syste

Ans: Kinetic and potential energy at different positions in a mass-spring system.



Q.4 How many times in one second a human eardrum can vibrate? ***(K.B)***

Ans: A human eardrum can oscillate back and forth up to 20,000 times in one second.

Q.5 In case of ball and bowl system and in case of simple pendulum, which force acts as restoring force

Ans:

RESTORING FORCE IN BALL & BOWL SYSTEM

When a ball is gently displaced from a centre of a bowl its starts oscillating about the centre due to force of gravity which acts as restoring force.

RESTORING FORCE IN PENDULUM

When pendulum is displaced from its extreme position, the component of gravitational force "mg $\sin\theta$" act as restoring force because mg $\cos\theta$ is balanced by tension in the string.

Q.6 Define simple pendulum and time period of simple pendulum. ***(K.B)***

(FSD-G1),(DGK-G2)-2014 / (BWP-G1)-2016 / (LHR-G2),(BWP-G2)-2017

Ans:

SIMPLE PENDULUM

Definition:

"A simple pendulum consists of a small bob of **mass** 'm' suspended from a light string of **length** 'ℓ' fixed at the upper end".

TIME PERIOD

Definition:

"Time period of a pendulum is the time to complete one cycle." It is denoted by **'T'**.

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

Q.7 Differentiate between time period and frequency in case of vibratory motion. ***(K.B)***

(GRW-G1)-14, (LHR-16), (SGD-G1/G2)-17, (RWL-G2)-17

Ans: *Given on Pg. # 6 and 7.*

Q.8 What is meant by spring constant? ***(K.B)*** **(MTN-G1)-2015 / (AJK-G1)-2016 / (SWL-G2**

Ans:

Spring Constant

Definition:

"The ratio of exerted force to the change in length is called spring constant."

Mathematical Equation:

$$k = \frac{F_{ext.}}{x}$$

The value of k is a measure of the stiffness of the spring. Stiff springs have large k values, and soft springs have small k values.

Unit:

It is measured in $\mathbf{Nm^{-1}}$.

Q.9 How the atoms vibrate in solids? OR Which type of motion solid molecules performed? *(K.B)*

Ans: MOTION OF ATOMS IN SOLIDS

The atoms in the solids are held together. But they can still move and vibrate as though connected by string. Solid molecules perform vibratory motion only.

Q.10 Define vibratory motion. OR What is meant by oscillation? (K.B) **(RWP-GI)-2017**

Ans: VIBORATORY OR OSCILLATORY MOTION

Definition:

"A body is said to be vibrating if it moves back and forth or to and fro about a point**"**.

Another term for vibration is oscillation. A special kind of vibratory or oscillatory motion is "Simple Harmonic Motion".

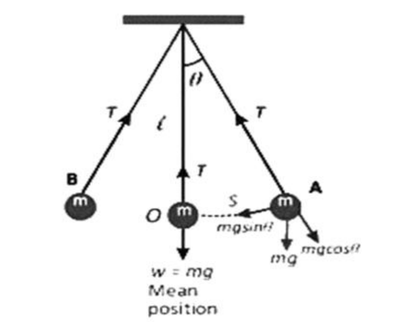


Figure: Vibratory or Oscillatory Motion of Simple Pendulum

Examples:

- Motion of mass attached to a spring.
- Motion of ball placed in a bowl.
- Motion of a Simple pendulum.
- Motion of a swing.

Q.11 Define Simple Harmonic Motion. Write conditions for SHM. (Exercise Question)

(LHR-G1),(MTN-G2),(GRW-G2),(BWP-G1)(SGD-G2),(SWL-G2)-2014 / (BWP-G1),(DGK-G2), (MTNG2),(SWL-G1/G2)-2015 / (BWP-G1),(DGK-G1),(GRW-G1)-2016 / (SWL-G1),(LHR-G2)-2017

Ans: SIMPLE HARMONIC MOTION (K.B) (given on previous page # 2)

Conditions/Requirements for SHM:

The conditions/requirements for a system executing SHM are summarized as:

- The oscillating system must have inertia.
- The oscillating system must have restoring force.
- The oscillating system must obey the Hook's law.
- The system should be frictionless.

Q.12 State Hooke's Law. Give its expression. *(K.B)*

Ans: HOOK's LAW

Statement:

"Within the elastic limit of the body. The applied force is directly proportional to the displacement**"**.

According to Hooke's law this force is directly proportional to the change in length **x** of the spring.

Mathematical Expression:

$$\mathbf{F \propto -x}$$

$$F = -kx$$

Where x is the displacement of the mass from its mean position O, and k is a constant called the spring constant.

Q.13 Is it possible for a body to execute SHM when due to applied force spring crosses its elastic limit? *(Conceptual Base + A.B)*

Ans: It is not possible for a body to execute SHM because when body crosses its elastic limit then Hook's Law does not apply on a body and spring will permanently deformed.

Q.14 Is it possible for a simple pendulum to oscillate about its mean position forever? *(Conceptual Base +A.B)*

Ans: No, it is not possible to a simple pendulum to oscillate forever because the amplitude of oscillation will damped due to frictional force of air and other factors.

Q.15 What is the displacement of an object in SHM when kinetic and potential energies are equal? *(K.B*

Ans: **DISPLACEMENT IN SHM WHEN K.E & P.E ARE EQUAL**

The energy conservation graph in SHM is not a straight line graph (as shown in figure), it's a (parabolic) curved line graph, at intersecting point of kinetic and potential energies, the displacement on horizontal axis is 0.7 which is 70% of amplitude. Hence, in SHM kinetic & potential energies are equal when the displacement of oscillator will be 70% of its amplitude (as shown in figure).

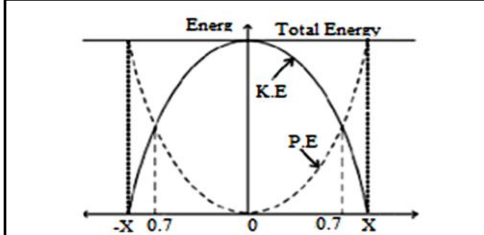
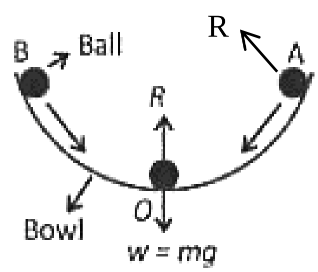


Figure: Energy-Displacement Graph in SHM

Q.16 Why in ball and bowl system weight is not balanced by the normal force of surface at extrem

Ans: At extreme position weight is not balanced by normal force of the surface because weight and normal force ar sition they have



Q.17 What are the factors upon which the time period of simple pendulum depends? *(K.B)*

Ans: **TIME PERIOD OF SIMPLE PENDULUM**

The relation for time period of simple pendulum is given by

$$\boxed{T = 2\pi\sqrt{\frac{\ell}{g}}}$$

The time period of simple pendulum depends upon:

- The length of string
- The value of acceleration due to gravity
- The time period of simple pendulum is **independent** of its **mass**.

Q.18 Tell whether or not these motions are examples of simple harmonic motion. *(U.B)*

(Check Your Understanding Text Book Pg. # 5)

Ans: **SHM & NON-SHM MOTIONS**

(a) Up and down motion of a leaf in a pond **(SHM)**
(b) Motion of a ceiling fan **(Not SHM)**
(c) Motion of hands of clock **(Not SHM)**
(d) Motion of a plucked string fixed at both its ends **(SHM)**
(e) Movement of honey bee **(Not SHM)**

Q.19 Why does the pendulum lose time in summer and gains time in winter?

(Conceptual Base + U.B)

Ans: **VARIATION OF TIME PERIOD**

As the time period of a simple pendulum is directly proportional to the square root of its length

- In summer due to increase in temperature, the length of simple pendulum increases and hence the time period of simple pendulum also increases.
- In winter due to decrease in length its time period also decreases.

Q.20 What happens to the frequency of pendulum, as its oscillations dies down from large amplitude to small? *(K.B+U.B+A.B + Conceptual Base)*

Ans: **VARIATION IN FREQUENCY**

The dissipation effect in the oscillations of simple pendulum is due to the frictional forces. The amplitude of motion of bob gradually becomes smaller and smaller due to air friction. Hence the friction has also an effect in reducing the frequency slightly.

Q.21 What is second pendulum? *(K.B+U.B)*

Ans: **SECOND PENDULUM**

Definition:

"A pendulum which completes one vibration in two seconds is called second pendulum". Thus time period of second pendulum is 2 seconds.

Q.22 What is the frequency of second pendulum? *(K.B+U.B+A.B)*

Ans: **FREQUENCY OF SECOND PENDULUM**

In SHM, the frequency and time period are related as

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

As the time period of second pendulum is 2 sec. Therefore, its frequency will be

$$f = \frac{1}{2} = 0.5 \text{ Hz}$$

Q.23 What will be the time period of simple pendulum at the center of the Earth? *(KB+U.B)*

Ans: **TIME PERIOD AT THE CENTER OF EARTH**

When the length of the pendulum is adjusted such that L=R, the bob will be at the center of the Earth. We know that at this position the value of 'g' is zero i.e g = 0.
Thus when length of simple pendulum is adjusted such that the bob is at the center the Earth, the time period of simple pendulum will be **infinity**.

Q.24 Can we realize an ideal simple pendulum? *(K.B)*

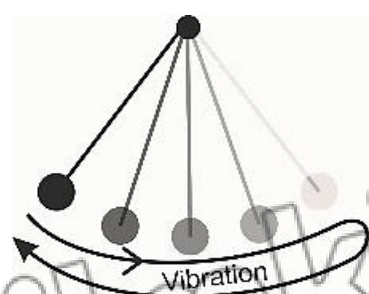
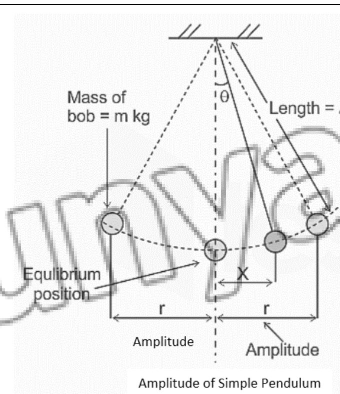
Ans: **AN IDEAL SIMPLE PENDULUM**

We cannot realize an ideal simple pendulum. An ideal simple pendulum consists of a heavy but small metallic bob suspended from a rigid frictionless support by means of long weightless and inextensible string.

Q.25 With respect to simple pendulum, what is the difference between vibration and amplitude? *(K.B+U.B)* **(LHR-G1)-2014**

Ans: **DIFFERENTIATION**

The differences between time period and frequency in case of vibratory motion are as follows:

Vibration	Amplitude
Definition	
• One complete round trip of a vibrating body about its mean position is called one vibration.	• The maximum displacement of a vibrating body on either side from its mean position is called its amplitude.
Figure	
	

Q.26 Who invented the pendulum clock and when? *(K.B)*

Ans: **INVENTION OF PENDULUM CLOCK**

Christian Huygens invented the pendulum clock in 1656. He was inspired by the work of Galileo who had discovered that all pendulums of the same length took the same amount of time to complete one full swing. Huygens developed the first clock that could accurately measure time.

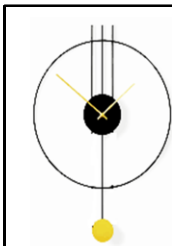


Figure:
Pendulum Clock

10.1 MULTIPLE CHOICE QUESTIONS

1. The maximum P.E of a vibrating mass attached to a spring is at: *(K.B+U.B)*
(A) Equilibrium position (B) Extreme position
(C) Between equilibrium and extreme positions (D) All the above

2. In F = -kx , k indicates: *(K.B)*
(A) Force constant (B) Spring constant
(C) Constant (D) Displacement

3. The value of k depends upon: *(K.B)*
(A) Length of spring (B) Width of spring
(C) Elasticity of spring (D) Stiffness of spring

4. The value of spring constant in case of soft springs is: *(K.B)*
(A) Small (B) Large
(C) Mild (D) None

5. In SHM displacement of mass and force exerted on the body is always directed: *(K.B)*
(A) Towards (B) Opposite to
(C) At same position (D) Away from

6. With the distance from the mean position, the magnitude of the restoring force: *(K.B)*
(A) Decreases (B) Increases
(C) Not change (D) Both (A) & (B)

7. In SHM, the mass does not stop at the mean position but continues its motion due to: *(K.B)*
(A) Restoring force (B) Inertia
(C) Reaction force (D) Gravitational force

8. In SHM, as the mass moves towards extreme position its speed: *(K.B)*
(A) Remains some (B) Increases
(C) Decreases (D) None of these

9. The ratio of exerted force to displacement is called: *(K.B)*
(A) Hooke's Law (B) Spring constant
(C) Restoring force (D) All of these

10. A human eardrum can oscillate in one second back and forth up to: *(K.B)*
(A) 20,000 times (B) 2,000 times
(C) 200,000 times (D) 200 times

11. The displacement of an object in SHM when the kinetic and potential energies are equal is: *(K.B+U.B)*
(A) Equilibrium position
(B) Extreme position
(C) In the middle of equilibrium and extreme positions
(D) 70% of its amplitude

12. The restoring force in case of ball and bowl system is: *(K.B)*
(A) Gravitational force (B) Applied force
(C) Reaction force (D) None of these

13. The to and fro motion of ball about mean position continues till all its energy is lost due to: *(K.B)*
(A) Gravitational (B) Reaction force
(C) Friction (D) Weight

14. The period of a pendulum is independent of its: *(K.B)*
(A) Length (B) Mass
(C) Amplitude (D) Both (B) and (C)

15. The time period T of simple harmonic motion of a mass m attached to a spring is given by: *(U.B+A.B)* **(GRW)-2014**

(A) $T = 4\pi\sqrt{\frac{\ell}{g}}$ (B) $T = 2\pi\sqrt{\frac{\ell}{g}}$
(C) $T = 2\pi\sqrt{\frac{m}{k}}$ (D) $T = 2\pi\sqrt{\frac{\ell}{k}}$

16. If the mass of bob of a simple pendulum is doubled, its time period: *(U.B)*
(A) Is doubled (B) Becomes four times
(C) Remains the same (D) None of the above

17. If the length of a simple pendulum is halved, its time period T will become: *(U.B + A.B)* (LHR-15)
(A) $\frac{T}{2}$ (B) $\frac{T}{\sqrt{2}}$
(C) $\sqrt{2}T$ (D) $2T$

18. Frequency and time period are: *(U.B)* (GRW-16)
(A) Reciprocal (B) Inversely proportional
(C) Directly proportional (D) None of these

19. The product of frequency and time period is equal to: *(U.B)* (GRW-16)
(A) V (B) 1
(C) 0 (D) λ

20. Christian Huygen invented the pendulum clock in: *(K.B)*
(A) 1658 (B) 1657
(C) 1656 (D) 1654

21. In case of simple pendulum which component of weight acts as restoring force? *(K.B+U.B+A.B)*
(A) mg sinθ (B) mg cosθ
(C) mg (D) None of these

22. Mathematically, S.H.M is represented as: *(K.B+U.B)*
(A) $a \propto x$ (B) $a \propto -x$
(C) $a \propto -x^2$ (D) $a = x$

23. If length of simple pendulum become double, its time period becomes: *(U.B+A.B)*
(A) $\frac{T}{2}$ (B) $\frac{T}{\sqrt{2}}$
(C) $\frac{1}{\sqrt{2T}}$ (D) $\sqrt{2}T$

24. Time period of simple pendulum is independent of: *(K.B)*
(A) Mass (B) Amplitude
(C) Length (D) Both a and b

25. Who developed first pendulum clock that could accurately measure time? *(K.B)*
(A) Galileo (B) Archimedes
(C) Einstein (D) Huygens

EXAMPLE 10.1 (U.B + A.B)

Find the time period and frequency of a simple pendulum 1.0 m long at a location where g = 10.0 ms^{-2}. **(AJK-G2)-2014 / (FSD-G2)-2015 / (FSD-G1)-2017**

Solution:

Given Data:
Length of simple pendulum = l= 1.0 m
Gravitational acceleration = g = 10.0 ms^{-2}

To Find:
(i) Time period is simple pendulum = T = ?
(ii) Frequency of simple pendulum = f = ?

Formula:

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

Calculation:

By using formula, we have

(i) $$T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$T = 2\times3.14\times\sqrt{\frac{1.0\,m}{10.0\,ms^{-2}}}$$

$$T = 2\times3.14\times\sqrt{0.1}$$

$$T = 2\times3.14\times0.316$$

$$T = 1.99\,s$$

(ii) By using formula, we have

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

$$f = \frac{1}{1.99} = 0.50\,Hz$$

Result:

Hence, the time period and frequency of simple pendulum will be 1.99s and 0.50 Hz.

10.2 DAMPED OSCILLATIONS

LONG QUESTION

Q.1 What are damped oscillations? How damping progressively reduces the amplitude of oscillation? Describe its one application. ***(K.B +A.B)***

(LHR-G1)-2016 / (SGD-G2)-2017

Ans: **DAMPED OSCILLATIONS**

Definition:

"The oscillations of a system in the presence of some **resistive force** are called damped oscillations**"**.

Explanation:

Vibratory motion of **ideal systems** in the absence of any friction or resistance continues indefinitely under the action of a restoring force.

Practically, in all systems, the force of friction retards the motion, so the system do not oscillate indefinitely. The friction reduces the mechanical energy of the system as time passes, and the motion is said to be **damped**. This damping progressively reduces the amplitude of the motion (as shown in figure).

Application:

The practical application of damped motion is 'shock absorbers' used in automobiles.

Shock Absorbers:

A shock absorber consists of a piston moving through a liquid such as oil as shown in fig. the upper part of the shock absorber is firmly attached to the body of the car. When the car travels over a

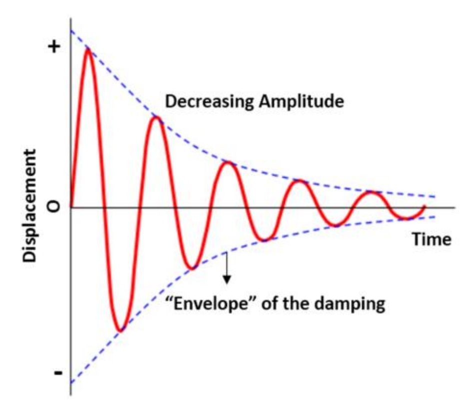


Figure: The variation of amplitude with time of damping system bump on the road, the car may vibrate violently. The shock absorbers damp these vibrations and convert their energy into heat energy of the oil.

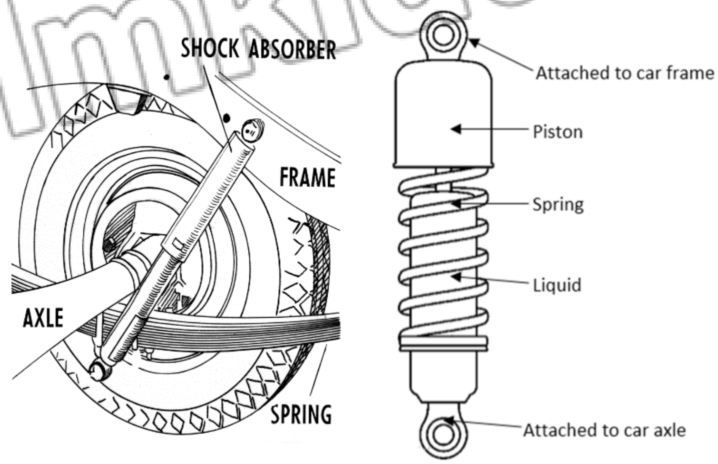


Figure: **Shock Absorber in Automobiles**

10.2 SHORT QUESTIONS

Q.1 Define damped oscillations. Give its two examples for daily life. ***(K.B +A.B)***

(AJK-G1)-2014 / (GRW-G2), (MTN-G2)-2017

Ans: *Given on Page # 14*

Q.2 Why the amplitude of damped oscillator decrease with the time? ***(K.B)***

Ans: The amplitude of oscillator decrease because it moves in resistance medium. If we remove all the resistance which damped the motion of oscillator. It will move for infinite time because its amplitude will remain same.

10.2 MULTIPLE CHOICE QUESTIONS

1. **Vibratory motion of ideal systems in the absence of any friction or resistance continues:** ***(K.B)***
   (A) Indefinitely (B) Directly
   (C) Definitely (D) All of these
2. **Shock absorbers damp vibrations and convert their energy into:** ***(A.B)***
   (A) Kinetic energy of oil (B) Potential energy of oil
   (C) Solar energy of oil (D) Heat energy of oil

10.3 WAVE MOTION

LONG QUESTION

Q.1 Define wave justify the particles of the wave always vibrate about their mean position. ***(K.B+A.B)***

Ans: **WAVE**

Definition:

"A wave is a disturbance in the medium which causes the particles of the medium to undergo vibratory motion about their mean position in equal intervals of time".

Importance of waves:

Waves play an important role in our daily life. It is because waves are carrier of energy and information over large distances. Waves require some oscillating or vibrating source. Here we demonstrate the production and propagation of different waves with the help of vibratory motion of objects experimentally.

Experiment 1:

Dip one end of a pencil into a tub of water, and move it up and down vertically as shown in fig. The disturbance in the form of ripples produces water waves, which move away from the source. When the wave reaches a small piece of cork floating near the disturbance, it moves up and down about its original position while the wave will travel outwards. The net displacement of the cork is zero. The cork repeats its vibratory motion about its mean position.

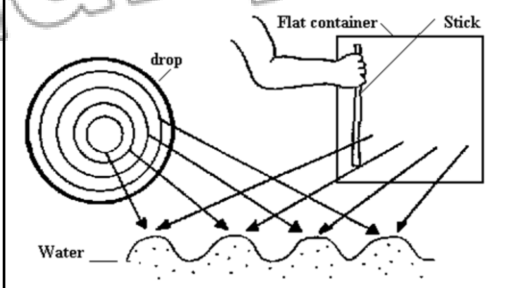


Figure: Waves Produced by Dipping a Pencil in a Water Tub

Experiment 2:

Take a rope and mark a point P on it. Tie one end of the rope with a support and stretch the rope by holding its other and in your hand as shown in fig. Now, flipping the rope up and down regularly will set up a wave in the rope which will travel towards the fixed end. The point P on the rope will start vibrating up and down as the wave passes across it.

The motion of point P will be perpendicular to the direction of the motion of wave.

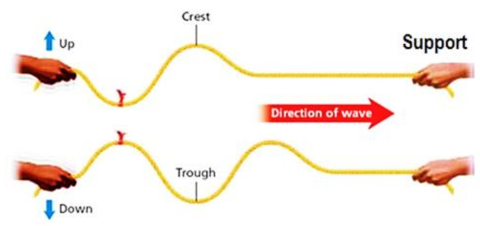


Figure: Waves Produced in a Rope

Conclusion:

From above experiments we can conclude that:

- **The vibratory motion of the pencil produces a disturbance in the constituent molecules of the water, due to which they start exhibiting vibratory motion about their mean position. Thus, this disturbance is transferred along with the wave, and a visible water wave can be observed.**
- **The up and down motion by flipping the rope produces a disturbance in the constituent molecules of the rope, due to which they start exhibiting vibratory motion about their mean position. Thus, this disturbance is transferred along with the wave, and a visible wave produced in a rope can be observed.**

Q.2 State and explain types of waves? **(MTN-G2)-2016 / (SGD-G2)-2017**

There are two basic categories of waves

- Mechanical waves
- Electromagnetic waves

MECHANICAL WAVES

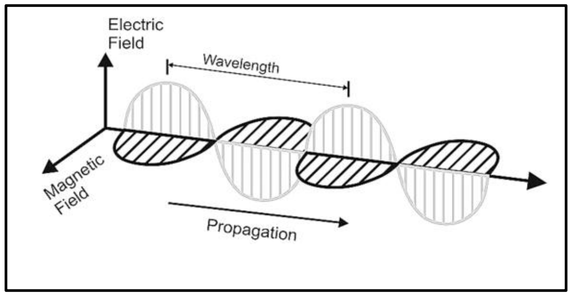
Definition:

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

Examples:

- Waves produced on water surface
- Sound waves
- Waves produced in strings and spring etc.

ELECTROMAGNETIC WAVE



Definition:

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

Examples:

- Radio waves,
- Television waves,
- X-rays, heat and light waves

Note: Electromagnetic waves consist of electric and magnetic fields oscillating perpendicular to each other.

10.3 SHORT QUESTIONS

Q.1 Define Mechanical and Electromagnetic waves with example? *(K.B)*
(SWL-G1)-2014 / (FSD-G1)-2016 / (MTN-G1)-2016 / (GRW-G2)-2017 / (SWL-G1)-2014 / (FSD-G1)-2016 (MTN-G1)-2016 / (BWP-G1), (FSD-G2)- (GRW-G2)-2017

Ans: *Given on page # 17*

Q.2 Do the mechanical waves pass through a space? *(K.B)* (Quick Quiz Text Book Pg. # 8)

Ans: **MECHANICAL WAVES IN SPACE**

No, mechanical waves do not pass through the space because they require medium for their propagation.

10.3 MULTIPLE CHOICE QUESTIONS

1. A travelling disturbance is called: *(K.B)*
(A) Wave (B) Power
(C) Frequency (D) Time

2. Wave transfer: *(K.B+A.B)* **(GRW-2015)**
(A) Energy (B) Power
(C) Frequency (D) Disturbance

3. Such waves which require medium for their production and propagation are called: *(K.B)*
(A) Radio waves (B) Electromagnetic waves
(C) Mechanical waves (D) X-rays

4. Electromagnetic waves consist of electric and magnetic fields oscillating: *(K.B)*
(A) Opposite to each other (B) Perpendicular to each other
(C) Parallel to each other (D) Both a and b

5. Heat and light waves are: *(K.B+U.B)*
(A) Electromagnetic (B) Damped
(C) Mechanical (D) None

6. Electromagnetic waves consist of: *(K.B)*
(A) Electric field (B) Magnetic field
(C) Electric field and magnetic field (D) None of these

7. Upon which, the amount of energy carried by the wave of stretched string from its rest position depends: *(K.B)*
(A) Amplitude (B) Wave length
(C) Distance (D) Frequency

8. Energy is transferred from one place of medium to the other in the form of: *(K.B)* **(LHR 2016)**

(A) Heat (B) Particles
(C) Waves (D) None of these

9. High frequency wave carries: *(K.B+A.B)*

(A) Less energy (B) More energy
(C) Both a and b (D) None of these

10.4 TYPES OF MECHANICAL WAVES

LONG QUESTIONS

Q. 1 Explain the types of mechanical waves with suitable examples. *(K.B+A.B)*
(MTN-G2),(DGK-GI),(BWP-G2)-2016 / (LHR-G1),(RWL-G2),(MTN-G2)(DGK-G1),(FSDG1/2)-2017

Ans. **TYPES OF MECHANICAL WAVES**

Depending upon the direction of displacement of medium with respect to the direction of propagation of wave itself, mechanical waves may be classified as:

- Longitudinal waves
- Transverse waves

LONGITUDINAL WAVES

Definition:

"In longitudinal waves the particles of the medium move back and forth along the direction of the propagation of wave**"**.

Examples:

- Sound Waves
- Waves produced in a spring

Explanation:

Waves produced in a slinky are longitudinal in nature, sound waves also travel from one place to another in longitudinal pattern. Longitudinal waves are also called compressional waves. These waves travel in the form of compressions and rarefactions.

Production:

Longitudinal waves can be produced on a spring (slinky) placed on a smooth floor or a long bench. Fix one end of the spring (slinky) with a rigid support and hold another end into your hand. Now give it a regular push and pull quickly in the direction of its length (as shown in figure).

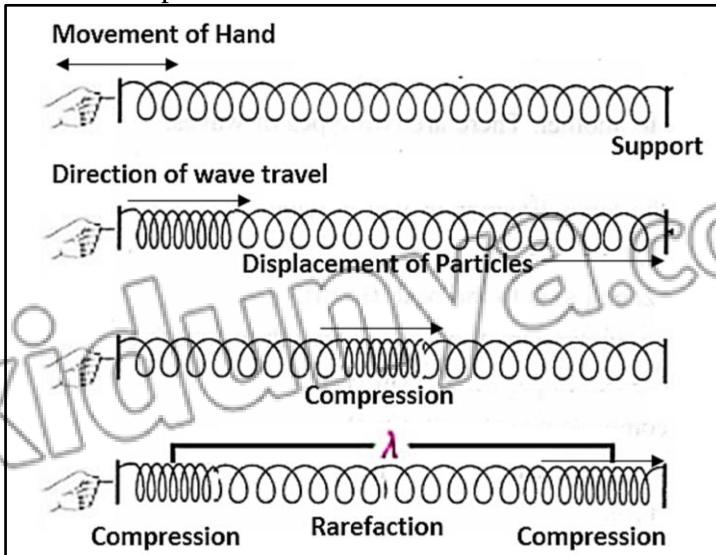


Figure: Longitudinal Wave on a Slinky

A series of disturbances will start moving along the length of the slinky such waves consist of regions called compression and rarefaction.

The compression and rarefactions move back and forth along the direction of motion of the wave.

Compression:

"The regions where the loops of the spring are close together and particles of the medium are closed together are called as compressions**"**.

Rarefactions:

"The regions where the loops are spaced apart and particles of the medium spaced apart are called **rarefactions** (expansions)**"**.

Wavelength:

"The distance between two consecutive compressions is called wavelengths**".**

TRANSVERSE WAVES

Definition:

"In the case of transverse waves, the vibratory motion of particles of the medium is perpendicular to the direction of propagation of wave**"**.

Examples:

- Waves produced on water surface
- Waves produced in a string
- Light Waves

Production:

We can produce transvers waves with the help of slinky. Stretch out a slinky along a smooth floor or on a long bench with one end fixed. Grasp one end of slinky and move it up and down quickly (as shown in figure)

A wave in the form of alternative crests and troughs will start traveling towards fixed end. The crests and troughs move perpendicular to the direction of the wave.

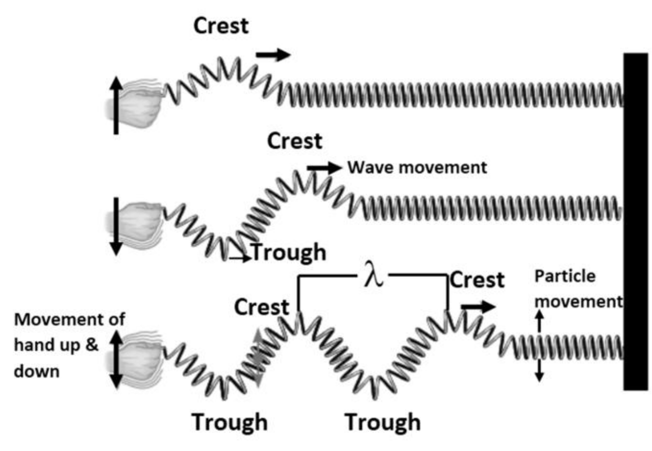


Figure: Longitudinal Wave on a Slinky

The Crests:

"The Crests are the highest points of the particles of the medium from the mean position**"**.

The Troughs:

"The Troughs are the lowest points of the particles of the medium from the mean position**"**.

Wavelength:

"The distance between two consecutive crests or troughs is called wavelengths**".**

Q.2 Describe waves as a carrier of energy in detail. ***(K.B+A.B)***

OR Waves are means of energy transfer without transfer of matter. Justify this statement with the help of a simple experiment. (Exercise Question) (BWP-G2)-2015

Ans:

WAVES AS CARRIERS OF ENERGY

Energy can be transferred from one place to another through waves.

Example:

When we shake the stretched string up and down, we provide our muscular energy to the string. As a result, a set of waves can be seen traveling along the string. The vibrating force from the hand disturbs the particles of the string and sets them in motion. These particles then transfer their energy to the adjacent particles in the string. Energy is thus transferred from one place of the medium to the other in the form of wave.

The amount of energy carried by the wave depends on the distance of the stretched string from its rest position. That is the energy in a wave depends on the amplitude of the wave. If we shake the string faster, we give more energy per second to produce wave of higher frequency, and the wave delivers more energy per second to the particles of the string as it moves forward.

Water waves also transfer energy from one place to another as explained below:

Experiment:

Drop a stone into a pond of water. Water waves will be produced on the surface of water and will travel outwards as shown in fig place a cork at some distance from the falling stone. When waves reach the cork, it will move up and down along with the motion of the water particles by getting energy from the wave.

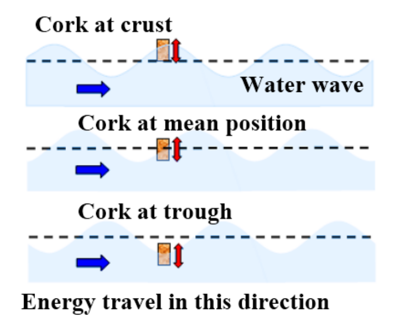


Figure: Waves as a Carrier of Energy

Conclusion

This experiment shows that water waves like other waves transfer energy from one place to other without transferring matter, i.e. water.

Q.3 Derive a relation between speed, frequency and wavelength of a wave. Write its formula relating speed of wave to its time period of wave length. *(A.B)*

(Exercise Question)

(LHR-G-2)-2015 / (SGD-G2)-20116 / (MTN-G1)-2017

Ans: **RELATION BETWEEN SPEED, FREQUENCY AND WAVELENGTH**

The relation between the velocity, frequency and wavelength of the wave is known as wave equation.

Formula Derivation:

Wave is a disturbance in a medium which travels from one place to another and hence have a specific velocity of traveling. This is called the velocity of wave which is defined by

Velocity = distance/time

$$v = \frac{d}{t}$$

If time taken by wave in moving from one point to another is equal to the **time period** then the distance covered by the wave will be equal to one **wavelength**,

Hence we can write: $v = \frac{\lambda}{T}$

But time period T is reciprocal of the frequency i.e. $T = \frac{1}{f}$ therefore,

$$\boxed{v = f\lambda}$$

Conclusion:

Above equation is called the wave equation it is true for all type of waves i.e. longitudinal, transverse etc. The above equation shows the relation between Speed, frequency and wavelength of a wave.

10.4 SHORT QUESTIONS

Q.1 Relate the speed of longitudinal and transvers waves through solid, liquid and gas. ***(K.B+U.B)*** *For Y*

Ans: **Speed of longitudinal and transvers waves**

Longitudinal waves move faster through solids than through gases or liquids. Transvers waves move through solids at a speed of less than half of the speed 0f longitudinal waves. Reason: it is because the restoring force exerted during this up and down motion of particles of the medium is less than the restoring force exerted by a back and forth motion of particles of medium in case of longitudinal waves.

Q.2 Which wave requires more energy for generation? ***(K.B)***

For Your Information Text Book Pg. # 11

Ans: **HIGH AND LOW FREQUENCY WAVES**

Generating a high frequency wave, require more energy per second than to generate to low frequency wave. Thus, a high frequency wave carries more energy than a low frequency waves of the same amplitude.

Q.3 What do you know about seismic waves? ***(K.B)*** Do You Know Text Book Pg. # 11

Ans: **SEISMIC WAVES**

Earthquake produces waves through the curst of the earth in the form of seismic waves. By studying such waves, the geophysicist learns about the internal structure of the Earth and information about the occurrence of future Earth activity.

Q.4 Differentiate between compression and rarefaction? ***(K.B)*** **(SWL-G1)-2017**

Ans: *Given on the page # 18.*

Q.5 Differentiate between crest and trough? ***(K.B)*** **(BWP-G1)-2014**

Ans: *Given on the page # 19.*

Q.6 Differentiate between transverse waves and compressional or longitudinal waves. ***(K.B)***

Ans: *Given on the page # 18+19.*

Q.7 How can you define term wave? Elaborate difference between mechanical and electromagnetic wave. ***(K.B)*** **(**

Ans: **WAVE**

A wave is a disturbance in the medium which causes the particles of the medium to undergo vibratory motion about their mean position in equal intervals of time. Mechanical and electromagnetic wave are given on page # 17

10.4 MULTIPLE CHOICE QUESTIONS

1. The parts of longitudinal wave where loops of spring are far apart from each other: ***(K.B)***

(A) Compressions (B) Rarefactions
(C) Crest (D) Troughs

2. The speed of transverse waves as compared to the speed of longitudinal waves through solids, is: ***(K.B+U.B)***

(A) More than half (B) Half
(C) Less than half (D) Equal

3. The distance between two consecutive crests and troughs is called: ***(K.B)***

(A) Wave motion (B) Wave frequency
(C) Wave amplitude (D) Wave length

4. **Highest points are: *(K.B)***
(A) Crest (B) Through
(C) Amplitude (D) None of these

5. **Lowest points are: *(K.B)***
(A) Crest (B) Trough
(C) Amplitude (D) None of these

6. **Water and light waves are: *(K.B)***
(A) Transverse waves (B) Longitudinal wave
(C) Electromagnetic waves (D) None of these

7. **The relation between the velocity frequency and wavelength of the wave is known as: *(K.B+U.B+A.B)***
(A) Spring constant (B) Amplitude
(C) Wave equation (D) Spring constant

8. **Earthquake produces waves through the body of the Earth in form of: *(K.B)***
(A) Transverse wave (B) Longitudinal waves
(C) Seismic waves (D) None of these

9. **The region where pressure on the layer of air is more than surroundings: *(K.B)***
(A) Compression (B) Rarefaction
(C) Diffraction (D) Interference

10. **The region where pressure on the layer of the air is less than surrounding: *(K.B)***
(A) Compression (B) Rarefaction
(C) Diffraction (D) Interference

11. **The relation between velocity, wavelength and time period is: *(A.B+U.B)* (GRW 2014, LHR 2016)**
(A) $\lambda = \frac{v}{T}$ (B) $v = \lambda T$
(C) $\lambda = vf$ (D) $T = \frac{\lambda}{v}$

12. **Wave equation is true for: *(K.B+U.B)***
(A) Transverse waves (B) Longitudinal waves
(C) Both a and b (D) None of these

EXAMPLE 10.2

A wave moves on a slinky with frequency of 4 Hz and wavelength of 0.4 m. What is the speed of the wave? *(U.B+A.B)*

Solution:

Given Data:

Frequency of wave = f = 4 Hz

Wavelength = λ = 0.4 m

To Find:

Speed of wave = v = ?

Formula:

$v = f\lambda$

Calculation:

By using formula, we have

$v = f\lambda$

$v = (4\text{Hz})(0.4\text{m})$

$v = 1.6\ \text{ms}^{-1}$

Result:

Hence, the speed of wave moves on a slinky will be 1.6 ms^{-1}.

10.5 RIPPLE TANK

LONG QUESTIONS

Q.1 What is ripple tank? Write the construction and working of ripple tank. ***(K.B+A.B)***

(GRW-G2)-2016 / (SWL-G2)-2017

Ans: **RIPPLE TANK**

Definition:

"Ripple tank is a device to produce **water waves** and to study their characteristics**"**.

Construction:

This apparatus consists of a rectangular tray having glass bottom and is placed nearly half meter above the surface of a table (as shown in figure) waves can be produced on the surface of water present in the tray by means of a vibrator (paddle).

Working:

This vibrator is an oscillating electric motor fixed on a wooden plate over the tray such that its lower surface just touches the surface of water. On setting the vibrator ON, this wooden plate starts vibrating to generate water waves consisting of straight wave fronts. An electric bulb is hung above the tray to observe the image of water waves on the paper or screen. The **crests** and **troughs** of the waves appear as **bright** and **dark** lines, respectively, on the screen.

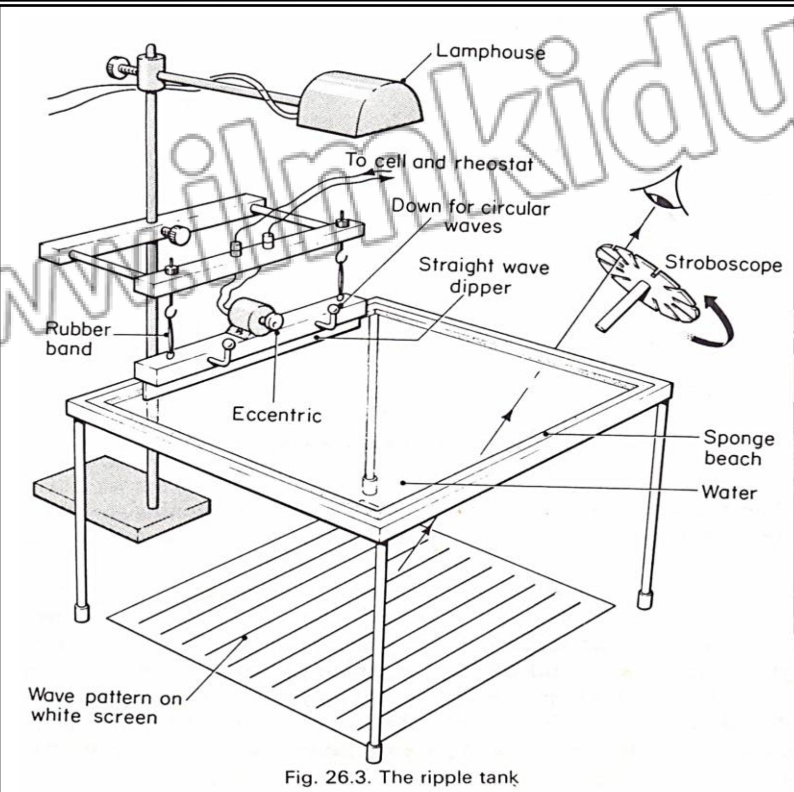


Figure: **Ripple Tank Apparatus**

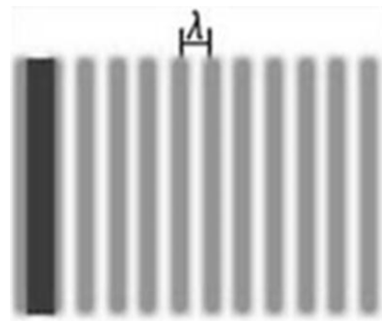


Figure: **Waves Consisting of Straight Wave fronts**

Q.2 Explain the properties of waves with reference to the ripple tank. ***(K.B+A.B)***
(Exercise Question) (RWL-G2), BWP-G1/G2)-2017

Ans: By using the ripple tank, we can produce the water waves to observe the properties of waves which are described below:

- Reflection
- Refraction
- Diffraction

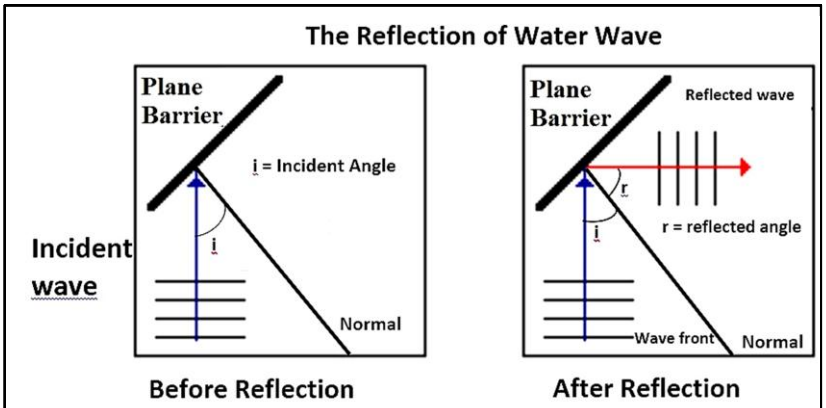
REFLECTION

Definition:

"When waves moving in one medium fall on the surface of another medium they bounce back into the first medium such that the angle of incidence is equal to the angle of reflection. This phenomenon is called reflection of waves**"**.

Explanation:

Place a barrier in the ripple tank. The water waves will reflect from the barrier which is placed at an angle to the wave front, the reflected waves can be seen to obey law of reflection i.e, the angle of the incident wave along the normal will be equal to the angle of the reflected wave (as shown in figure).



$\angle i = \angle r$

Figure: Reflection of Water Waves from a Plane Barrier

REFRACTION

Definition:

"When a wave from one medium enters into the second medium at some angle, its direction of travel changes. This phenomenon is called refraction of waves.**"**

Explanation:

The speed of a wave in water depends on the depth of water. If a block is submerged in the ripple tank, the depth of water in the tank will be shallower over the block than elsewhere. When water waves enter the region of shallow water their wavelength decreases and its speed also decreases as shown in fig but the frequency of the water waves remains the same in both parts of water because it is equal to the frequency of the vibrator as shown in Fig. 10.14 ($V = f\lambda$).

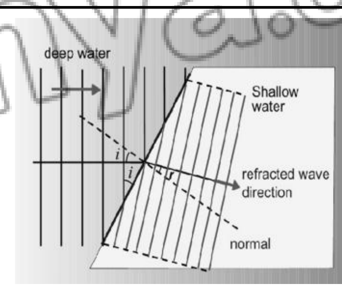


Figure: Refraction of Water Waves

In deep water the wave length of the water wave is greater as compared to wave length in shallow water due to increase in wave length its speed also increases and its frequency remain same because both types of waves in deep water and in shallow water are produced by same vibrator.

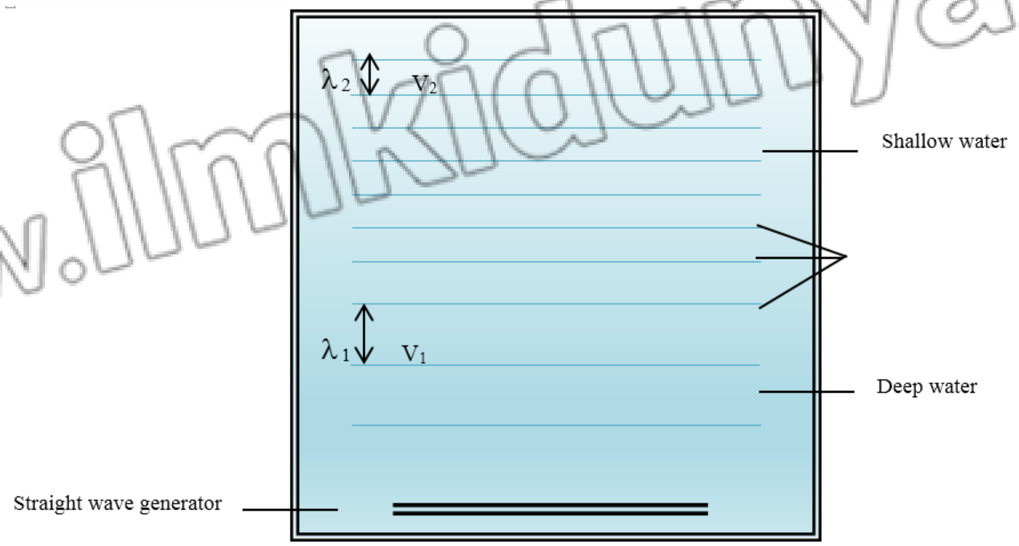


Fig. 10.14

For the observation of refraction of water waves, we repeat this experiment such that the boundary between the deep and the shallower water is at same angle to the wave front (as shown in figure). Now we will observe that in addition to the change in wavelength the waves change their direction of propagation as well. The direction of propagation is always normal to the wave fronts.

This change of path of water waves while passing from a region of deep water to that of shallower is called refraction.

DIFFRACTION

Definition:

"The bending or spreading of waves around the sharp edges or corners of obstacles or slits is called diffraction."

Explanation:

Now we observe the phenomena of diffraction of water waves. Generate straight plane waves in a ripple tank and place two obstacles in line in such a way that separation between them is equal to the wavelength of water waves. After passing through a small slit between the two obstacles, the waves will spread in every direction and change into almost semicircular pattern (as shown in figure).

(As shown in Figure) the diffraction of waves while passing through a slit with size larger than the wavelength of the wave. Only a small diffraction occurs near the corners of the obstacle.

Figure: **Diffraction of Water Waves through a Small Slit**

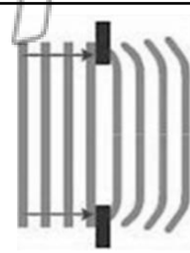


Figure: **Diffraction of Water Waves through a Large Slit**

Condition for the Diffraction:

Diffraction of waves can only be observed clearly if the size of the obstacle is comparable with the wavelength of the wave.

10.5 SHORT QUESTIONS

Q.1 What is the function of ripple tank? ***(K.B+A.B)***
(DGK-G2)-2013

Ans: **FUNCTION OF RIPPLE TANK**

Ripple tank is a device used to produce **water waves** and to study their characteristics (Reflection, Refraction, Diffraction).

Q.2 Define refraction of wave. ***(K.B+A.B)*** **(LHR-G1),(GRW-G2)-2016**

Ans: *Given on Page # 24*

Q.3 Define diffraction of waves. ***(K.B+A.B)*** **(BWP-G2)-2014 / (SGD-G2)-2015 / (SGD-G1),(GRW-G2)-2017**

Ans: *Given on page # 25*

Q.4 What do the dark and bright fringes on the screen of ripple tank represent? ***(K.B+U.B)***

(Quick Quiz Text Book Pg. # 13)

Ans: **DARK AND BRIGHT FRINGES**

Bright fringes represent crests whereas dark fringes represent troughs of the waves on the screen.

Q.5 What is the condition for diffraction? ***(K.B)***

Ans: *Given on page # 25*

Q.6 What happens to the direction of wave when water wave pass from deep to shallow part of the water? Are the magnitude of angle of incidence and angle of refraction equal? Which will be greater? ***(K.B+U.B+A.B+Conceptual Base)***

(ACTIVITY: Text Book Pg. # 14)

Ans: **DIRECTION OF WAVE**

When water wave enters from deep to shallow depth, wave changes its direction in addition to decrease in wavelength. It is clear that when water enters the shallow part, water wave bend towards the normal on line separating the two parts. Hence the angle of refraction becomes less than angle of incidence.

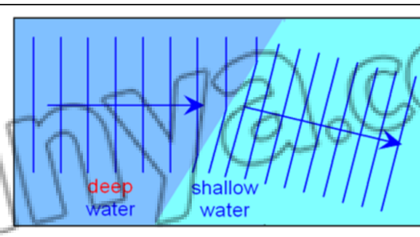
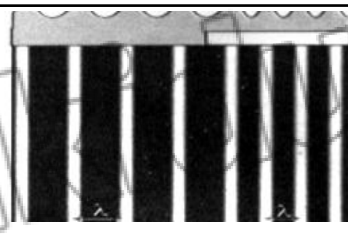


Figure: **Refraction of Water Waves**

Q.7 Why bright lines are seen on the screen of the ripple tank? ***(K.B+U.B)***

Ans: **BRIGHT LINES ON SCREEN**

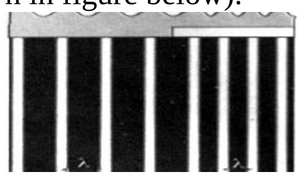
The crests of the waves appear as bright lines on the paper because they behave like a convex lens and converge the rays of light falling on them. So, bright lines are seen on the screen of the ripple tank (as shown in figure below).



Q.8 Why dark lines are seen on the screen of the ripple tank? ***(K.B+U.B)***

Ans: **DARK LINES ON SCREEN**

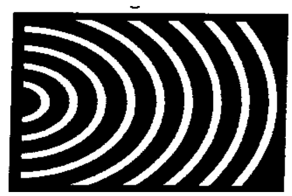
The troughs of the waves appear as dark lines on the paper because they behave like a concave lens and diverge the rays of light falling on them. So, dark lines are seen on the screen of ripple tank (as shown in figure below).



Q.9 How can we generate circular waves in a ripple tank? ***(K.B+A.B)***

Ans: **CIRCULAR WAVES IN A RIPPLE TANK**

We can generate circular waves in a ripple tank by attaching a knob on the lower side of vibrating bar. Now it is lowered in such a way that knob touches the water surface. When vibrator is set on, circular waves are produced on the water surface (as shown in figure below).



Q.10 In relation $v = f\lambda$ which two quantities depend upon the properties of the medium and why does third one not? ***(K.B+A.B+U.B)***

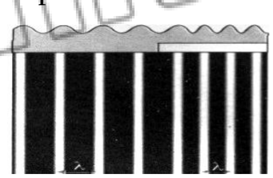
Ans: **DEPENDANCE OF v, λ and f**

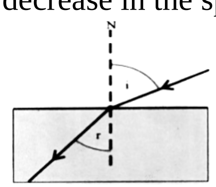
In relation $v = f\lambda$., v and λ depend on the properties of the medium while f does not depend on the properties of the medium because frequency (f) depends upon the frequency of the vibrator.

Q.11 Why does wavelength decrease in shallow part of water? ***(Conceptual Base+K.B+A.B)***

Ans: **DECREASE OF WAVELENGTH IN SHALLOW PART**

As wavelength changes with the depth of water so there will be a decrease in wavelength of the waves in shallow part of water due to decrease in the speed of the waves.





Q.12 What are the factors which affect refraction? ***(K.B)***

Ans: **FACTORS AFFECTING REFRACTION**

Refraction of water waves depends upon the depth of water waves because speed of water waves depends upon the depth of water. Its speed is reduced when it enters in shallow water. So when water waves enter from deep water to shallow water their wavelength changes but frequency remains the same and refraction of water waves takes place.

Q.13 What is the effect of diffraction on water waves? *(K.B)*

Ans: **EFFECT OF DIFFRACTION**

If we place two obstacles in a line of straight water waves in such a way that separation between them is equal to wavelength of water waves. After passing through the slits between two obstacles, straight water waves are changed into circular waves. But diffraction of waves can only be observed clearly if the size of the slit is nearly equal to wavelength of the wave.

Q.14 What is the importance of diffraction in daily life? *(A.B)*

Ans: **IMPORTANCE OF DIFFRACTION**

The importance of diffraction in our daily life is given as follow:

- Due to diffraction of radio waves, transmission can be heard in such areas where the waves cannot reach directly.
- The closely spaced tracks on a CD or DVD act as a diffraction grating to form the familiar rainbow pattern we see when looking at a disk.

Q.15 How do ocean waves cause destruction? *(K.B+A.B)*

Ans: **OCEAN WAVES CAUSE DESTRUCTION**

Sometime, the ocean waves cause the destruction of ships and coastal areas because in case of any disturbance in the ocean, energy is carried by the waves and they travel towards coastal area and causes destruction.

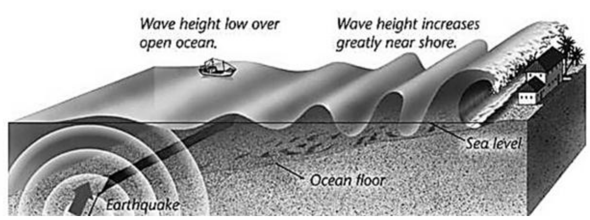


Figure: Ocean Waves Cause Destruction

10.5 MULTIPLE CHOICE QUESTIONS

1. **The apparatus used to study the properties of waves is: *(K.B+A.B)***
   (A) Ripple tank (B) Stroboscope
   (C) Stethoscope (D) Endoscope
2. **Vibrator is: *(K.B+A.B)***
   (A) Oscillating motor (B) Moving motor
   (C) Wave (D) None of these
3. **Crests and troughs appear as: *(K.B)***
   (A) Dark and light (B) Bright and dark
   (C) Dull and shining (D) Shining and dull
4. **Refraction of light rays depend upon: *(K.B)***
   (A) Speed (B) Frequency
   (C) Amplitude (D) Wavelength
5. **Refraction of water waves depend upon: *(K.B)***
   (A) Depth (B) Frequency
   (C) Amplitude (D) All of them

6. **Diffraction of waves can clearly be observed if size of the slit or obstacle is nearly equal to the:** ***(K.B)***
(A) Trough of wave (B) Crest of wave
(C) Amplitude of wave (D) Wavelength

7. **Transmission can be heard in such areas where the waves cannot reach directly due to:** ***(K.B + A.B)***
(A) Reflection (B) Refraction
(C) Interference (D) Diffraction

8. **The observe the diffraction properly the slit or obstacles must be equal to the:** ***(U.B)***
(A) Frequency (B) Amplitude
(C) Wavelength (D) Time period

9. **On screen crest appear as:** ***(K.B)***
(A) Bright line (B) Dark line
(C) Silver line (D) Golden line

EXAMPLE 10.3

A student performs an experiment with waves in water. The student measures the wavelength of a wave to be 10 cm. By using a stopwatch and observing the oscillations of a floating ball, the student measures a frequency of 2 Hz. If the student starts a wave in one part of a tank of water, how long will it take the wave to reach the opposite side of the tank 2 m away? (U.B + A.B)

Solution:

Given Data:

Wavelength = λ = 10 cm = 0.1 m

Frequency of wave = f = 2 Hz

To Find:

Time taken by wave = t = ?

Formula:

$$v = f\lambda$$

$$t = \frac{d}{v}$$

Calculation:

By using formula, we have

$$v = f\lambda$$

$$v = (2\,\text{Hz})(0.1\text{m})$$

$$v = 0.2\ \text{ms}^{-1}$$

Use this value to calculate the time:

$$t = \frac{2\text{m}}{0.2\text{ms}^{-1}} = 10\text{s}$$

Result:

Hence, the time taken by the wave to reach the opposite side of then tank2 m away will be 10 s.

MCQ'S ANSWER KEY (TOPIC WISE)

10.1 SIMPLE HARMONIC MOTION (SHM)

1	2	3	4	5	6	7	8	9	10	11	12
B	B	D	A	B	D	B	C	B	A	D	A
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
C	D	C	C	B	A	B	C	A	B	D	D
25	**D**										

10.2 DAMPED OSCILLATIONS

1	2
A	D

10.3 WAVE MOTION

1	2	3	4	5	6	7	8	9

A	A	C	B	A	C	C	C	B

10.4 TYPES OF MECHANICAL WAVES

1	2	3	4	5	6	7	8	9	10	11	12
B	C	D	A	B	A	C	C	A	B	D	C

10.5 RIPPLE TANK

1	2	3	4	5	6	7	8	9
A	A	B	A	A	D	D	C	A

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. Which of the following is an example of simple harmonic motion? *(K.B)*

(a) motion of a simple pendulum (b) the motion of ceiling fan
(c) the spinning of the Earth on its axis (d) a bouncing ball on floor

ii. If the mass of the bob of a pendulum is increased by a factor of 3, the period of the pendul

(a) be increased by a factor of 2 (b) remain the same
(c) be decreased by a factor of 2 (d) be decreased by a factor of 4

iii. Which of the following devices can be used to produce both a transverse and longitu

(a) a string (b) a ripple tank
(c) a helical spring (slinky) (d) a tuning fork

iv. Waves transfer: *(K.B)* (SWL-G2)(LHR-G1)(RWP-G2)(GRW-G2)-2014 / (FSD-G1)(BWP-G2)(GRW-G1)-2015 / (R

(a) energy (b) frequency
(c) wavelength (d) velocity

v. Which of the following is a method of energy transfer? *(K.B)* (SGD-G1)(SWL-G1)(DGK-G1)-2014 / (FSD-G1

(a) conduction (b) radiation
(c) wave motion (d) all of these

vi. In a vacuum all electromagnetic waves have the same: *(K.B)*

(a) speed (b) frequency
(c) amplitude (d) wavelength

vii. A large ripple tank with a vibrator working at a frequency of 30 Hz produces 25 complete waves in

(BWP-G1)(LHR-G2)(SGD-G2)-2014 / (RWP-G1)-2016

(a) 53 cm^{-1} (b) 60cms^{-1}
(c) 750 cms^{-1} (d) 1500 cms^{-1}

viii. Which of the following characteristics of a wave is independent of the others? *(K.B)*

(MTN-G1)(SGD-G1)-2014 / (RWP-G1)(FSD-G2)-2015 / (FSD-G2)(DGK-G1)-2016 / (LHR-G2)-2017

(a) speed (b) frequency
(c) amplitude (d) wavelength

ix. The relation between v, f and λ of a wave is: *(U.B+A.B)*

(GRW-G1 / G2)(FSD-G1)-2014 / (MTN-G2)(LHR-G1)-2015 / (RWP-G1)(MTN-G1)(FSD-G1)(DGK-G2)-2016 / (SGD-G2)-2017

(a) $vf = \lambda$ (b) $f\lambda = v$
(c) $v\lambda = f$ (d) $v = \frac{\lambda}{f}$

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
a	b	c	a	d	a	b	c	b

REVIEW QUESTIONS

10.1 What is simple Harmonic Motion? What are the necessary conditions for a body to execute simple harmonic motion? *(K.B)*

Ans: (See Topic 10.1, Short Question-3)

10.2 Think of several examples in everyday life of motion that are simple harmonic. *(U.B)*

Ans: **<u>EXAMPLES OF SHM IN DAILY LIFE</u>**

Example of Simple Harmonic Motion (SHM) in everyday life are as follows:

- Motion of a body attached to one end of spring.
- Motion of bob of simple pendulum.
- Motion of ball in bowl system.
- Motion of the prong of the tuning Fork.

10.3 What are damped oscillations? How damping progressively reduces the amplitude of oscillation? *(K.B + U.B)*

Ans: (See Topic 10.2, Long Question-1)

10.4 How can you define term wave? Elaborate difference between mechanical and electromagnetic waves. *(K.B)*

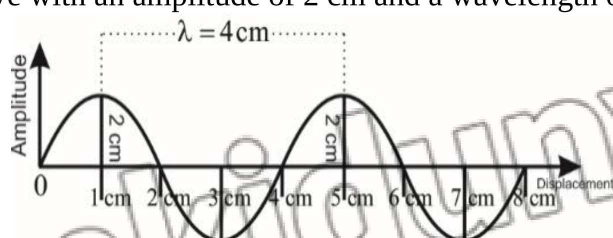
Ans: (See Topic 10.3, Short Question-3)

10.5 Distinguish between longitudinal and transverse waves with suitable examples. *(K.B)*

Ans: (See Topic 10.4, Short Questions-6)

10.6 Draw a transverse wave with an amplitude of 2 cm and a wavelength of 4cm. Label a crest and trough on the wave. *(U.B)*

Ans: A transverse wave with an amplitude of 2 cm and a wavelength of 4 cm is drawn below:



10.7 Derive a relationship between speed, frequency and wavelength of a wave. Write a formula relating speed of a wave to its time period and wavelength. *(U.B + A.B)*

Ans: (See Topic 10.4, Long Question-3)

10.8 Waves are the means of energy transfer without transfer of matter. Justify this statement with the help of a simple experiment. *(K.B + U.B + A.B)*

Ans: (See Topic 10.4, Long Question-2)

10.9 Explain the following properties of waves with reference to ripple tank experiment.
a. Reflection b. Refraction c. Diffraction *(K.B + A.B)*

Ans: (See Topic 10.5, Long Question-2)

10.10 Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related? *(K.B + U.B)*

Ans. **<u>RELATION BETWEEN FREQUENCY & WAVELENGTH</u>**

No, wavelength does not increase with increase of frequency of waves because frequency depends upon the source which produces waves per second. But the wavelength of the wave depends on the magnitude of vibrating particles.

Relationship of frequency (f) and wavelength (λ)

Generally, frequency (f) and wavelength (λ) are inversely related to each other when speed kept constant by the following equation.

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

Hence from this equation we conclude that when frequency (f) of waves increases then their wavelength (λ) decreases.

CONCEPTUAL QUESTIONS (A.B)

10.1 If the length of the simple pendulum is doubled what will be change in its time period?

(LHR-G1)-2015 / (DGK-G2), (MTN-G1)-2017

Ans: **VARIATION IN TIME PERIOD**

When the length of simple pendulum is increased its time period increases as we know that

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

According to given condition

If $\ell = 2\ell$

$$T' = 2\pi\sqrt{\frac{2\ell}{g}} = \sqrt{2}\left(2\pi\sqrt{\frac{\ell}{g}}\right) \Rightarrow T' = \sqrt{2}T$$

Thus time period become $T' = \sqrt{2}T$

10.2 A ball is dropped from certain height onto the floor and keeps bouncing. Is the motion of the ball is simple harmonic motion.

Ans: **MOTION OF BALL**

No, the motion of the bouncing ball is not the example of SHM. Because it does not fit the definition of SHM which is as follows:

SHM occurs when the net force is proportional to the displacement from the mean position and is always directed towards the mean position.

10.3 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?

Ans: **EFFECT ON TIME PERIOD**

As $T = 2\pi\sqrt{\frac{\ell}{g}}$

Above formula clearly shows that the time period of the simple pendulum is independent of mass therefore, when a student performed two experiments with the simple pendulum by using two bobs of different mass by keeping other parameters constant. Then time period of simple pendulum remains same.

10.4 What types of waves do not require any material medium for their propagation?

Ans: *Given on the previous page.*

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

Ans: As we know that

$$V = f\lambda$$

In ripple tank frequency of waves is constant because it is equal to the frequency of vibrator Hence wave speed is directly proportional to wave length. With increase of wavelength, speed will also be increased similarly with decrease in wavelength, wave speed also decreases. As the water wave enter into the shallow region from deep region its wavelength (λ) decreases, due to this speed of wave also decreases.

NUMERICAL PROBLEMS

(U.B+A.B)

10.1 The time period of a simple pendulum is 2s. What will be its length on Earth? What will be its length on the moon if $g_m = g_e / 6$? Where $g_e = 10ms^{-2}$. **(FSD-G1)-2015**

Solution:

Given Data:

Time period of simple pendulum = T = 2 sec.

Value of 'g' on Earth = g_e = 10 ms^{-2}

Value of 'g' on Moon = $g_m = \frac{g_e}{6} = \frac{10}{6} = 1.6\,ms^{-2}$

To Find:

(i) Length of pendulum on earth = ℓ_e = ?

(ii) Length of pendulum on moon = ℓ_m = ?

Formula:

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

Calculation:

(i) For Earth

$$T = 2\pi\sqrt{\frac{\ell_e}{g_e}}$$

By taking square on both sides, we have

$$T^2 = 4\pi^2 \frac{\ell_e}{g_e}$$

or

$$\ell_e = \frac{T^2 \times g_e}{4\pi^2}$$

By putting the values, we have

$$\ell_e = \frac{(2)^2 \times 10}{4\times(3.14)^2} = \frac{4\times 10}{4\times 9.86}$$

$$\boxed{\ell_e = 1.02\text{m}}$$

(ii) For Moon

$$T^2 = \frac{4\pi^2\ell_m}{g_m}$$

$$\ell_m = \frac{T^2 g_m}{4\times\pi^2}$$

By putting the values, we have

$$\ell_m = \frac{(2)^2\times 1.6}{4\times(3.14)^2} = \frac{6.44}{39.44}$$

$$\boxed{\ell_m = 0.17\,\text{m}}$$

Result:

Hence, the length of pendulum on Earth and on Moon will be 1.02 m and 0.17 m respectively.

10.2 A pendulum of length 0.99 m is taken to the Moon by an astronaut. The period of the pendulum is 4.9s. What is the value of g on the surface of the moon? **(MTN-G2)-2015**

Solution:

Given Data:

Length of pendulum on Moon = ℓ_m = 0.99m

Time period of pendulum = T = 4. 9 s

To Find:

Value of g on moon = g = ?

Formula:

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

Calculation:

By using formula, we have

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

$$4.9\text{sec} = 2\times 3.14\sqrt{\frac{0.99}{g}}$$

Squaring

$$g = \frac{4\times(3.14)^2\times 0.99}{(4.9)^2}$$

g = 1.63 ms^{-2}

Result:

Hence, the value of 'g' of the surface of Moon will be 1.6 ms^{-2}.

10.3 Find the time periods of a simple pendulum of 1 meter length, placed on Earth and on moon. The value of g on the surface of moon is 1/6th of its value on Earth. When g_e is $10ms^{-2}$.

Solution:

Given Data:

Length of simple pendulum = ℓ = 1m

Value of 'g' on Earth = g_e = 10 ms^{-2}

Value of 'g' on Moon = g_m = 1.62 ms^{-2}

To Find:

Time period on earth = T_e = ?

Time period on moon = T_m = ?

Formula:

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

Calculation:

(i) For Earth:

$$T = 2\pi\sqrt{\frac{\ell_e}{g_e}}$$

$$T_e = 2(3.14)\sqrt{\frac{1}{10}}$$

$$T_e = (6.28)\sqrt{0.1}$$

T_e = (6.28) (0.316)

T_e = 1.985 sec.

T_e = 2sec. Ans

(ii) For Moon:

$$T_m = 2\pi\sqrt{\frac{\ell_m}{g_m}}$$

$$T_m = 2(3.14)\sqrt{\frac{1}{1.67}}$$

$$T = 2(3.14)\sqrt{0.6172}$$

T = 4.9 sec

Result:

Hence, the time period of simple pendulum on Earth and Moon will be 2 s and 4.9 s respectively.

10.4 A simple pendulum completes one vibration in two seconds. Calculate its length when g = 10.0 ms^{-2}

Solution:

Given Data:

Time period of second pendulum = T = 2sec

Gravitational acceleration = g = 10 ms^{-2}

To Find:

Length of simple pendulum = ℓ = ?

Calculation:

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

Squaring on both sides

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

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

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

$$\ell = \frac{\cancel{4} \times 10}{\cancel{4} \times 9.85}$$

ℓ = 1.02 m

Result:

Hence, the length of simple pendulum will be 1.02 m.

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

Solution:

Given Data:

No. of waves passed through a point = n = 100

Time taken = t = 20s

Wavelength = λ = 6cm = 0.06 m

To Find:

(i) Frequency of wave = f = ?

(ii) Time period of wave = T = ?

(iii) Speed of wave = v = ?

Formula:

(i) f = n/t $\frac{\text{no. of waves passed}}{\text{Time taken}}$

(ii) Time period of wave $= T = \frac{1}{f}$

(iii) Speed of wave = v = fλ

Calculation:

(i) By using formula, we have

$$f = \frac{n}{t}$$

$$f = \frac{100}{20}$$

f = 5Hz

(ii) As, we know that

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

$$T = \frac{1}{5Hz}$$

T = 0.2 sec

(iii) By using wave equation, we have

V = f λ

V = 5 $\times$ 0.06

V = 0.3 ms^{-1}

Result:

Hence, the frequency, time period and speed of the wave will be 5 Hz, 0.2 s and 0.3 ms^{-1} respectively.

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

Solution:

Given Data:

Frequency of wooden bar = f = 12 Hz

Wavelength = λ = 3cm = 0.03 m

To Find:

Speed of wave = v = ?

Formula:

We know that

V = λ f

Calculations:

By using wave equation,

v = fλ

v = (0.03) (12)

v = 0.36 ms^{-1}

Hence, the speed of wave will be 0.36 ms^{-1}.

Result:

10.7 A transverse wave produced on a spring has a frequency of 190 Hz and travels along the length of the spring of 90m, in 0.5s.
(a) What is the period of wave?
(b) What is the speed of the wave?
(c) What is the wavelength of the wave?

Solution:
Given Data:
Frequency of wave = f = 190 Hz
Distance travelled by wave = d = 90 m
Time taken = t = 0.5s
To Find:
(i) Time period of wave = T = ?
(ii) Speed of wave = V = ?
(iii) Wavelength = λ = ?
Formula:
(i) $T = \frac{1}{f}$
(ii) $v = \frac{d}{t}$
(iv) $\lambda = \frac{v}{f}$
Calculations:
(i) Time period:
By using formula, we have
T = 1/f
T = 1/190
T = 0.005
T = 0.01s
(ii) Speed of wave:
By using formula, we have
V = d/t
V = 90/0.5
V = 180 m/s
(iii) Wavelength:
By using wave equation, we have
λ = v/f
λ = 180/190
λ = 0.95 m
Result:
Hence, the time period, speed and wavelength of the wave will be 0.01 s, 180 ms^{-1} and 0.05 m respectively.

10.8 Water waves in a shallow dish are 6.0 cm long. At one point, the water moves up and down at a rate of 4.8 oscillations per second.
(a) What is the speed of the water waves?
(b) What is the period of the water waves?

Solution:
Given Data:
Length of dish = d = 6.0 cm = 0.06 m
Frequency of wave = f = 4.8 Hz
To Find:
(i) Speed of waves = ?
(ii) Time period of waves = ?
Formula:
(i) $v = \frac{d}{t}$
(ii) $T = \frac{1}{f}$
Calculations:
(i) Time period:
By using formula, we have
T = 1/f
T = 1/4.8
T = 0.21 s
(ii) Speed of waves:
By using formula, we have
V = d/t
V = 0.06/0.21
V = 0.29m/s
Result:
Hence, the speed and time period of water wave will be 0.29 ms^{-1} and 0.21 s respectively.

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

Solution:

Given Data:

Distance travelled = d = 80 cm = 0.8 m

Frequency = f = 5Hz

Wavelength = λ = 40mm = 0.04 m

To Find:

Time taken by the wave = t = ?

Formula:

(i) $v = \frac{d}{t}$

Calculation:

Using wave equation

$v = f\lambda$

v = (5) (0.04) = 0.2 m/s

Know by using formula, we have

$$v = \frac{d}{t}$$

So, $t = \frac{d}{v}$

t = 0.8/0.02

t = 4s

Result:

Hence, time taken by the wave to cross the tang will be 4s.

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 x 10^8ms^{-1}.

Solution:

Given Data:

Frequency of radio waves = f = 90 MHz

$f = 9\times10^7$ Hz

Speed of radio waves = v = $3 \times 10^8 ms^{-1}$

To Find:

Wave length of the radio waves = λ = ?

Formula:

According to the wave equation

$v = f\lambda$

$\lambda = v/f$

Calculation:

By wave equation,

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

$$\lambda = \frac{3\times10^8}{9\times10^7}$$

$$\lambda = \frac{3\times10^{8-7}}{9.0}$$

λ = 3.333m

Result:

Hence, the wavelength of the radio waves transmitted by an FM station will be 3.33

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. When a body moves to and fro about a point its motion is called:
(A) Random motion (B) Linear motion
(C) Vibratory motion (D) Rotatory motion

2. What is the SI unit of frequency?
(A) Hz (B) Ampere
(C) Second (D) Coulomb

3. Which of the following quantities is not changed during refraction of light?
(A) Its speed (B) Its direction
(C) Its wavelength (D) Its frequency

4. If the length of a simple pendulum is halved its time period will become:
(A) $\frac{T}{2}$ (B) $T = \frac{T}{\sqrt{2}}$
(C) $\sqrt{2}T$ (D) $2T$

5. In which state of matter longitudinal waves move faster?
(A) Liquid (B) Solid
(C) Gas (D) Both A & B

6. Which of the following characteristics of a wave is independent of the others?
(A) Speed (B) Frequency
(C) Amplitude (D) Wavlength

Q.2 Give short answers to following questions. **(5×2=10)**

i. What do you mean by vibrating body?
ii. Define spring constant and give its unit.
iii. What is the relation between frequency and time period? Also write its unit.
iv. What is meant by damped oscillations?
v. What is meant by a crepst and trough?

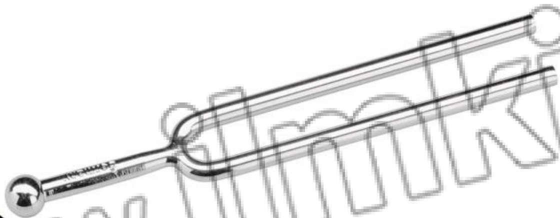
Q.3 Answer the following questions in detail. **(4+5=9)**

a) Prove that the motion of a mass attached to a spring is SHM.
b) The time period of a simple pendulum is 2 s. What will be its length on Earth? What will be its length on the moon if $g_m = g_e / 6$? Where $g_e = 10 ms^{-2}$.

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.

UNIT 11



SOUND

11.1 SOUND WAVES

LONG QUESTIONS

Q.1. Explain the production and sensation of sound waves with the help of an experiment. ***(K.B+A.B+U.B)***

Ans: **PRODUCTION AND SENSATION OF SOUND WAVES**

Production of Sound:
Like other waves sound is also produced by vibrating bodies.

Sensation of Sound:
Due to vibration of bodies the air around them also vibrates and the air vibrations produce sensation of sound in our ear.

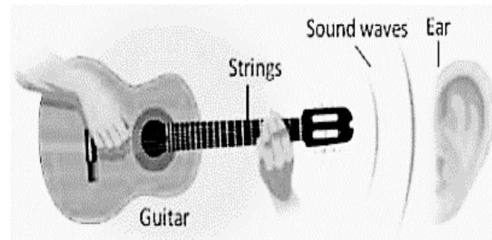


Figure: Vibrations of Guitar Strings Produce Sound Waves

Examples:
- In a guitar, sound is produced due to the vibrations of its strings (As shown in Figure)
- Our voice results from the vibrations of our vocal chords.
- Human heart beats and vibrations of other organs like lungs also produce sound waves. Doctors use stethoscope to hear this sound.

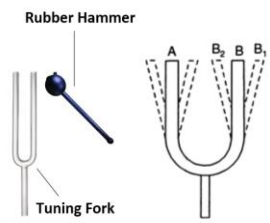


Figure: Strike a Rubber Hammer on a Tuning Fork

Experiment:
In school laboratories, we use a device called tuning fork to produce a particular sound. If we strike the tuning fork against rubber hammer, the tuning fork will begin to vibrate (As shown in Figure). We can hear the sound produced by tuning fork by bringing it near our ear.

We can also feel the vibrations by slightly touching one of the prongs of vibrating tuning fork with a plastic ball suspended from a thread (as shown in figure). Touch the ball gently with the prong of vibrating tuning fork. The tuning fork will push the ball because of its vibrations.

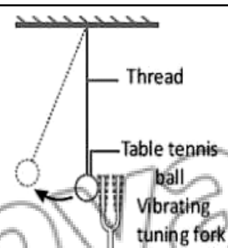


Figure: The Production of Waves from a Vibrating Tuning Fork

If we dip the vibrating tuning fork into a glass of water, we can see a water splash due to the vibrating prongs of tuning fork.

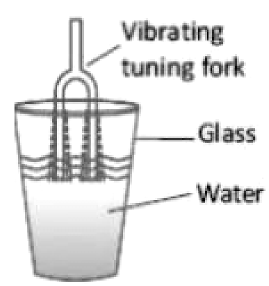


Figure: Vibrating Tuning Fork

Conclusion:

From above experiments, we can conclude that sound is produced by vibrating bodies.

Q.2. With the help of an experiment prove that sound requires material medium for its propagation. ***(U.B+A.B)*** **(Ex. Q# 11.3)** **(DGK-G1)-2015**

Ans: **SOUND REQUIRES MEDIUM FOR PROPAGATION**

Unlike light waves which are electromagnetic in nature and can also pass through vacuum, sound waves require some material medium for their propagation which are longitudinal in nature. This can be proved with the help of an experiment by using bell jar apparatus. (As shown in Figure).

Bell Jar Apparatus:

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.

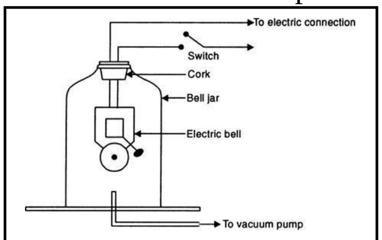


Figure: Bell Jar Apparatus

Experiment:

By switching ON the power supply, electric bell will begin to ring. We can hear the sound of the bell. Now start pumping out air from the jar by means of a vacuum pump. The sound of the bell starts becoming more and more feeble and eventually dies out, although bell is still ringing. When we put the air back into the jar we can hear the sound of the bell again.

Conclusion:

From the above experiment, we can conclude that sound waves can only travel/propagate in the presence of air (medium).

Q.3. Describe the Longitudinal nature of sound waves. ***(K.B+U.B)*** **(Ex. Q# 11.4)**

Ans: **LONGITUDINAL NATURE OF SOUND WAVES**

Propagation of sound waves produced by a vibrating tuning fork can be understood with the help of an experiment as shown in figure.

Experiment:

Before the vibration of tuning fork, density of air molecules on the right side is uniform as shown in above figure-(a). When the right prong of tuning fork moves from mean position 0 to B as shown in above Figure-(b), it exerts some pressure on the adjacent layer of air molecules and produces a **compression**.

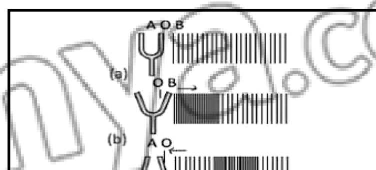


Figure: Vibrations of Tuning Fork after Striking with a Rubber Hammer

This compressed air layer in turn compresses the layer next to it and so on. A moment later, the prong begins to move from B towards A as shown in above Figure-(c). Now the pressure in the adjacent layer decreases and a **rarefaction** is produced. This rarefaction is transferred to the air layer next to it and so on. As the tuning fork moves back and forth rapidly, a series of compressions and rarefactions are created in the air. In this way, sound wave propagates through the air.

Wavelength:

"Distance between two consecutive compressions or rarefactions is called as the wavelength of sound wave**"**.

Conclusion:

From the above experiment, we can conclude that the direction of propagation of sound wave is along the direction of oscillating molecules, which shows the longitudinal nature of sound waves.

11.1 SHORT QUESTIONS

Q.1 Sound is a form of wave. List at least three reasons to support the idea that sound is a wave. *(K.B+U.B)* (Ex. Q# 11.5)

Ans: **SOUND-WAVE**

Definition:

"Sound is the form of energy that travels in the form of pressure waves from one place to another and require medium for its propagation**"**.

We know that waves manifest the phenomenon of reflection, refraction and diffraction. Since the sound can also be reflected, refracted and diffracted like other waves. This proves that they are waves.

Q.2 How sound waves are produced?

OR What do you know about the production and propagation of sound waves? What is the necessary condition for the production and propagation of sound? *(K.B)* (Ex. Q# 11.1)

(Physics of Sound Text Book Pg. # 20)

Ans: **PRODUCTION & PROPAGATION OF SOUND WAVES**

Production of Sound:

Like other waves sound is also produced by vibrating bodies.

Propagation of Sound:

Sound is a form of energy that travels/propagates in the form of waves from one place to another place in the presence of a medium.

Condition:

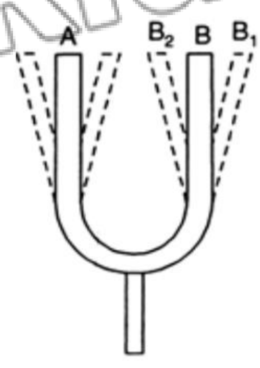
Sound require material medium for its production and propagation.

Q.3 What is tuning fork? *(Knowledge Base)*

Ans: **TUNING FORK**

Definition:

"It is a U-shaped body having two metal prongs with a stem at the bottom and is used for producing sound of particular frequency."



Q.4 What do you know about stethoscope? OR How stethoscope works? *(A.B)*
(For Your Information Text Book Pg. # 20)

Ans:

STETHOSCOPE

Working:

Stethoscopes operate on the transmission of sound from the chest-piece, via air-filled hollow tubes, to the listener's ears. The chest-piece usually consists of plastic disc called diaphragm. If the diaphragm is placed on the patient's body sound vibrate the diaphragm, creating acoustic pressure waves which after multiple reflection travel up the tubing to the doctor's ears.

Q.5 If we dip a vibrating tuning fork into a glass of water, we will see a splash. What does make the water splash? *(A.B)*

Ans: *Given on Page# 40*

Q.6 Define the wavelength of sound wave. OR How will you define wavelength in the case of longitudinal waves (sound waves)? *(K.B)*

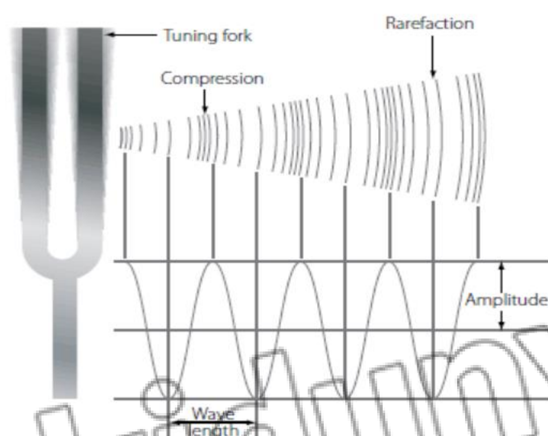
Ans: *Given on Page# 41*

Q.7 With the help of wave form illustrate the longitudinal nature of sound waves formed by the vibrating tuning fork. Also define the compressions and rarefactions.
(K.B+U.B) ***(Physics Insight Text Book Pg. 22)***

Ans:

WAVE FORM

In the figure given below waveform illustrate the longitudinal nature of wave formed by vibrating tuning fork in the air.



COMPRESSIONS

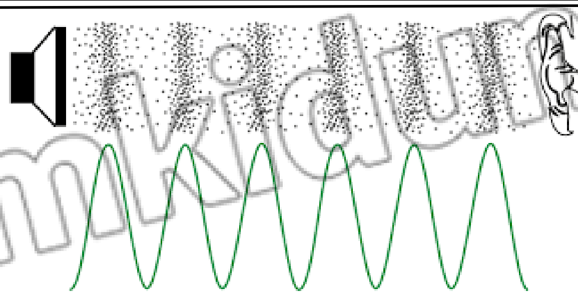
Definition:

"Compressions are places where air pressure is slightly higher than the surrounding air pressure due to high density of air particles."

RAREFACTIONS

Definition:

"Rarefactions are the regions that correspond to low air pressure due to low density of air particles."



Q.8 Identify which part of these musical instruments vibrates to produce sound. ***(U.B+A.B)***

• Electric bell • Loud speaker • Piano • Violin • Flute

(Quick Quiz Text Book Pg. # 22)

Ans: **VIBRATING PART OF ELECTRIC BELL**

When the switch is pressed. Due to the movement of armature, the hammer vibrates and strikes the gong so the bell rings. As a result, the hammer vibrates and the bell continuous to ring as long as the push button/switch is pressed.

VIBRATING PART OF LOUD SPEAKER

The most basic sound in the loud speaker can be produced by vibration of speaker's diaphragm in and out at a single frequency. The speaker cone moves very fast in and out which causes vibrations in the air. Those vibrations are picked up by our ears.

VIBRATING PART OF PIANO

A piano has strings which are struck by the small "hammers" when you press the keys. The strings vibrate and create the sound, which is amplified by the sound board.

VIBRATING PART OF VIOLIN

When we touch the strings of violin, they vibrate, effecting all the molecules in the area around these strings. These vibrations produce the sound.

VIBRATING PART OF FLUTE

Flute is a hollow pipe. When the air is blown over its mouth, the air inside the pipe set into vibrations. As a result, a pleasant sound is produced.

Q.8 Explain how sound is produced by a school bell? ***(U.B)***
(Self-Assessment Text Book Pg. # 22)

Ans: **PRODUCTION OF SOUND BY A SCHOOL BELL**

When the school bell is struck by the hammer, due to vibration of the medium particles of the air around it also vibrates and the air vibrations produce sensation of sound in our ear.

Q.9 Why are sound waves called, the mechanical waves? ***(K.B)***
(Self-Assessment Text Book Pg. # 22) / (RWP-G2)-2016 / (SWL-G2)-2017

Ans: **SOUND WAVES ARE MECHANICAL WAVES**

Sound waves require a medium for their propagation and they cannot travel in vacuum. When sound waves pass through a medium (air), the particles of medium vibrate back and forth along the direction of propagation of sound wave so that, sound waves are longitudinal in nature. That is why sound waves are called mechanical waves.

Q.10 Suppose you and your friend are on Moon. Will you be able to hear any sound produced by your friend? ***(K.B)*** **(Self-Assessment Text Book Pg. # 22)**

Ans: **NO SOUND ON MOON**

As there is no air on Moon, and the vacuum has no molecules to carry vibration. So that we will not be able to hear any sound produced by our friend on Moon.

Q.11 On what factors do the frequency of tuning fork depend? *(K.B)* **(FSD-G2)-2014**

Ans: **<u>FACTORS AFFECTING THE FREQUENCY</u>**

Following are the factors affecting the frequency of tuning fork:

- Mass of prongs of tuning fork.
- Amplitude of prongs.
- Stiffness of material of tuning fork.

Q.12 Why medium is required for propagation of sound. *(K.B)*

Ans: **<u>MEDIUM FOR PROPAGATION</u>**

Sound waves are compressional waves in nature. That is type of mechanical waves and we know that mechanical waves require medium for their propagation. So we can say material medium is necessary for the propagation of sound from one point to another. This material medium can be a gas, a liquid or a solid.

11.1 MULTIPLE CHOICE QUESTIONS

1. The study of sound is called: *(K.B)*

(A) Acoustic (B) Optics
(C) Electrostatics (D) All of these

2. Sound is produced by: *(K.B)*

(A) Propagation (B) Vibration
(C) Both of these (D) None of these

3. Sound can travel only in presence of: *(K.B)*

(A) Medium (B) Vacuum
(C) Air (D) Both a and c

4. Sound waves are: *(K.B)* **(GRW-G1)-2013**

(A) Electromagnetic (B) Transverse
(C) Longitudinal (D) None of these

5. Sound is a form of energy: *(K.B)*

OR Which form of energy sound is?

(MTN-G1),(FSD-G2)-2014 / (FSD-G2),(SGD-G1),(GRW-G1/G2)-2015 / (BWP-G1)-2016 / (DGK-G2),(SGD-G2),(SWL-G1),(GRW-G1),(LHR-G2),(MTN-G1)-2017

(A) Chemical (B) Thermal
(C) Electrical (D) Mechanical

6. The distance between two consecutive compressions and rarefactions is called: *(K.B)* **(SGD-G2)-2015**

(A) Time period (B) Frequency
(C) Wavelength (D) Focal length

7. Which is an example of longitudinal waves? *(U.B)*

OR The example of longitudinal waves is:

(GRW-G1)-2014 / (FSD-G1),(SGD-G2),(LHR-G1)-2015 / (RWP-G2),(MTN-G1),(DGK-G1)-2016 / (DGK-G1),(RWP-G1),(MTN-G2),(DGK-G2),(SGD-G1),(BWP-G2),(SWL-G2),(GRW-G1)-2017

(A) Sound waves (B) Light waves
(C) Radio waves (D) Water waves

8. Which of these waves consist of compressions and rarefactions? *(U.B)* **(GRW-G1)-2016**

(A) Radio waves (B) Sound waves
(C) Television waves (D) X-Rays

11.2 CHARECTERISTICS OF SOUND

LONG QUESTIONS

Q.1 Enlist the characteristics of sound waves. Define the loudness of sound. Also describe the factors upon which it depends? ***(K.B + U.B + A.B)***
(MTN-G1), (SGD-G2), (SGK-G1), (BWP-G2), (DGK-G2)-2014, (SGO-G2), (LHR-G2), (MTN-G2), (AJK-G2)-2015, (AJK-G1), (RWP-G2)-2016, (DGK-G1), (FSD-G1), (SGD-G1)-2017

Ans: **CHARACTERISTICS OF SOUND**

Sounds of different objects can be distinguished on the basis of different characteristics which are described below:

- **Loudness**
- **Pitch**
- **Quality**
- **Intensity**

LOUDNESS OF SOUND

Definition:

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

Example:

When we talk to our friends, our voice is low, but when we address a public gathering our voice is loud.

Dependence:

Loudness of a sound depends upon a number of factors. Some of them are discussed below:

Amplitude of the vibrating body:

The loudness of the sound varies directly with the amplitude of the vibrating body.

Loudness $\propto$ amplitude of vibrating body.

Examples:

- The sound produced by a sitar will be loud if we pluck its wires more violently.
- When we beat a drum forcefully, the amplitude of its membrane increases and we hear a loud sound.

Area of the vibrating body:

The loudness of sound also depends upon the area of the vibrating body.

Loudness $\propto$ Area of vibrating body.

Examples:

- Sound produced by a large drum is louder than that by small one because of its large vibrating area.
- If we strike a tuning fork on a rubber pad, a feeble sound will be heard. But if the vibrating tuning fork is placed vertically on the surface of a bench, we will hear a louder sound.

Distance from the vibrating body:

Loudness of sound also depends upon the distance of the vibrating body from the listener. It is caused by the decrease in amplitude due to increase in distance.

Physical condition of the ears:

Loudness also depends upon the physical condition of the ears of the listener.

Example:

- A sound appears louder to a person with sensitive ears than to a person with defective ears.

Conclusion:

From this we can conclude that the loudness increases with the amplitude and area of the vibrating body and vice versa.

Q.2 What do you know about the pitch and quality of sound? Explain. ***(K.B + U.B + A.B)***
(FSD-G1), (GRW-G2), (DGK-G1)-2014, (FSD-G1), (DGK-G1), (SWL-G1), (SGD-G1), (BWP-G1), (MTN-G1/G2), (DGK-G2), (RWP-G2), (LHR-G1)-2016, (MTN-G1), (LHR-G1), (RWP-G2), (LHR-G2), (BWP-G1), (FSD-G2), (RWP-G2)-2017

Ans:

PITCH

Definition:

"Pitch is the characteristic of sound by which we can distinguish between a **shrill** and a **grave** sound**"**.

Dependence:

It depends upon the frequency. A higher pitch means a higher frequency and vice versa.

Pitch ∝ frequency

Frequency:

The number of vibration or cycle of vibrating body in 1 second is called its frequency. ($f = \frac{1}{T}$)

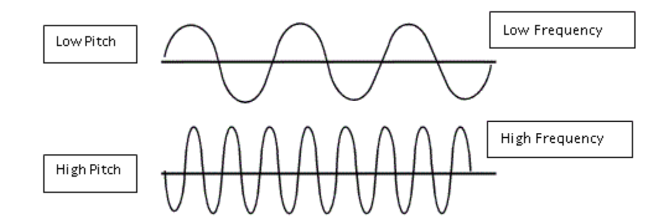


Figure: Variation of Pitch with Frequency

Frequency depends upon the source.

Example:

The frequency of the voice of ladies and children is higher than that of men. Therefore, the voice of ladies and children is shrill and of high pitch. The relationship between frequency and pitch is illustrated as shown in figure.

QUALITY

Definition:

"The characteristic of sound by which we can **distinguish** between two sounds of same **loudness** and **pitch** is called quality**"**.

Example:

While standing outside a room, we can distinguish between the notes of a piano and a flute being played inside the room. This is due to the difference in the quality of these notes.

Dependence:

It depends upon the waveform of the sound waves. The loudness and pitch of these two sounds are the same but their waveforms are different. So their quality is different and can be distinguished from each other

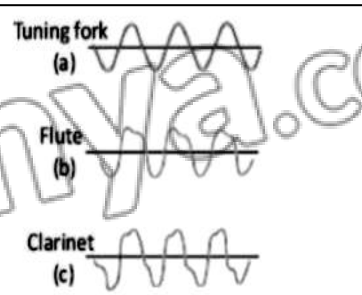


Figure: Sound Waveforms produced by (a) a Tuning Fork, (b) a Flute, and (c) a Clarinet, are All at Approximately the Same Frequency. Pressure is plotted Vertically, Time Horizontally

Wave form:

The waveform of the sound produced by a tuning fork, flute and clarinet, shown in the figure. The loudness and the pitch of these three sounds are the same but their waveforms are different. So their quality is different and they can be distinguished from each other.

Q.3 What do you know about the intensity and sound intensity level? Also derive the relationship between loudness and intensity of sound. ***(K.B + A.B + U.B)***
(DGK-G1), (RWP-G1), (BWP-G1), (GRW-G2), (BWP-G2), (LHR-G1)-2014, (RWP-G2), (BWP-G1), (AJK-G2), (LHR-G1), (DGK-G2), (SWL-G1)-2015, (SGD-G2), (DGK-G1), (RWP-G2)-2016, (FSD-G2), (DGK-G1), (LHR-G1), (GRW-G2)-2017

Ans: **INTENSITY OF SOUND**

Definition:

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

Dependence:

The intensity of sound depends on the amplitude of sound wave.

Quantity:

Intensity is a physical quantity and can be measured accurately.

Mathematical Form:

$$\textbf{Intensity} = \frac{\textbf{Energy}}{\textbf{Time} \times \textbf{Area}}$$

$$\textbf{Intensity} = \frac{\textbf{Power}}{\textbf{Area}}$$

Unit:

The unit of intensity of sound is watt per square meter (Wm^{-2}).

SOUND INTENSITY LEVEL

Definition:

"The difference $(\mathbf{L} - \mathbf{L_o})$, between the loudness **L** of an unknown sound and the loudness $\mathbf{L_o}$ is called the intensity level of the unknown sound.

Mathematical Equation:

$$\text{Intensity level} = K \log \frac{I}{I_o}$$

Where **K** is the constant of proportionality, **I** is the intensity of unknown sound and $\mathbf{I_o}$ is the intensity of faintest audible sound.

Reference Intensity:

The human ear responds to the intensities ranging from $10^{-12}\,Wm^{-2}$ to more than $1Wm^{-2}$ (which is loud enough to be painful). Because the range is so wide, intensities are scaled by factors of ten. The barely audible and the faintest intensity of sound i.e., $10^{-12}\,Wm^{-2}$ is taken as reference intensity, called zero bel (a unit named after Alexander Graham Bell).

The loudness of a sound depends not only on the intensity of sound but also on the physical conditions of the ear. The human ear is more sensitive to some frequencies than the others.

Derivation:

By Weber Fechner Law

The loudness ***(L)*** of a sound is directly proportional to the logarithm of intensity i.e.

$$\mathbf{L \propto \log I}$$

$$L = K \log I \ldots(i)$$

Where K is a constant of proportionality. Let L_o be the loudness of the faintest audible sound of intensity I_o and L be the loudness of an unknown sound of intensity I, then by Eq. (i), we can write

$$L_o = K \log I_o \ldots(ii)$$

Subtracting Eq. (ii) from Eq. (i), we get

$$L - L_o = K\left(\log I - \log I_o\right) = K \log \frac{I}{I_o}$$

Therefore, $$\text{Intensity level} = K \log \frac{I}{I_o} \ldots(iii)$$

Dependence of K:

The value of K depends not only on the units of I and I_o but also on the unit of intensity level. If intensity I of any unknown sound is 10 times greater than the intensity I_o of the faintest audible sound i.e., $I = 10I_o$ and the intensity level of such a sound is taken as unit, called bel, the value of K becomes 1.

Therefore, using K =1, Eq. (iii) becomes

$$\text{Intensity level} = \log \frac{I}{I_o}(\text{bel})\ldots.(iv)$$

Decibel (Unit of Intensity Level):

Bel is a very large unit of intensity level of a sound. Generally, a smaller unit called decibel is used. Decibel is abbreviated as (dB). It must be remembered that 1 bel is equal to 10 dB. If the intensity level is measured in decibels, Eq. (iv) becomes

$$\text{Intensity level} = 10 \log \frac{I}{I_o}(\text{dB})\ldots(v)$$

Decibel Scale:

By using equation (v), we can construct a scale for measuring the intensity level of sound. Such scale is known as "decibel scale". The intensity level of different sounds in decibel is given in table below.

The decibel scale is a logarithmic measure of the amplitude of sound waves. In a logarithmic scale, equal intervals correspond to multiplying by 10. Instead of adding equal amounts.

(Table for MCQs)

Intensity Level of Different Sounds in decibel

Sources of Sound	Intensity (Wm^{-2})	Intensity Level (dB)
Nearby jet airplane	10^3	150
Jackhammer/ fast train	10^1	130
Siren	10^0	120
Lawn mover	10^{-2}	100
Vacuum cleaner	10^{-5}	70
Mosquito buzzing`	10^{-8}	40
Whisper	10^{-9}	30
Rustling of leaves	10^{-11}	10
Faintest audible sound i.e, Threshold	10^{-12}	0

11.2 SHORT QUESTIONS

Q.1 Define loudness of sound and what are the factors which affect it? (Ex. Q# 11.8)
(SGD-G2),(SGK-G1),(BWP-G2),(MTN-G1),(DGK-G2)-2014 / (SGD-G2),(LHR-G2),(MTN-G2),AJK-G2)-2015 / (AJK-G1),(RWP-G2)-2016 / (DGK-G1),(FSD-G1),(SGD-G1)-2017

Ans: (K.B) Given on Page # 46.

Q.2 Define pitch of the sound. On which factors does it depend?
(GRW-G2)-2014 / (FSD-G1),(DGK-G1/G2),(SWL-G1)-2015 / (MTN-G1/G2),(DGK-G2),(RWP-G2)-2016 / (MTN-G1),(LHR-G1),(RWP-G2)-2017

Ans: (K.B) Given on Page # 47.

Q.3 Define the quality of sound. Upon which factors it depends?
(FSD-G1)-2014 / (FSD-G2),(RWP-G1)-2015 / (RWP-G1),(LHR-G1),(DGK-G1)-2016 / (BWP-G1),(FSD-G2),(RWP-G2)-2017

Ans: (K.B + U.B) Given on Page # 47

Q.4 What is the difference between the frequency and pitch? *(K.B)*

Ans: *(Ex. Q.# 11)*

The differences between the frequency and pitch are as follows:

Frequency	Pitch
Definition	
• The number of vibrations or cycle of vibrating body in one second is called frequency.	• Pitch is the characteristics of sound by which we can distinguish between a shrill and a grave sound.
Dependence	
• Frequency depends upon the source.	• Pitch depends upon the frequency.

Q.5 Define intensity of sound? Also write the intensity of faintest and loudest sound. ***(K.B)***
(GRW-G2),(BWP-G2)-2014 / (LHR-G1),(DGK-G2),(SWL-G1)-2015 / (SGD-G2),(DGK-G1) 2016 / (FSD-G2),(DGK-G1),(LHR-G1),(GRW-G2)-2017

Ans: *Given on Page # 48.*

Q.6 Write down the relation between loudness and intensity of a sound. (Define Weber Fechner Law) ***(K.B+U.B+A.B)*** **(Ex. Q# 11.7)**

Ans: *Given on Page # 48*

Q.7 Define intensity level or sound intensity level. ***(K.B+U.B+A.B)*** **(Ex. Q# 11.9)** **(RWP-G2)-2016**

Ans. *Given on Page # 48*

Q.8 Define SI unit of sound level (bel). ***(K.B+A.B+U.B)*** **(Ex. Q# 11.9)** **(BWP-G1)-2016**

Ans. **bel**

Definition:

"If the intensity of any unknown sound is **10** times greater than the intensity $\mathbf{I_0}$ of the faintest audible sound i.e. $\mathbf{I = 10I_0}$ then the intensity level of such sound is taken as unit, called Bel. The value of **K** becomes **1**".

Mathematical Equation:

$$\text{Sound Level} = K \log \frac{I}{I_0} \text{ (bel)} \ldots \text{(i)}$$

By substituting K = 1, equation (i) becomes

Hence, the time period and frequency of simple pendulum will be 1.99s and 0.50 Hz

Q.9 Find sound level of sound of train (in bel and dB scale). If Intensity of sound of train (I) is $10^{-2}Wm^{-2}$ and intensity of faintest sound (I_o) is $10^{-12}Wm^{-2}$. *(A.B + U.B)*

Ans: **SOUND LEVEL OF SOUND OF TRAIN**

Solution:

Given Data:

Intensity of sound of train $= I = 10^{-12}Wm^{-2}$

Intensity of faintest audible sound $= I_o = 10^{-12}Wm^{-2}$

To Find:

(i) Sound intensity level (in Bel) $= L - L_o = ?$

(ii) Sound intensity level (in decibel) $= L - L_o = ?$

Formula:

(i) Sound level $= \log\frac{I}{I_o}$

(ii) Sound level $= \log\frac{I}{I_o}$ dB

Calculation:

By using formula, we have

(i) Sound level $= \log\frac{10^{-2}}{10^{-12}}(\text{bel})$

$= \log 10^{10} = 10(\log 10)$

$= 10 \times 1 = 10\ (\text{bel})$

By using formula, we have

(ii) Sound level $= 10\log\frac{10^{2}}{10^{-12}}(\text{dB})$

$= 10\log 10^{10} = 10 \times 10(\log 10)$

$= 10 \times 10 \times 1 = 100\text{dB}$

Q.10 How opera singers are able to break thin glass goblet? *(K.B + A.B)*

(For your info. Text book Pg. # 23)

(RWP-G1)-2016,

Ans: **RESONANCE**

Thin-walled glass goblets can vibrate when hit by sound waves. This is due to the phenomenon of sound known as resonance. Some singers can produce a loud note of particular frequency such that it vibrates the glass so much that it shatters.

Q.11 What do you know about silent whistle? *(K.B+A.B)* (Interesting Information)

(Text book Pg. # 23) **(GRW-G2)-2017**

Ans: Some people use silent whistle to call dogs whose frequency lies between 20,000 Hz to 25,000 Hz. It is silent for human but not for dogs because the audible frequency range for dogs is much higher.

Q.12 Draw the waveforms of sound produced by the following instruments: *(K.B)*

- **Tuning fork**
- **Flute**
- **Clarinet**

(For your info. Text book Pg. # 23)

Ans: *Given on Page # 47*

Q.13 Why voice of women is more shrill than that of men? **(BWP-G2)2017, (Quick quiz Pg. # 24)**

Ans: **SHRIL VOICE OF WOMEN**

Pitch is the characteristics of sound which distinguishes between shrill and grave sound. As the pitch of sound depends on frequency. The pitch of sound of women is higher than that of men. That is why voice of women is more shrill than that of men.

Q.14 Which property of sound wave determines its: (a) loudness (b) pitch? ***(K.B)***

(Quick quiz Pg. # 24)

Ans: **DEPENDANCE OF LOUDNESS & PITCH**

The properties which determines the loudness and pitch are also the factors upon which loudness and pitch depends, these are:

Loudness:

Loudness of sound depends on:

- Amplitude of vibrating body
- Area of vibrating body
- Distance from the vibrating body

Pitch:

Pitch of sound depends upon the frequency. A higher pitch means a higher frequency and vice versa.

Q.15 What would happen to the loudness of sound with increase in its frequency? ***(K.B)***

(For your Information Text Book Pg. # 24), (Quick quiz Pg. # 24)

Ans: **RELATION BETWEEN LOUDNESS & FREQUENCY**

A sound wave with a frequency of 3500 Hz and an intensity of 80 dB sounds about twice as loud to us a as a sound of 125 Hz and 80 dB. It is because our ears are more sensitive to the 3500 Hz sound than to the 125 Hz. Therefore, intensity by itself does not mean loudness. Loudness is how our ears detects and our brain perceives the intensity of sound waves.

In terms of physics, loudness does not change with frequency, however your ear's response is not flat - it is less sensitive at low and high frequencies and most sensitive around 1kHz. So for lower and higher frequencies perceived loudness is less. That is why hifi equipment allows for boosting of bass and treble, to compensate for this.

Q.16 Frequency of tuning fork depends on which factors? ***(K.B)*** (Do you Know Text book Pg. # 24)

Ans: **FREQUENCY OF TUNING Fork**

Frequency of tuning fork depends on the mass of its prongs. The greater the mass, the lower the frequency of vibration which means the lower the pitch and vice versa.

Q.17 Prove that k = 1 when $I = 10\ I_0$ and $L - L_0 = 1$ ***(Conceptual Base + A.B)***

Ans: $\mathbf{L - L_0 = k \log \frac{I}{I_0}}$ …(i)

We know that

$I = 10\ I_0$ and $L - L_0 = 1$ Put in eq. (i)

$\mathbf{1 = k \log \frac{10 I_0}{I_0} \Rightarrow 1 = k \log 10}$ …(ii)

We know that

$\mathbf{\log 10 = 1}$ Put in eq. (ii)

$k = 1$

Q.18 Give comparison of logarithmic scale to the linear scale. ***(K.B)***

(For your info. Text book Pg. # 25)

Ans: The decibel scale is a logarithmic measure of the amplitude of sound waves. In a logarithmic scale, equal intervals correspond to multiplying by 10 instead of adding equal amounts.

Table for MCQs

Logarithmic Scale Decibels (dB)	Linear Scale Amplitude (m)
0	1
20	10
40	100
60	1,000
80	10,000
100	1000,000
120	1,000,000

11.2 MULTIPLE CHOICE QUESTIONS

1. Characteristic by which We can distinguish between two sounds of same loudness and pitch is called: ***(K.B)*** **(GRW 2013)**
(A) Loudness (B) Pitch
(C) Quality (D) Intensity of sound

2. Pitch of sound depends on: ***(K.B)*** **(BWP-G1)-2017**
(A) Amplitude (B) Frequency
(C) Time period (D) Displacement

3. Loudness of sound depends on: ***(K.B)***
(A) Amplitude of vibrating body (B) Area of vibrating body
(C) Distance of vibrating body (D) All of these

4. Which is the characteristic of sound distinguish between a shrill and a grave sound? ***(K.B)***
(A) Pitch (B) Loudness
(C) Intensity (D) Quality

5. Frequency of silent whistle lies between: ***(K.B)***
(A) 20,000Hz - 25,000Hz (B) 20,000Hz - 35,000Hz
(C) 20Hz - 20,000Hz (D) 15,000Hz - 40,000Hz

6. The intensity of sound depends on: ***(K.B)***
(A) Time period (B) Frequency
(C) Amplitude (D) None of these

7. Intensity is a quantity: ***(U.B)***
(A) Vector (B) Scalar
(C) Physical quantity (D) None of these

8. Intensity of faintest sound is: ***(K.B)***
(A) 10^{12} Wm^{-2} (B) $10^{-12}Wm^{-2}$
(C) $10^{-8}Wm^{-2}$ (D) $10^{-9}Wm^{-2}$

9. Intensity of loudest audible sound is: ***(K.B)***
(A) $10^{-12}Wm^{-2}$ (B) $1Wm^{-2}$
(C) $20Wm^{-2}$ (D) None of these

10. **Intensity of whispering:** ***(K.B)***
(A) $10^{-5}Wm^{-2}$ (B) $10^{-8}Wm^{-2}$
(C) $10^{-9}Wm^{-2}$ (D) $10^{-12}Wm^{-2}$

11. **The loudness of sound is directly proportional to logarithm of intensity, this Law is called:** ***(K.B+U.B)***
(A) Weber Fechner Law (B) Law of Gravitation
(C) Intensity Level (D) Echo

12. **Voice of women and children as compare to men is:** ***(K.B)***
(A) Grave (B) Shrill
(C) Faint (D) Loud

13. **I bell is equal to:** ***(K.B + U.B)*** **(FSD-G2)-2017**
(A) 20dB (B) 10dB
(C) 100dB (D) 50dB

14. **The amplitude of 100 dB sound is:** ***(K.B)***
(A) 1000 (B) 10,000
(C) 100,000 (D) 1001000

15. **The unit of intensity of sound is:** ***(U.B)***
(A) Wm^{-1} (B) Wm^{-2}
(C) Wm^{-3} (D) Wm

16. **Intensity of rustling of leaves is:** ***(K.B)***
(MTN-G2)-2014, (MTN-G2), (BWP-G2)-2016, (MTN-G2), (LHR-G1)-2017
(A) 10^{-9} Wm^{-2} (B) 10^{-10} Wm^{-2}
(C) $10^{-11}Wm^{-2}$ (D) 10^{-12} Wm^{-2}

17. **Intensity level of train siren is:** ***(K.B)*** **(LHR-G1)-2014, (BWP-G2), (SGD-G1), (DGK-G1)-2017**
(A) 150 dB (B) 130 dB
(C) 100 dB (D) 120 dB

<u>Example: 11.1</u>

Calculate the intensity levels of the (a) faintest audible sound (b) rustling of leaves. ***(U.B + A.B)***

(AJK-G2)-2015 / (DGK-G2)-2016

Ans: **<u>Solution:</u>**

Intensity level $= 10\log\frac{I}{I_o}$ (dB)

(a) Intensity level of faintest audible sound can be calculated by substuting $I = I_o = 10^{-12}$ Wm^{-2}

Therefore,

Intensity level of faintest audible sound $= 10\log\frac{10^{-12}}{10^{-12}}$ dB

$= 0$ dB

(b) As the intensity of the rustle of leaves is $I = 10^{-11} W m^{-2}$,

Therefore,

Intensity level due to rustling of leaves $= 10\log 10^{-11}/10^{-12}$ dB

$= 10$ dB

11.3 REFLECTION (ECHO) OF SOUND

LONG QUESTION

Q.1 Define and explain reflection (echo) of sound with the help of an experiment.

(MTN-G1)-15 / (LHR-G1)-17

Ans: **REFLECTION (ECHO) OF SOUND**

Definition:

"When sound is incident on the surface of a medium it bounces back into the first medium. This phenomenon is called reflection (echo) of sound**"**.

Example:

When we clap or shout near a reflecting surface such as a tall building or a mountain, we hear the same sound again a little later. This sound which we hear is called an echo and is a result of reflection of sound from the surface.

Explanation:

The sensation of sound persists in our brain for about 0.1s. To hear a clear echo, the time interval between our sound and the reflected sound must be at least 0.1s. If we consider speed of sound to be 340 ms^{-1} at a normal temperature in air, we will hear the echo after 0.1s.

Dependence upon Distance:

The total distance covered by the sound from the point of generation to the reflecting surface and back should be at least **$340\ ms^{-1} \times 0.1s = 34.0\ m$.** Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is, **17 m**. Echoes may be heard more than once due to successive or multiple reflections.

Experiment:

Take two identical plastic pipes of suitable length, as shown in figure (We can make the pipes using chart paper).

- Arrange the pipes on a table near a wall.
- Place a clock near the open end of one of the pipes and try to hear the sound of the clock through the other pipe.
- Adjust the position of the pipes so that you can hear the sound of the clock clearly.
- Now, measure the angle of incidence and angle of reflection. The echo of sound can only be heard if both the angle are equal.
- Lift the pipe on the right vertically to a small height and we will observe that the sound will start becoming fainter and finally no sound will be heard at some certain distance.

11.3 SHORT QUESTIONS

Q.1 Define reflection (ECHO) of sound? *(K.B)*

(MTN-G2)-2014 / (LHR-G1),(GRW-G1),(DGK-G2)-2015, (AJK-G1), (GRW-G1), (LHR-G1)-2016, (RWP-G2), (BWP-G1), (MTN-G2), (GRW-G2)-2017

Ans: When sound is incident on the surface of a medium it bounces back into the first medium. This phenomenon is called echo or reflection of sound.

Q.2 For how much time sound persists in our mind? Calculate the minimum distance for Echo. ***(K.B + U.B + A.B)***
(AJK-G1/G2),(BWP-G1)-2014 / (AJK-G1),(GRW-G1),(LHR-G1)-2016 / (RWP-G2),(BWP-G1),(MTN-G2),(GRW-G2)-2017

Ans. **SENSATION OF SOUND**

The sensation of sound persists in our brain for about **0.1s.** to hear a clear echo, the time interval between our sound and the reflected sound must be at least **0.1s.**

MINIMUM DISTANCE FOR ECHO

Calculation:

If we consider speed of sound to be 340 ms^{-1} at a normal temperature in air, we will hear the echo after 0.1s. The total distance covered by the sound from the point of generation to the reflecting surface and back should be at least $340ms^{-1} \times 0.1s = 34.0m$. Thus, for hearing distance echoes, the minimum distance of the obstacle from the source of sound must be half of this distance that is 17m. Echoes may be heard more than once due to successive or multiple reflections.

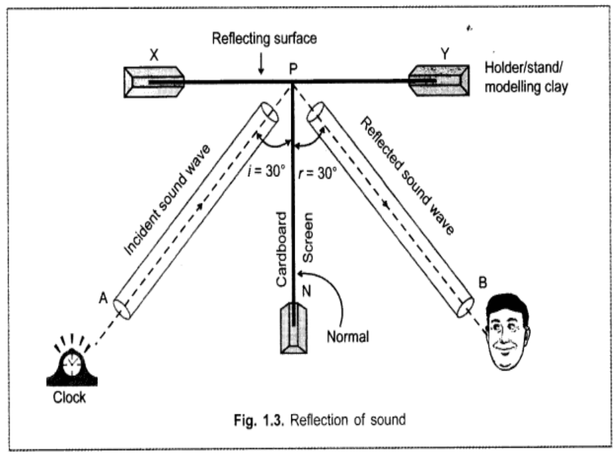


Figure: **Reflection (Echo) of Sound**

Q.3 Is there any difference between echo and reflection of sound? Explain. ***(K.B)*** **(RWP-G2)-2014**

Ans: **DIFFERENTIATION**

The differences between echo and reflection of sound are as follows:

Echo	Reflection of sound
• While to hear an echo the minimum distance must be **17 m** and minimum time interval must be **0.1 s.**	• Reflection can occur from any distance.

Q.4 What do you know about blue whale's rumble? ***(K.B + A.B)(Interesting Info. Text book Pg. # 26)***

Ans: **BLUE WHALE'S RUMBLE**

A blue whale's **180 dB** rumble is the loudest animal sound ever recorded. Whale sound also appear to be a part of a highly evolved communication system. Some whales are thought to communicate over hundreds and may be thousands of kilometers. This is possible, in part, because sound waves travel five times faster in water than in air. In addition, the temperature characteristics of ocean water –decrease in temperature with depth-create a unique sound phenomenon.

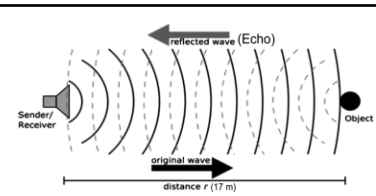


Figure: **Minimum Distance for Echo**

Q.5 Why do the elephants use low frequency sound waves to communicate? *(K.B+A.B)*
(Do you know Text book Pg. # 26)

Ans: **ELEPHANTS'S SOUND FREQUENCY**

Elephants use low frequency sound waves to communicate with one another. Their large ears enable them to detect these low frequency sound waves, which have relatively long wavelengths. Elephants can effectively communicate in this way, even when they are separated by many kilometers.

Q.6 Relate the speed of sound in water with the speed of sound in air. *(K.B)*

Ans: **SPEED OF SOUND**

Sound waves travels five times faster in water than in air, because the force of attraction between molecules of liquid is greater than gas that is why energy transferred more rapidly in liquid as compared to gas.

Q.7 How speed of sound depend upon elasticity and density of medium? *(A.B+Conceptual)*

Ans: If the elasticity of medium increases the speed of sound also increase because speed is directly proportion to elasticity of the medium but speed of sound decreases when the density of the medium increases. That is why speed of sound is minimum in water, when the temperature of water is $+4C^o$ because density of water is maximum at this temperature.

11.3 MULTIPLE CHOICE QUESTIONS

1. Echo of sound is: *(K.B)*

(A) Refraction (B) Reflection
(C) Diffraction (D) Interference

2. The sensation of sound persists in our brain about: *(K.B)* **(RWP-G2)-2017**

(A) 1s (B) 0.1s
(C) 0.01s (D) 2s

3. For hearing distinct echoes, the minimum distance of obstacle from source of source of sound must be: *(K.B + U.B)*

(A) 34m (B) 17m
(C) 38m (D) 16m

4. We can see sound waves with the help of: *(K.B)*

(A) Electroscope (B) Stroboscope
(C) Gastroscope (D) Oscilloscope

EXAMPLE 11.2

Calculate the frequency of a sound wave of speed 340 ms^{-1} and wavelength 0.5m. (*U.B + A.B)* (LHR-G1)-2015, (AJK-G1)-2016

Solution:

Given that; speed of waves v= 340 ms^{-1}

Wavelength $\lambda = 0.5m$

Using the formula $v = f\lambda$

Putting the values

$$f = 340ms^{-1}/0.5m = 680Hz$$

11.4 SPEED OF SOUND

LONG QUESTIONS

Q.1 Explain the speed of sound by relating the speed of sound in different media. Write down the speed of sound in air. How can we calculate the speed of sound? *(K.B + U.B + A.B) (Ex. Q# 11.2)*

SPEED OF SOUND

Sound waves can be transmitted only by any medium containing particles that can vibrate. They cannot pass through vacuum.

Relation Between Speed and Medium:

In general, the relation between the speed of the sound in solid, liquid and gas is:

Speed of sound in liquid = 5 × speed of sound in a gas (air)

Speed of sound in solid = 15 × speed of sound in a gas (air)

Speed of sound in various media is given as follows:

Speed of Sound in Various Media

Medium	Speed (ms^{-1})
Gases:	
Air (0 °C)	331
Air (25 °C)	346
Air (100 °C)	386
Hydrogen (0 °C)	1290
Oxygen (0° C)	317
Helium (0 °C)	972
Liquids at 25 °C:	
Distilled water	1498
Sea water	1531
Solids 25 °C:	
Wood	2000
Aluminum	6420
Brass	4700
Nickel	6040
Iron	5950
Steel	5960
Flint Glass	3980

(Table for MCQs)

Speed of Sound is Affected by:

The nature of the medium will affect the speed of the sound waves. The speed of sound in air is also affected by the changes in some physical conditions such as:

- temperature
- pressure
- humidity

The speed of sound in air is **343 ms^{-1}** at one atmosphere of pressure and room temperature (21°C).

Variation in speed:

The speed varies with temperature and humidity. The speed of sound in solids and liquids is faster than in air.

Mathematical Equation:

Following relation can be used to find the speed of sound:

$$v = f\lambda$$

Where v is the **speed**, *f* is the **frequency** and A is the **wavelength** of sound wave.

Q.2 How can you measure the speed of sound by Echo method?

MEASURING SPEED OF SOUND BY ECHO METHOD

Experiment:

We can measure the speed of sound with the help of an experiment by using the apparatus given below:

Apparatus:

Measuring tape, stopwatch, flat wall that can produce a good echo.

Procedure:

- Use the tape to measure a distance of 50 meters from the wall.
- Now clap your hands in front of the wall at a distance of 50 meters and check if you can clearly hear an echo from the wall. Make sure the echo is not coming from any other wall in the area. The time taken by the sound to travel 100 meters is the time difference between the clap and the echo.
- Now restart the clapping and start the stopwatch at the first clap. Count the number of claps, and stop the clapping and the stopwatch when you hear the echo of the 10th clap (say).
- Now find the average time for 10 claps. After calculating the time interval t between claps and using the formula S = vt, we can calculate the speed of the sound.

11.4 SHORT QUESTIONS

Q.1 When and how the speed of sound in air was first accurately measured?

(K.B + U.B+A.B) **(Do you know Text book Pg. # 28)**

Ans: **MEASURING SPEED OF SOUND**

The speed of sound in air was first accurately measure in 1738 by members of the French Academy. Two cannons were set up on two hills approximately 29 km apart. By measuring the time interval between the flash of a cannon and the "Boom", the speed of sound was calculated. Two cannons were fired alternatively to minimize errors due to the wind and to delayed reactions in the observes. From their observations, they deducted that sound travels ate about 336 ms^{-1} at 0^oC.

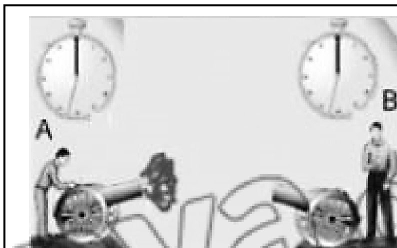


Figure: Measuring Speed of Sound by Echo Method

Q.2 Why the speed of sound is greater in solid and liquid as compared to gases. ***(Conceptual Base + A.B)***

Ans: The speed of sound is greater in solid and in liquid because the inter molecular forces in solid and liquid is greater than gases that is why the Atom and the molecule of solids and liquid are tightly arranged and they transfer sound energy more rapidly as compared to molecule of gases.

Q.3 Why sound travel faster on rainy day than on dry day? ***(Conceptual Base + A.B)***

Ans: On rainy day sound travel faster because humidity of air increases on rainy day. The density of water vapours is low as compared to the air molecules and when density decreases speed increases that is why sound move faster when the air has more water vapours.

11.4 MULTIPLE CHOICE QUESTIONS

1. **The speed of sound in solid than in gases is about: *(K.B)***
(A) 5 times (B) 15 times
(C) 20 times (D) 10 times

2. **The speed of sound in air at 1 atm pressure and at room temperature (21°C) is: *(K.B + U.B)***
(A) 320ms^{-1} (B) 360m/s
(C) 343ms^{-1} (D) None of these

3. **The speed of sound varies with: *(K.B)***
(A) Temperature (B) Humidity
(C) Pressure (D) All of these

4. **In general, the speed of sound is greater in: *(K.B)***
(A) Solids (B) Liquids
(C) Gases (D) None of these

5. **The speed of sound in air was first accurately measured in: *(K.B)***
(A) 1838 (B) 1738
(C) 1638 (D) 1938

6. **Formula of finding the speed of sound is: *(U.B + A.B)*** **(GRW-G1)-2016**
(A) $v = f\lambda$ (B) $f = \frac{v}{\lambda}$
(C) $v = \frac{f}{\lambda}$ (D) $f = \frac{v}{\lambda}$

7. **The speed of sound in air: *(K.B)*** **(GRW-G2), (LHR-G2), (RWP-G2)-2014**
(A) 1246 kmh^{-1} (B) 1264 kmh^{-1}
(C) 1262 kmh^{-1} (D) 2162 kmh^{-1}

8. **If speed of sound is 320 ms^{-1} , the distance covered in a time of 1.5 s will be: *(U.B + A.B)*** **(RWP-G2)-2014**
(A) 408 m (B) 480 cm
(C) 480 m (D) 221 m

9. **The speed of sound at 0° C is: *(K.B)***
(LHR-G2)-2015, (LHR-G1), (AJK-G1), (LHR-G1)-2016, (BWP-G1)-2017
(A) 386 ms^{-1} (B) 376 ms^{-1}
(C) 231 ms^{-1} (D) 331 ms^{-1}

10. **Calculate the frequency of sound wave of speed 340 ms^{-1} and wavelength 0.5 m? *(U.B + A.B)*** **(FSD-G2)-2017**
(A) 340 Hz (B) 0.5 Hz
(C) 170 Hz (D) 680 Hz

11. **A doctor counts 72 heart beats in 1 minute, the frequency of heat beat is: *(U.B + A.B)***
(A) 1.2 Hz (B) 1.5 Hz
(C) 1 Hz (D) 2.1 Hz

EXAMPLE 11.3

Flash of lighting is seen 1.5 seconds earlier than the thunder. How far away is the cloud in which the flash has occurred? (speed of sound = 332 ms^{-1}) *(U.B + A.B)*
(AJK-G1)-2015 / (DGK-G1), (RWP-G1), (FSD-G1)-2016

Ans: **Solution:**
Given that, time t = 1.5 s, speed of sound v=332 ms^{-1}
Therefore, distance of the cloud S =vt = 1.5s × 332 ms^{-1}= 498 m.

11.5 NOISE POLLUTION

LONG QUESTIONS

Q.1 Define noise. Also describe the noise pollution in detail. ***(K.B + U.B + A.B)***

(Ex. Q# 11.16)

Ans:

NOISE

Definition:

"Sound which has jarring and **unpleasant effect** on our ears is called noise. Noise corresponds to **irregular** and **sudden** vibrations produced by some sounds**"**.

Example:

- Sound of machinery
- The slamming of a door
- Sounds of traffic in big cities

NOISE POLLUTION

Definition:

"Noise become noise pollution when it exceeds from its safe level**"**.

Sources of Noise Pollution:

Transportation equipment and heavy machinery are the main sources of noise pollution.

Example:

- Noise of machinery in industrial areas
- Loud vehicle horns
- Hooters and alarms

Major Issue:

Noise pollution has become a major issue of concern in big cities. Noise is an undesirable sound that is harmful for health of human and other species.

Effects of Noise:

Noise has negative effects on human health as it can cause conditions such as:

- hearing loss
- sleep disturbances
- aggression
- hypertension
- high stress levels
- accidents by interfering with communication and warning signals.

Safe Level of Noise:

A safe level of noise depends on two factors:

- the level (volume) of the noise
- the period of exposure to the noise.

The level of noise recommended in most countries is usually 85-90 dB over an eight-hour workday.

Methods to Reduce Noise:

Noise pollution can be reduced to acceptable level by replacing the noisy machinery with environment friendly machinery and equipment, putting sound-reducing barriers, or using hearing protection devices.

11.5 SHORT QUESTIONS

Q.1 Differentiate between musical sound and noise? ***(K.B)***

(LHR-G1), (RWP-G1)-2016 / (LHR-G2)-2015 / (SGD-G2), (FSD-G1), (RWP-G1), (DGK-G2)-2017

Ans: **DIFFERENTIATION**

The differences between musical sound and noise are as follows:

Musical Sound	Noise
Definition	
• Sound which have pleasant effect on our ears are called musical sound.	• Noise is a sound that has jarring or unpleasant sound or effect on our ears and is harmful to human or other species.
Regular / Irregular Manner	
• Frequency and amplitude of musical sounds change in a regular manner.	• Frequency and amplitude of noise change in an irregular manner.
Examples	
• Violin • Flute • Piano	• Sound of machinery • The slamming of a door

Q.2 What is meant by noise pollution? Describe its sources. *(K.B)*
(SWL-G1)-2014 / (SGD-G2), (GRW-G2)-2016 / (SWL-G1)-2017

Ans: **NOISE POLLUTION**

Definition:

"Noise become noise pollution when it exceeds from its safe level".

Sources of Noise Pollution:

Transportation equipment and heavy machinery are the main sources of noise pollution.

Example:

- Noise of machinery in industrial areas
- Loud vehicle horns
- Hooters and alarms

Q.3 How can noise pollution be reduced? *(K.B)* **(SWL-G1)-2017**

Ans: **NOISE REDUCTION**

Trees and different appliances are used to **reduce** the noise.

Q.4 What are effects of noise? *(A.B)*

Ans: *Given on Page # 61*

Q.5 What do you know about safe level of sound? *(K.B)*

Ans: *Given on page # 61*

Q.6 What are major sources of noise in our society? *(K.B)*

Ans: *Given on page # 61*

11.5 MULTIPLE CHOICE QUESTIONS

1. Noise correspond to: *(K.B)*

(A) Vibration (B) Sudden vibrations
(C) Regular vibrations (D) Both (A) and (B)

2. Noise has negative effects on human health it cause except: *(K.B)*

(A) Aggression (B) Hypertension
(C) High stress level (D) Fever/flue

3. The level of noise recommended in most countries over an eight hour workday is usually: *(K.B)* **(BWP-G2)-2014**

(A) 82-90 dB (B) 83-90 dB
(C) 84-90 dB (D) 85-90 dB

11.6 IMPORTANCE OF ACOUSTICS

LONG QUESTIONS

Q.1 What do you know about acoustic protection and reverberation? Also describe the methods to enhance acoustic protection? *(K.B+A.B)*

Ans: **ACOUSTICS PROTECTION**

Definition:

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

Importance:

Reflection of sound is more prominent if the surface is rigid and smooth, and less if the surface is soft and irregular. Soft, porous materials, such as draperies and rugs absorb large amount of sound energy and thus quiet echoes and softening noises.

Thus by using such material in noisy places we can reduce the level of noise pollution. However, if the surface of classrooms or public halls are too absorbent. The sound level may be low for the audience.

REVERBERATIONS

Definition:

"When sound reflects from the walls, ceiling and floor of a room, the reflecting surfaces are too reflective and the sound becomes garbled. This is due to multiple reflections called reverberations**"**.

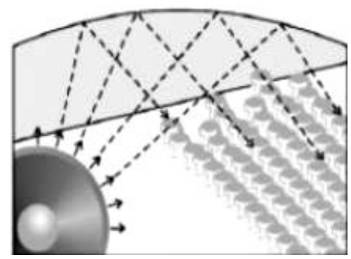


Figure: Curved Ceiling of a Conference Hall

Balance in designing of lecture halls:

In the design of lecture halls, auditorium, or theater halls, a balance must be achieved between reverberation and absorption. Sometimes reflective surfaces like sound boards are placed behind the stage and / or curved ceilings are used to reflect sound to distribute or reach all corners of hall.

METHODS

Reflective Surfaces:

It is often advantageous to place reflective surfaces behind the stage to direct sound to the audience.

Curved ceilings:

Generally, the ceilings of lecture halls, conference halls and theatre halls are curved so that sound after reflection may reach all the corners of the hall (as shown in figure).

Curved sound boards:

Sometimes curved sound boards are placed behind the stage so that sound after reflection distributed evenly across the hall (as shown in figure).

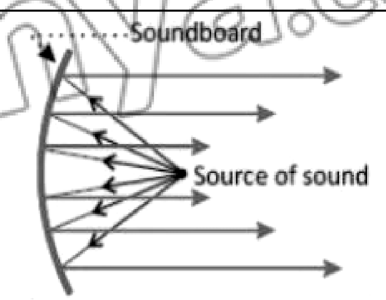


Figure: Soundboard Used in Big Hall

11.6 SHORT QUESTIONS

Q.1 Define acoustics protection and reverberations. *(K.B)*

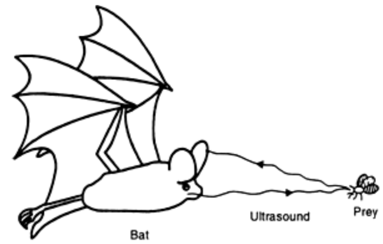
(SGD-G1)-2014 / (BWP-G2), (DGK-G1)-2016 / (RWP-G1), (MTN-G2)-2017

Ans. *Given on Page # 63*

Q.2 Why the phrase "blind as bat" is a false statement? ***(K.B)*****(For your info. Text book Pg. # 30)**

Ans: **BLIND AS A BAT**

The phrase "Blind as bat" is a false statement. Bats have some vision using light, but when placed in pitch-black rooms crisscrossed with fine wires, they can easily fly around and unerringly locate tiny flying insects for food. We usually assume that vision requires light but both bats and dolphins have the ability to "see" using sound waves.



Q.3 Why do pilots wear special headphones? ***(A.B)*** ***(For your info. Text book Pg. # 30)***

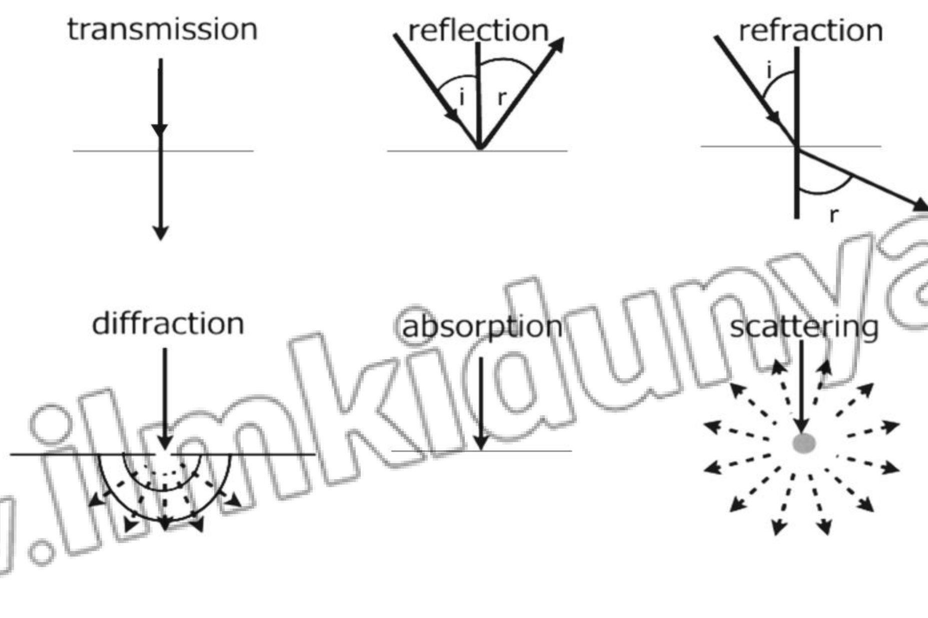
Ans: **SPECIAL HEADPHONES**

Pilots wear special headphones that reduce the roar of an airplane engine to a quite hum.

Q.4 Prove with the help of diagram that sound displays all the properties of waves. ***(K.B + U.B)***

Ans: **PROPERTIES OF SOUND WAVES**

Sound displays all the properties of waves when it interacts with materials and boundaries.



Q.5 Write the advantage of acoustic protection. ***(K.B) (Ex. Q# 11.17)***

Ans: **ACOUSTIC PROTECTION**

Following are the advantages of acoustic protection.

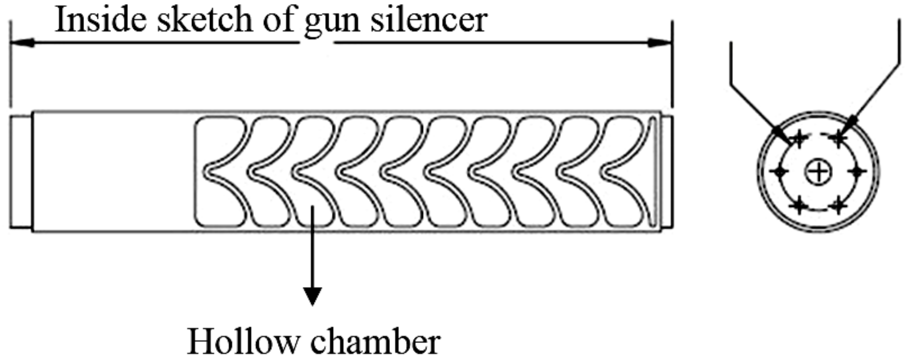
- Soft porous materials, such as draperies and rugs absorb large amount of sound energy and thus quiet echoes and softening noises. Thus by using such materials in noisy places we can reduce the level of noise pollution.

Q.6 Why balance between Reverberation and absorption is necessary in construction of classroom? *(Conceptual Base + A.B)*

Ans: In classroom when reverberation is greater due to more reflecting surfaces the sound become garbled and when the absorption is greater due to absorbing surfaces the intensity of sound become very low. So that is why the balance is necessary.

Q.7 How does silencer reduce noise?

Ans: Both types of silencers (gun and automobile silencers) reduce noise by allowing the rapidly expanding gases from the firing of the cartridge to be decelerated and cooled through a series of hollow chambers. Silencers have a lot of hollow chambers. The trapped gas exits the suppressor over a longer period of time and at a greatly reduced speed, producing less noise signature.



11.6 MULTIPLE CHOICE QUESTIONS

1. **The method used to absorb undesirable sound by soft and porous surface is called: *(K.B)***
   (A) Acoustics (B) Echos
   (C) Intensity (D) Pitch
2. **Multiple reflections called: *(K.B)***
   (A) Acoustics (B) Reverberations
   (C) Vibration (D) All of these
3. **Sound produce by flute, violin, harmonium and drum is called: *(K.B)***
   (A) Music (B) Noise
   (C) Reverberation (D) Acoustic protection
4. **All are the acoustic protection except: *(K.B)***
   (A) Lecture Halls (B) Auditorium
   (C) Theater halls (D) Kitchen

11.7 AUDIBLE FREQUENCY RANGE

SHORT QUESTIONS

Q.1 What do you know about the audible frequency range? *(K.B + A.B) (Ex. Q# 11.15)*
(GRW-G2), (AJK-G2), (FSD-G2)-2014 / (DGK-G1)-2015 / (GRW-G2)-2016 / (RWP-G1), (GRW-G2), (BWP-G2)-2017

Ans: **AUDIBLE FREQUENCY RANGE**

Definition:

"The range of the frequencies which a human ear can hear is called the audible frequency range".

Range:

A normal human ear can hear a sound only if its frequency lies between 20Hz and 20,000 Hz.

Explanation:

A human ear neither hears a sound of frequency less than 20 Hz nor a sound of frequency more than 20,000 Hz. Different people have different range of audibility. It also decreases with age. Young, children can hear sounds of 20,000 Hz but old people cannot hear sound even above 15,000 Hz.

Q.2 What is audible frequency range for human and why we cannot hear if sound ranges more than this range. *(K.B + U.B)*

Ans: **AUDIBLE FREQUENCY RANGE FOR HUMAN**

A human ear can hear sound only if its frequency lies between 20 to 20000 Hz. A human ear can neither hear a sound of frequency less than 20 Hz nor a sound of frequency are more than 20,000 Hz. Sounds of frequency beyond the 20,000 Hz inaudible because the eardrum of human ear cannot vibrate so rapidly. The audible range is different for different persons and it also varies with the age. Young children can hear 20,000 Hz but old people cannot sound hear sounds above 15,000 Hz.

MULTIPLE CHOICE QUESTIONS

1. **For normal person, audible frequency range lies between: *(K.B)***
(SGD-G2)-2014 / (RWP-G1), (MTN-G1)-2016 / (LHR-G2), (GRW-G2), (SWL-G1), (SGD-G1), (FSD-G1)-2017
(A) 200Hz-2000Hz (B) 15Hz-15000Hz
(C) 20Hz-20KHz (D) 20Hz-15000Hz

2. **Old people cannot hear sound even above: *(K.B)***
(A) 20,000Hz (B) 15 KHz
(C) 15,000 Hz (D) Both (B) and (C)

3. **Which bird flies easily between wires in the black room? *(K.B)***
(A) Sparrow (B) Bat
(C) Cow (D) Parrot

4. **The range of the frequency which human, ear can hear is called as: *(K.B)***
(A) Audible frequency range (B) Ultrasonic waves
(C) Transonic waves (D) None of these

5. **Bats can hear Frequencies up to 120,000Hz: *(K.B)***
(A) 10,000Hz (B) 120,000Hz
(C) 12,00,000Hz (D) 120,00,000Hz

6. **Mice can hear frequencies up to: *(K.B)***
(A) 35,00Hz (B) 35,000Hz
(C) 45,00Hz (D) 100,000 Hz

11.8 ULTRASOUND

Q.1 What is ultrasound? Write its uses. ***(K.B + A.B)*** **(FSD-G1)-2015**

Ans:

ULTRASOUND

Definition:

"Sounds of frequency higher than 20, 000 Hz which ore Inaudible to normal human ear are called ultrasound or ultrasonic".

USES OF ULTRASOUND

Detection of Small Objects:

Ultrasonic waves carry more energy and higher frequency than audible sound waves. Therefore, according to the wave equation $v = f\lambda$, the wavelength of ultrasonic waves is very small and is very useful for detecting very small objects.

Ultrasonic are utilized in medical and technical fields as well.

USE IN MEDICAL FIELD:

Treatment of diseases in medical field:

In medical field, ultrasonic waves are used to diagnose and treat different ailments. For diagnosis of different diseases, ultrasonic waves are made to enter the human body through transmitters. These waves are reflected differently by different organs, tissues or tumors etc. The reflected waves are then amplified to form an image of the internal organs of the body on the screen (As shown in Fig.)

Figure: Doctors are taking ultrasound test of a patient with an ultrasound machine

Such an image helps in detecting the defects in these organs.

Removal of blood clots:

Powerful ultrasound is now being used to remove blood clots formed in the arteries.

Diagnosis purposes:

Ultrasound can also be used to get the pictures of thyroid gland for diagnosis purposes.

USE IN TECHNICAL FIELD:

SONAR:

Ultrasound is used to locate underwater depths or is used for locating objects lying deep on the ocean floor, etc. The technique is called SONAR, (sound navigation and ranging). The sound waves are sent from a transmitter, and a receiver collects the reflected sound (As shown in figure).

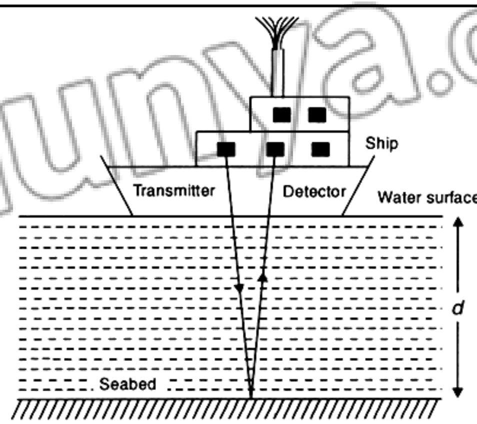


Figure: Ultrasonic are used to measure the depth of water by echo method

The time-lapse is calculated, knowing the speed of sound in water, the distance of the object from the ocean surface can be estimated.

SONAR ranging is also used to see the shape and the size of the object.

Detection of Cracks:

Cracks appear in the interior of moving parts of high speed heavy machines such as turbines, engines of ships and airplanes due to excessive use. These cracks are not visible from outside but they can be very dangerous. Such cracks can be detected by ultrasonic. A powerful beam of ultrasound is made to pass through these defective parts. While passing, these waves are reflected by the surface of these cracks and flaws. The comparison of the ultrasonic waves reflected from cracks and from the surfaces of these parts can give a clue of the existence of the cracks.

Destroying germs and bacteria:

Germs and bacteria in liquids can also be destroyed by using high intensity ultrasonic waves.

11.8 SHORT QUESTIONS

Q.1 What are ultrasonic and why they are used in our life? *(K.B+A.B)* (GRW 2013, LHR 2015)

Ans: **ULTRASONICS / ULTRASOUND**

Definition:

"Sounds of frequency higher than 20, 000 Hz which ore Inaudible to normal human ear ore called ultrasound or ultrasonic**"**.

Uses:

It has been seen that ultrasonic waves carry more energy than audible sound waves. Moreover, according to the relation $v = f\lambda$, the wavelength of ultrasonic waves is very small. Due to these characteristics they are usefully utilized in medical and technical fields.

Q.2 How we can find the depth of ocean? *(K.B+A.B)* (SGD-G1), (LHR-G1), (BWP-G2)-2016

OR What do you know about SONAR? (SGD-G2), (MTN-G1), (DGK-G2)-2017

Ans: *Given on Page # 67*

Q.3 Write down the maximum hearing frequency range of the following. *(K.B)*

- **Bats** • **Mice** • **Dogs** • **Cats** • **Humans**

Ans: **MAXIMUM HEARING REQUENCY**

The maximum hearing frequency rage of the bats, mice, dogs, cats and humans are given as follows:

- Bats can hear frequencies upto 120000 Hz, other ani8mal cannot hear such high-pitched sounds.
- Mice can hear frequencies upto 100,000 Hz.
- Dogs can hear frequencies upto 35,000 Hz.
- Cats can hear frequencies upto 25,000 Hz.
- Humans can hear frequencies upto 20,000 Hz.

Q.4 State two uses of ultrasound in medical field. *(K.B+A.B)* (Ex. Q# 11.18)
(FSD-G1), (RWP-G1), (SWL-G2), (AJK-G1)-2014 / (FSD-G2), (BWP-G2), (RWP-G2), (AJK-G2), (SWL-G2)-2015, (BWP-G1), (MTN-G1,2), (FSD-G1), (BWP-G2)-2016 / (SGD-G1), (LHR-G1)-2017

Ans: *Given on Page # 67*

Q.5 The side effect of SONAR on blue whales? *(K.B+A.B + Conceptual Base)*

Ans: Blue Whales are dying due to SONAR because they swim hundreds of miles rapidly changed their depth that is why the blood pressure in their veins become very high in causes bleeding from their eyes and ears. And even they beach themselves get away from the sound of SONAR. (In January 2005, 34 whales become stranded and died a long North Carolina's due to Sonar)

11.8 MULTIPLE CHOICE QUESTIONS

1. Ultrasonics are used to measure the depth of water by: *(K.B)*

(A) Acoustics (B) Echo Method
(C) Sound Level (D) Diffraction

2. **Which waves carry more energy and higher frequency than sound waves? *(K.B)***
(A) Ultrasonics (B) Infrasonic
(C) Audible sound (D) All of these

3. **Ultrasonics are used to locate under-water depth the technique is called: *(K.B)***
(A) Acoustics (B) Reverb ration
(C) Sonar (D) Infrasonics

4. **Sound waves with frequency less than 20Hz are called: *(K.B)***
(A) Ultrasonic (B) Infrasonics
(C) Notes (D) Acoustic

5. **Ultrasound is the frequency of sound higher than: *(K.B)***
(A) 20Hz (B) 20KHz
(C) 15,000 Hz (D) 25,000 Hz

6. **Infrasonic is the frequency of sound less than: *(K.B)***
(A) 20Hz (B) 20 KHz
(C) 15,000 Hz (D) 25,000 Hz

7. **According to wave equation $v = f\lambda$ the wavelength of ultra-sonic waves are: *(U.B)***
(A) Very small (B) Very big
(C) Both "a" and "b" (D) None of these

8. **Powerful ultrasound is now being used to remove blood clot from: *(A.B)***
(A) Capillaries (B) Arteries
(C) Convoluted tubule (D) None of these

9. **By which waves small cracks can appear: *(A.B)***
(A) Ultrasonics (B) Infrasonic
(C) NOTSE (D) Sound frequency

10. **By ultrasonic waves destroyed: *(A.B)***
(A) Germs (B) Bacteria
(C) Fungus (D) Both "a" and "b"

11. **When the frequency of a sound wave is increased which of following decrease: *(U.B)***
(A) Wave length (B) Period
(C) Amplitude (D) Both (A) & (B)

MCQ'S ANSWER KEY (TOPIC WISE)

11.1 SOUND

1	2	3	4	5	6	7	8	9	10	11	12
A	B	B	B	D	A	B	D	D	B	C	B
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
D	A	D	A	C	D	C	A	D	C	D	B

11.2 CHARACTERISTICS OF SOUND

1	2	3	4	5	6	7	8	9	10	11	12
C	B	D	A	A	C	C	B	B	C	A	B
13	**14**	**15**	**16**	**17**							
B	C	B	C	D							

11.3 REFLECTION (ECHO) OF SOUND

1	2	3	4
B	B	B	D

11.4 SPEED OF SOUND

1	2	3	4	5	6	7	8	9	10	11
B	C	D	A	B	A	A	C	D	D	A

11.5 NOISE POLLUTION

1	2	3
D	D	D

11.6 IMPORTANCE ACOUSTICS

1	2	3	4
A	B	A	D

11.7 AUDIBLE FREQUENCY RANGE

1	2	3	4	5	6
C	C	B	A	B	D

11.8 ULTRASOUND

1	2	3	4	5	6	7	8	9	10	11
B	A	C	B	B	A	A	B	A	D	D

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. Which is an example of a longitudinal wave? *(K.B)*
(GRW-G1)-2014 / (FSD-G1), (SGD-G2), (LHR-G1)-2015 / (RWP-G2), (MTN-G1), (DGK-G1)-2016 / (DGK-G1), (RWP-G1), (MTN-G2), (SGD-G1), (SGD-G1), (SWL-G1)-2017

(a) sound wave (b) light wave
(c) radio wave (d) water wave

ii. How does sound travel from its source to your ear? *(K.B)*

(a) by changes in air pressure (b) by vibrations in wires or strings
(c) by electromagnetic wave (d) by infrared waves

iii. Which form of energy is sound? *(K.B)* **(Copy from Mcq. 5 Topic 11.1)**

(a) electrical (b) mechanical
(c) thermal (d) chemical

iv. Astronauts in space need to communicate with each other by radio links because: *(K.B+A.B)* **(SWL-G2), (RWP-G1,G2)-2017**

(a) Sound waves travel very slowly in space (b) Sound waves travel very fast in space
(c) Sound waves cannot travel in space (d) Sound waves have low frequency in space

v. The loudness of a sound is most closely related to its: *(K.B)*

(a) Frequency (b) Period
(c) Wavelength (d) Amplitude

vi. For a normal person, audible frequency range for sound wave lies between: ***(K.B)***

(Copy from Mcq. 5 Topic 11.1)

(a) 10 Hz and 10 kHz (b) 20 Hz and 20 kHz
(c) 25 Hz and 25 kHz (d) 30 Hz and 30 kHz

vii. When the frequency of a sound wave is increased, which of the following will decrease? ***(K.B)***

i. Wavelength ii. Period iii. Amplitude

(a) i only (b) iii only
(c) i and ii only (d) i and iii only

ANSWER KEY

i	ii	iii	iv	v	vi	vii
a	a	b	c	d	b	c

REVIEW QUESTIONS

11.1. What is the necessary condition for the production of sound? ***(K.B)***

Ans: (See Topic 11.1, Short Question-4)

11.2. What is the effect of the medium on the speed of sound? In which medium sound travels faster: air, solid or liquid? Justify your answer. ***(K.B+U.B)***

Ans: (See Topic 11.4, Long Question-1)

11.3. How can you prove the mechanical nature of sound by a simple experiment? ***(K.B+U.B+A.B)***

Ans: (See Topic 11.1, Long Question-4)

11.4. What do you understand by the longitudinal wave? Describe the longitudinal nature of sound waves. ***(K.B+U.B)***

Ans: (See Topic 11.1, Long Question-4)

11.5. Sound is a form of wave. List at least three reasons to support the idea that sound is a wave. ***(K.B)***

Ans: (See Topic 11.1, Short Question-2)

11.6. We know that waves manifest phenomenon of reflection, refraction and diffraction. Does sound also manifest these characteristics? ***(K.B+U.B)***

Ans: Yes, they do manifest phenomenon of reflection, diffraction and refraction.

11.7. What is the difference between the loudness and intensity of sound? Derive the relationship between the two. ***(K.B)***

Ans: (See Topic 11.2, Short Question-5) + Definition

11.8. On what factors does the loudness of sound depend? ***(K.B)***

Ans: (See Topic 11.2, Short Question-1)

11.9. What do you mean by the term intensity level of the sound? Name and define the unit of intensity level of sound. ***(K.B+U.B+A.B)***

Ans: (See Topic 11.2, Short Question-6+7)

11.10. What is the units of loudness? Why do we use logarithmic scale to describe the range of the sound intensities we hear? *(K.B)*

Ans: **Unit of Loudness:**

Loudness is not a physical quantity, that's why it has no unit.

Logarithmic Scale:

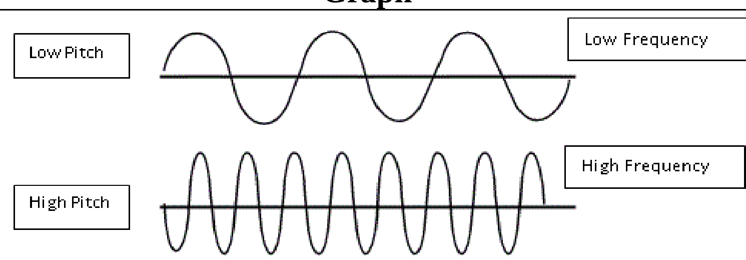
We use logarithmic scale to describe the sound intensities we hear because this range is so wide.

11.11. What is the difference between frequency and pitch? Describe their relationship graphically. *(K.B)*

Ans: **DIFFERENCE**

The difference between frequency and pitch are as follows:

Frequency	Pitch
Definition	
• Number of waves passing through a point in one second is called its frequency.	• Pitch is the characteristics of sound by which we can distinguish between a shell and grave sound.
Unit	
• Its unit is Hertz (Hz).	• It has no unit.
Graph	



11.12. Describe the effect of change in amplitude on loudness and the effect of change in frequency on pitch of sound. *(K.B)*

Ans: **CHANGE IN AMPLITUDE:**

Loudness of sound depends upon the amplitude of vibrating body. So that, if there is an increase in the amplitude of a vibrating body there will be the increase in the loudness of sound and vice versa.

CHANGINE IN FREQUENCY:

Pitch of sound depends upon its frequency so that if there is increase in frequency there will be the increase its pitch and vise versa.

11.13. If the pitch of sound is increased, what are the changes in the following? *(U.B + A.B)*

a. The frequency **b. The wavelength**

c. The wave velocity **d. The amplitude of the wave**

Ans: According to wave equation, $v = f\lambda$, If there is an increase in the pitch of a wave then:

- frequency will increase
- wavelength will decrease

- wave velocity will increase
- amplitude of wave will remain unchanged

11.14. If we clap or speak in front of a building while standing at a particular distance, we rehear our sound after sometime. Can we explain how this happens? ***(K.B + A.B)***

Ans: It is due to reflection of sound. When sound is incident on the surface of a medium it bounces back into the first medium. This is known as reflection of sound or echo.

11.15. What is the audible frequency range for human ear? Does this range vary with the age of people? Explain. ***(K.B)***

Ans: (See Topic 11.7, Short Question-1)

11.16. Explain that noise is a nuisance. ***(K.B)***

Ans: (See Topic 11.5, Long Question-1)

11.17. Describe the importance of acoustic protection. ***(K.B)***

Ans: (See Topic 11.6, Short Question-1)

11.18. What are the uses of ultrasound in medicine? ***(A.B)***

Ans: (See Topic 11.8, Short Question-1) (In medical field)

CONCEPTUAL QUESTIONS (A.B)

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

Ans: **BETTER WAY TO COMMUNICATE**

String stretched between two tin cans could be better way to communicate than merely shouting through the air because sound waves propagate much better and faster in solids than air. Sound expands in air in all directions and communication between persons become difficult. In two tin cans and wire system, sound travel in a specific direction with greater speed than in air. So, it is a better way for communication.

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

Ans: **RECOGNITION OF VOICE**

We can recognize person speaking with same loudness from their voice because sound waves have different waveforms, so their quality is different and we can distinguished them from each other.

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

Ans: **LISTENING RATHER THAN WATCHING**

Voice can be listened around the corner because sound waves travel around obstacles, due to its very large wavelength it diffract around the corner of obstacle. We cannot watch a person around the corner because light wave cannot bend around normal sized objects due to its very small wavelength. So we can listen a friend around a corner but we cannot watch him.

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

Ans: **VOLUME OF STEREO IN A ROOM**

The volume of the stereo in a room with wall to wall carpet be tuned higher than in a room with wooden floor because it does not absorbs sound waves. So the loud sound is heard as compared to the room with wall to wall carpeted.

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

Ans: **SPEED VS FREQUENCY**

No, wave frequency is the amount of waves that you get in a single second, and the wave speed is the measure of how long it takes to travel in a given distance, so speed and frequency are two different quantities having time as common factor. Also frequency does not depend on the nature of medium but speed of sound is different in different medium.

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

Ans: **DIFFERENCE OF LOUDENSS AT SAME DISTNACE**

They disagree on loudness because loudness depends upon the sensitivity of the ear of the listener.

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

Ans: **ECHO AND REFLECTION OF SOUND**

The phenomenon of repetition of a sound caused by reflection of sound from a surface is called echo. For example, you shout from a valley, you hear an echo. While the reflection is the change in direction of a wave such as light or sound wave, away from a boundary.

Conditions for Echo:

To hear a clear echo, the minimum distance of obstacle and source of sound must be 17m, and the time interval between our sound and the reflected sound must be at least 0.1 s.

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

Ans: **CONSTITUTION OF A SOUND**

Since dB is the unit of sound level, and its value depend upon the log of intensities, therefore 50 dB sound from two bodies does not constitute 100 dB sound. Each 10 dB increase in sound makes the sound 10-times louder.

11.9. Why ultrasound is useful in medical field?

Ans: **ULTRASOUND IN MEDICAL FIELD**

Ultrasound is useful in medical field because it carries more energy and higher frequency, $(v = f\lambda)$ with very small wavelengths than audible sound waves. Ultrasound due to its characteristics has vast applications in medical and in technical field.

NUMERICAL PROBLEMS (U.B+A.B)

11.1 A normal conversation sound intensity of about 3.0 x 10-6 Wm-2. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB? *(A.B)*

(SGD-G2)-2015 / (GRW-G2)-2016

Solution:

(a) Given Data

Intensity of normal conversation = I = $3.0\times10^{-6}wm^{-2}$

Intensity of faintest sound = $I_o = 10^{-12}wm^{-2}$

To Find:

Intensity level = $L-L_o$ = ?

Formula:

$$L - L_o = 10 \log \frac{I}{I_o} \text{ dB}$$

Calculation:

By using formula, we have

$$= 10 \log \frac{3\times10^{-6} \cancel{wm^{-2}}}{10^{-12} \cancel{wm^{-2}}} \text{ dB}$$

Now intensity for 100 dB

$$L - L_o = 10 \log\left(\frac{3\times10^{-6}}{10^{-12}}\right)$$

$$= 10\log\left(3\times10^{-6+12}\right) dB$$

$$= 10\log\left(3\times10^{6}\right) dB$$

$$= 10\times6.47 dB$$

= 64.7 dB

(b)

Given Data:

Intensity level $L - L_o$ = 100 dB

Intensity of faintest sound = $I_o = 10^{-12}wm^{-2}$

To Find:

Intensity of given sound = I = ?

Formula:

$$L - L_o = 10 \log \frac{I}{I_o} \text{ dB}$$

Calculation:

By using formula, we have

$$100 \cancel{dB} = 10 \log \frac{I}{10^{-12} wm^{-2}} \cancel{dB}$$

$$\Rightarrow \frac{100}{10} = \log \frac{I}{10^{-12} wm^{-2}}$$

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

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

Taking antilog on both sides

$$\text{Antilog}10 = \text{Antilog}\left[\log\left(10^{12}\times I\right)\right]$$

$$1\times10^{10} = 10^{12} I$$

$$\frac{1\times10^{10}}{10^{12}} = I$$

$$I = 1\times10^{-2}$$

$$I = 0.01 Wm^{-2}$$

Result:

Hence, sound intensity level of normal conversation is 64.8 dB and intensity of sound for 100 dB is 0.01 Wm^{-2}

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

Solution:

Given Data:
Sound level at bazar = L – L_o = 80 dB
Intensity of faintest audible sound
= $I_o = 10^{-12} wm^{-2}$

To Find:
Intensity of sound at Anarkali bazar = I = ?

Formula:

$$L - L_o = 10 \log \frac{I}{I_o} \text{ dB}$$

Calculation:
By using formula, we have

$$80 \cancel{dB} = 10 \log \frac{I}{10^{-12} wm^{-2}} \cancel{dB}$$

$$\frac{80}{10} = \log \frac{I}{10^{-12} wm^{-2}}$$

$$8 = \log\left(10^{12} \times I\right)$$

Taking antilog on both sides

$$\text{Antilog } 8 = \text{Antilog } \left[\log\left(10^{12} \times I\right)\right]$$

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

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

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

$$I = 10^{-4} Wm^{-2}$$

Result:

Hence, the intensity of sound at Anarkali bazar is 10^{-4} Wm^{-2}

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

Solution:

Given Data:
Speed of sound = v = 330 ms^{-1}
Wavelength = λ = 5cm

$$\lambda = \frac{5}{100} m = 0.05m$$

To Find:
Frequency = f = ?

Formula:
v = fλ

Calculation:
By wave equation,
v = fλ

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

$$\Rightarrow \quad = \frac{330ms^{-1}}{0.05m}$$

$$= 6600s^{-1} \quad (\because s^{-1} = Hz)$$

$$f = 6.6\times10^3 Hz$$

∵ yes this frequency lies in the range of human ear

Result:

Hence, the frequency of sound wave is 6.6×10^3 Hz, which lies within the audible frequency range of human ear.

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

Solution:

Given Data:

No of heartbeats = n = 72
Time = t = 1 min = 60sec

To Find:

Frequency = f = ?
Time period = T = ?

Solution:

We know that

$$f = \frac{n}{t}$$

$$= \frac{72}{60\,\text{sec}} \Rightarrow 1.2\text{s}^{-1} \qquad \left(\because \text{s}^{-1} = \text{Hz}\right)$$

As $T = \frac{1}{f}$

$$= \frac{1}{1.2\,\text{s}^{-1}}$$

T = 0.833 sec.

Result:

Hence, the frequency and time period of heart beat is 1.2 Hz and 0.833 s respectively.

11.5 A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5s later. The speed of sound in a sea water is 1500 ms^{-1}. Find the depth of the sea at this position. **(BWP-G2)-2016**

Solution:

Given Data:

Time to hear echo = t = 1.5 s
Speed of sound = v = 1500ms^{-1}

To Find:

Depth of sea = h = ?

Formula:

S = v × t

Calculation:

By using formula, we have
S = vt
= (1500) (1.5)
= 2250m

For hearing echo, the minimum depth from sea bed to ship must be half of this depth (2250m)

Therefore,

$$h = \frac{S}{2}$$

$$= \frac{2250}{2} \Rightarrow h = 1125m$$

Result:

Hence, the depth of sea from a marine suwey ship is 1125 m.

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

Given data:

Time to clear echo = t = 5s

Speed = v = 346 ms^{-1}

To Find:

Distance = d = ?

Formula:

S = v × t

Calculation:

By using formula, we have

S = vt

= 346 x 5

S = 1730 m

For hearing echo, the minimum distance from obstacle to the source of sound must be half of this distance (1730m).

Therefore,

$$d = \frac{S}{2}$$

$$d = \frac{1730}{2}$$

d = 865 m

Result:

Hence, the distance of different from the student to hear the echo is 865 m.

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

Solution:

Given data:

Time taken by sound = t = 3.42S

Speed of sound = v = 1531 ms^{-1}

To Find:

Distance of seabed from ship = d = ?

Calculation:

By using formula, we have

S = vt

= 1531 x 3.42

= 5236.02 m

For hearing echo, the minimum depth of the seabed from the must be half of this distance (5236.02m)

$$d = \frac{s}{2}$$

$$d = \frac{5236.02}{2}$$

$$d = 2618m$$

Result:

Hence, the distance of seabed from ship is 2618 m.

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 temperature of 20°C? What is the wavelength of the lowest sounds we can hear of about 20 Hz? Assume the speed of sound in air at 20°'C is 343 ms^{-1}.

Solution:

Given Data:

Highest frequency = f_1 = 20,000 Hz

Lowest frequency = f_2 = 20 Hz

Speed of sound = v = 343 ms^{-1}

To Find:

Wavelength of highest frequency = λ_1 = ?

Wavelength of lowest frequency = λ_2 = ?

Formula:

$v = f\lambda$

Calculation:

By using wave equation, we have

$v = f\lambda$

$$\Rightarrow \lambda_1 = \frac{v}{f_1}$$

$$= \frac{343\,ms^{-1}}{20,000\,s^{-1}}$$

$\lambda_1 = 0.01715 \text{ m} = 1.7 \times 10^{-2} \text{ m}$

As $V = f_2 \lambda_2$

$$\lambda_2 = \frac{v}{f_2}$$

$$\Rightarrow = \frac{343ms^{-1}}{20s^{-1}}$$

$$= 17.15\,m$$

$$\lambda_2 = 17.2m$$

Result:

Hence, the wavelength of highest and wavelength of lowest frequency is 1.7×10^{-2} m respectively.

11.9 A sound wave has frequency of 2 kHz and wavelength 35cm. How long will it take to travel 1.5 km? (LHR-G2)-2015 / (LHR-G1)-2016

Solution:

Given Data:

Frequency of wave = f = 2×10^3 Hz

Wavelength = λ = 35 cm = 0.35m

Distance travelled = s = 1.5 Km = 1500 m

To Find:

Time taken = t = ?

Formula:

$S = v \times t$

Calculation:

By wave equation

$V = f\lambda$

$= 2 \times 10^3 \text{ Hz} \times 0.35 \text{ m}$

$V = 700 \text{ ms}^{-1}$

As $S = v \times t$

$1500 \text{ m} = 700 \text{ ms}^{-1} \times t$

$$t = \frac{1500\,m}{700\,ms^{-1}}$$

$t = 2.1 \text{ sec}$

Result:

Hence, to travel 1.5 km sound wave will take 2.1 s.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Sound waves are examples of:

(A) Transverse waves (B) Electromagnetic waves
(C) Longitudinal waves (D) All of these

2. The SI unit of intensity of sound is:

(A) Wm^{-1} (B) Wm^{-2}
(C) Wms^{-1} (D) Wm^2

3. Pitch of sound depends upon:

(A) Frequency (B) Amplitude
(C) Intensity (D) Time period

4. The speed of sound in air is:

(A) 1264 kmh^{-1} (B) 1264 mh^{-1}
(C) 1264 kms^{-1} (D) 1264 ms^{-1}

5. Which form of energy is sound?

(A) Electrical (B) Mechanical
(C) Thermal (D) Chemical

6. After how much time the echo must be heard?

(A) 0.1 s (B) 0.10 s
(C) 0.20 s (D) 0.50 s

Q.2 Give short answers to following questions. **(5×2=10)**

i. What is meant by loudness of sound?
ii. What is the effect of change in frequency on the pitch of sound?
iii. What is the relation between loudness and intensity of sound?
iv. Calculate the intensity levels of the faintest audible sound.
v. What is the difference between musical sounds and noise?

Q.3 Answer the following questions in detail. **(4+5=9)**

a) What do you mean by sound intensity level? Derive its mathematical formula. Name and define unit of intensity level of sound.
b) A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5 s later. The speed of sound in sea water is 1500 ms^{-1}. Find the depth of the sea at this position.

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.

UNIT 12

GEOMETRICAL OPTICS

12.1 REFLECTION OF LIGHT

LONG QUESTIONS

Q.1 Define reflection of light. Also describe the laws and types of reflection.

(K.B+ A.B+U.B)

(LHR-G2)-2015 / (BWP-G1),(FSD-G1),(LHR-G1 / G2),(MTN-G1 / G2)-2014 / (GRW-G1 / G2),(SGD-G2),(FSD-G1),(MTN-G2),(SWL-G1)-2015 / (SGD-G1),(RWP-G2),(AJK-G1)-2016 / (LHR-G2),(GRW-G2),(MTN-G1),(GRW-G2),(RWP-G2),(SGD-G1)-2017

Ans: **REFLECTION OF LIGHT**

Definition:

"When light travelling in a certain medium falls on the surface of another medium, a part of it turns back in the same medium. This is called reflection of light**"**.

Explanation:

When a ray of light from air along the path **AO** falls on a plane mirror **M**, it is reflected along the path **OB**. The ray **AO** is called incident ray while the ray OB is called reflected ray. The angle between incident ray **AO** and normal **N**, i.e., $\angle$**AON** is called the **angle of incidence** represented by **i**. The angle between the normal and the reflected ray **OB**, i.e., $\angle$NOB is called **angle of reflection** represented by **r**. (As shown in figure)

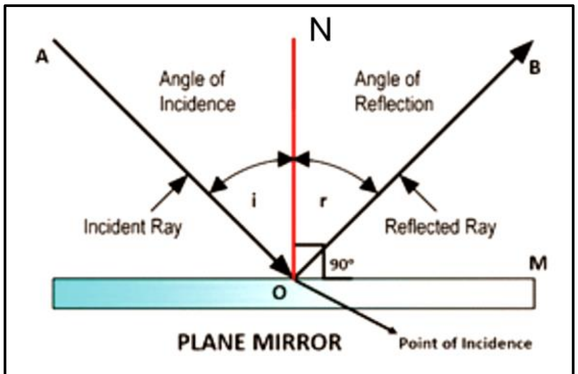


Figure: **Reflection of Light**

LAWS OF REFLECTION

Following are the laws of reflection:

- The incident ray, the normal, and the reflected ray at the point of incidence all lie in the same plane.
- The angle of incidence is equal to the angle of reflection i.e., $\angle \mathbf{i} = \angle \mathbf{r}$

TYPES OF REFLECTION

Nature of reflection depends on smoothness of the surface. On the basis of nature of surface there are two following types of reflection.

- Regular reflection
- Irregular reflection

Regular Reflection:

Definition:

"The reflection by **smooth surfaces** is called regular reflection**"**.

Example:
A smooth surface of silver reflects parallel rays of light in one direction only.

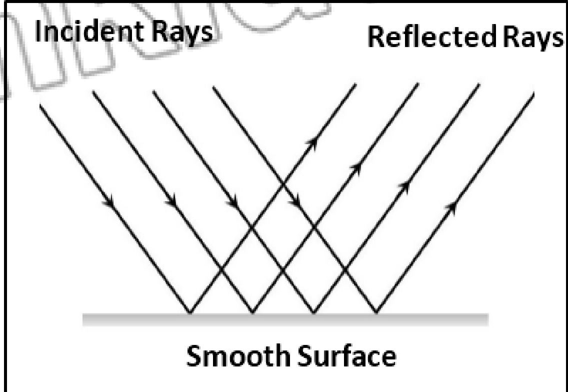


Figure: Regular Reflection

- Most of the objects in everyday life are not smooth on the microscopic level.

Irregular Reflection:

Definition:

"The reflection by **rough surfaces** is called irregular reflection".

Example:
The rough surfaces of objects reflect the ray of light in many directions.

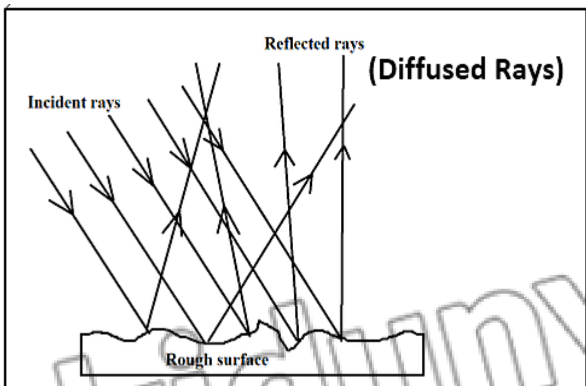


Figure: Irregular Reflection

12.1 SHORT QUESTIONS

Q.1 What is light? ***(K.B+C.B+A.B)***

Ans: Light is a form of energy which give us sensation of vision. Light radiates from its source rather as 'ripples' spread across the surface of a pond. However, in the case of light, the ripples are tiny, vibrating, electric and magnetic forces. Light waves have wavelengths of less than a thousandth of a millimeter.

Q.2 What is difference between luminous and non-luminous object? *(K.B+A.B)*

Ans:

DIFFERENTIATION

The differences between luminous and non-luminous object are as follows:

Luminous Object	Non-Luminous Object
Definition	
• The luminous are the objects which produce light.	• The non-luminous are the objects which do not produce light but they only reflect light which fall on them and that is why we can see them.
Example: • The Sun, lamps, lasers, and glowing TV screens all luminous objects.	**Example:** • Paper, wood, bottle, table etc.

Q.3 Why the diffraction of light is very very low? *(Conceptual Base + A.B)*

Ans: The phenomenon of diffraction of light is not prominent because the wave length of light is very very small. For diffraction the wave length of wave should be greater than or equal to the obstacle of object through which diffraction is happened. If we want to experience the diffraction of light for that purpose we have to find the size of obstacle compare able to the wave length of light which is not easy task.

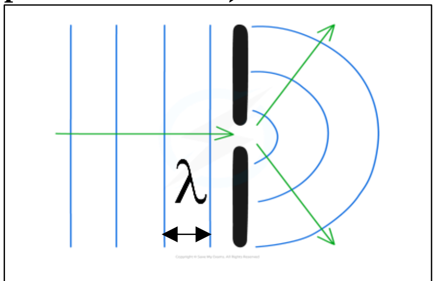


Figure: Diffraction of Light

Q.4 How we can see the beam of light? *(Conceptual Base + A.B)*

Ans: We can see the beam of light because tiny particles of test smoke or mist in the air are reflecting some of the light into our eyes.

Q.5 What do you know about the wave length and colours of light? *(Conceptual Base)*

Ans: When light enters the eyes, the brain senses different wavelengths as different colours. The wavelengths range from 0.000 4mm (violet light) to 0.000 7mm (red light), and white light is made up of all the wavelengths in this range.

Q.6 Why virtual image is formed by a plane mirror? *(Conceptual Base + A.B)*

Ans: A plane mirror always forms a virtual image (behind the mirror) because the light does not actually pass through the image. The image will be the same size as the object and will be the same distance behind the mirror as the object is in front of the mirror.

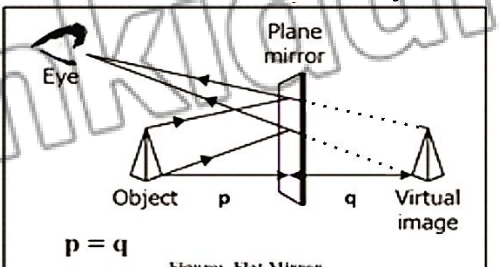


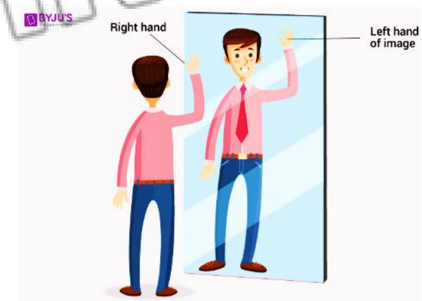
Figure: Flat Mirror

Q.7 Why the word Ambulanse is written inverted in front of Ambulanse vehicle? *(C.B+A.B)*

Ans: The letters on the front of an ambulance are written laterally inverted, so that the driver of the vehicle moving ahead of the ambulance can read the word properly after lateral inversion, in the rear view mirror which is mostly a convex mirror and allows ambulance to overtake smoothly.

Q.8 What is lateral inversion? *(C.B)*

Ans: Lateral inversion is the reversal of mirror image where the right side of the object appears on the left side behind the mirror.



Q.9 What is meant by reflection of light? *(K.B)* **(GRW-G1),(SWL-G2)-2014 / (RWP-G1)-2016**

Ans: *Given on Page # 82*

Q.10 State laws of reflection. *(K.B)*
(BWP-G1),(FSD-G1),(LHR-G1 / G2),(MTN-G1 / G2)-2014 / (GRW-G1 / G2),(SGD-G2),(FSD-G1),(MTN-G2),(SWL-G

Ans: *Given on Page # 82*

Q.11 What are the types of reflection? *(K.B)* **(SGD-G2),(MTN-G2)-2016**

Ans: *Given on Page # 83*

Q.12 Difference between regular and irregular reflection (Diffuse Reflection). *(K.B)*
(GRW-G2),(LHR-G1 / G2)-2014 / (BWP-G1)-2017

Ans: *Given on Page # 83*

Q.13 Differentiate between angle of incidence and angle of reflection. *(K.B)* **(MTN-G2)-2017**

Ans: *Given on page # 82*

Q.14 How are we able to see a page of a book? *(K.B+A.B)* **(Physics of Light Pg. # 37)**

OR Why do we see printed words as black area on a page?

Ans:

<u>PHYSICS OF LIGHT</u>

We can see a page of a book because light reflects from each part of page in all directions, so that some of the light rays from each part of the page enter our eye because almost no light is reflected by the printed words, therefore, we "see" them as black areas.

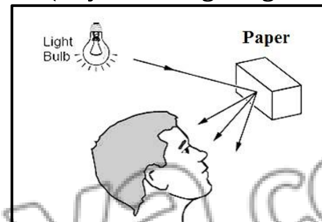


Figure: <u>Physics of Light</u>

Q.15 What were the main ideas about the nature of light in early 1700 s? *(K.B)*
(For your information Pg # 37)

Ans:

<u>NATURE OF LIGHT IN EARLY 1700 s</u>

In the early 1700 s, there were two main ideas about the nature of light:

- Particle nature
- Wave nature

Q.16 What theories were given by different scientist about the nature of light? *(K.B)*
(For your information Pg # 37)

Ans:

<u>THEORIES ABOUT THE NATURE OF LIGHT</u>

<u>Newton</u>:

Newton put forward the idea of corpuscular nature of light. According to him, light consist of tiny, fast-moving particles.

<u>Maxwell</u>:

He formulated the wave theory of light.

Thomas Young:
In 1802, Thomas Young proved the wave nature of light experimentally.
Planck:
In 1990, Planck suggested that light consist of small packets of energy called photons. Later on the idea of photon was confirmed by experiments.

Q.17 Why do we see an inverted image in a plane mirror? *(K.B)* (For Your Information Pg. # 38)

Ans: **INVERTED IMAGE**

Light rays are reflected in a plane mirror, causing us to see an inverted image.

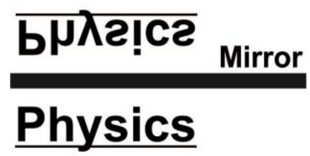


Figure: Plane Mirror

Q.18 What will be the nature of images formed by a flat mirror? *(K.B)*
(For Your Information Pg. # 38)

Ans: **NATURE OF IMAGE**

The image we see in a flat mirror is at the same distance behind the mirror as we are in front of it.

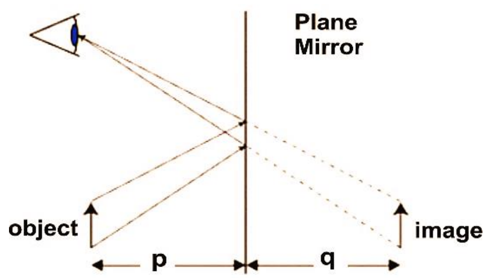


Fig: Plane Mirror

12.1 MULTIPLE CHOICE QUESTIONS

1. Laws of reflection are: *(K.B)* **(BWP-G2)-2015**
(A) 2 (B) 3
(C) 4 (D) 5

2. Plank suggested that light consists of small packets of energy called: *(K.B)*
(For you information Pg. # 37)
(A) Electrons (B) Neutrons
(C) Photons (D) Positrons

3. The angle between incident ray and normal N is: *(K.B)*
(A) Angle of reflection (B) Angle of incidence
(C) Angle of refraction (D) Normal angle

4. Angle of incidence is represented by: *(K.B)*
(A) i (B) e
(C) R (D) p

5. The angle between the normal and the reflected ray is called angle of: *(K.B)*
(A) Angle of reflection (B) Angle of refraction
(C) Angle of incidence (D) Diffraction

6. The incident ray, the normal, and the reflected ray at the point of incidence all lie in the: *(K.B)*
(A) Opposite direction (B) Same plane
(C) x and y axis (D) y & z - axis

7. According to the law of reflection: *(A.B + U.B)*

(A) i > r (B) i < r
(C) r > i (D) i = r

8. Regular reflection is reflection by the: *(K.B)*
(A) Rough surface (B) Smooth surface
(C) Irregular surface (D) Smooth and rough surfaces

9. The rough surfaces of object reflect the rays of light in many directions which is called: *(K.B)*
(A) Regular reflection (B) Irregular reflection
(C) Refraction (D) Interference

12.2 SPHERICAL MIRRORS

LONG QUESTIONS

Q.1 What do you know about spherical mirrors? Also describe the types of spherical mirrors. *(K.B+A.B+U.B)*

Ans: **SPHERICAL MIRRORS**

Definition:

"A mirror whose polished, reflecting surface is a part of a hollow sphere of glass or plastic is called a spherical mirror".

Construction:

In a spherical mirror, one of the two curved surfaces is coated with a thin layer of silver followed by a coating of red lead oxide paint. Thus, one side of the spherical mirror is opaque and the other side is a highly polished reflecting surface.

TYPES OF SPHERICAL MIRRORS

Depending upon the nature of reflecting surface, there are two types of spherical mirrors (as shown in figure)

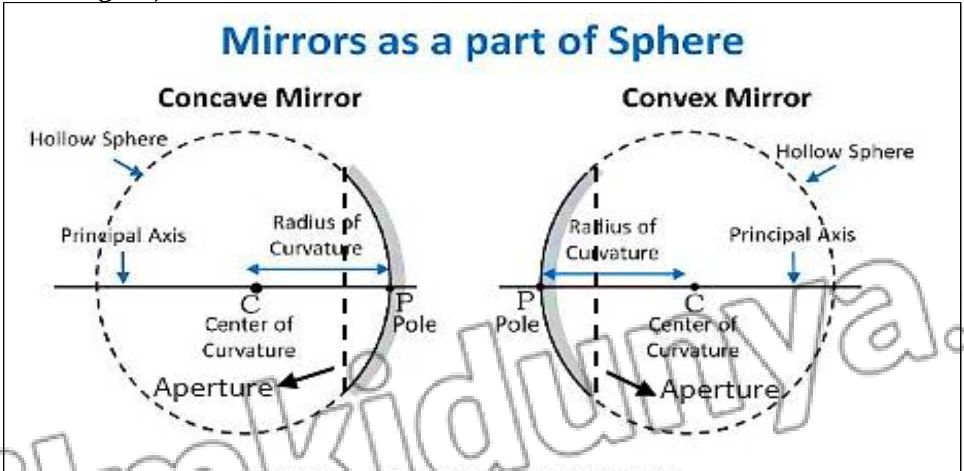


Figure: Types of Spherical Mirrors

Concave mirror:

Definition:

"A spherical mirror whose Inner curved surface is reflecting is called concave mirror".

Size of image:

In concave mirror the size of the image depends on the position of the object.

Nature of image:

Both virtual and real images can be formed by a concave mirror.

Convex Mirror:

Definition:

"A spherical mirror whose outer curved surface is reflecting is called convex mirror".

Size of image:
In convex mirror the size of the image is always smaller than the object.
Nature of image:
Only virtual and erect image is formed by a convex mirror.

Q.2 Describe the following terms associated with spherical mirrors. ***(K.B)***
(MTN-G1)-2016, (FSD-G2)-2014 / (SGD-G2),(BWP-G1)-2016 / (DGK-G2)-2017, (BWP-G1)-2014 / (BWP-G1),(DGK-G

- **Pole**
- **Center of Curvature**
- **Radius of Curvature**
- **Principal Axis**

Ans: **TERMS ASSOSIATED WITH MIRRORS**

Pole (P):
Definition:
“It is the **midpoint** of the curved surface of spherical mirror. It is also called vertex**”**.

Centre of Curvature (C):
Definition:
“A spherical mirror is a part of a sphere. The centre of this sphere is called centre of curvature**”**. It is denoted by C.

Radius of Curvature (R):
Definition:
“It is the radius of the sphere of which spherical mirror is a part**”**. It is denoted by R.

Principal Axis:
Definition:
“It is the line joining **centre of curvature** and **pole** of the spherical mirror**”**.

Q.3 Define the principal focus. How is the principal focus of concave mirror different from the principal focus of convex mirror? ***(K.B + U.B)***

Ans: **PRINCIPAL FOCUS**

Definition:
“After reflection from concave / convex mirror rays of light parallel to the principal axis converge to a point F or appeared to come from a point F. This point is called the principal focus of the mirror**”**.

Principal Focus of 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 concave mirror. (As shown in Figure). Hence, Concave mirrors are also called **converging mirrors**. Since rays actually pass through this point, therefore, it is called **real focus**. It is denoted by F.

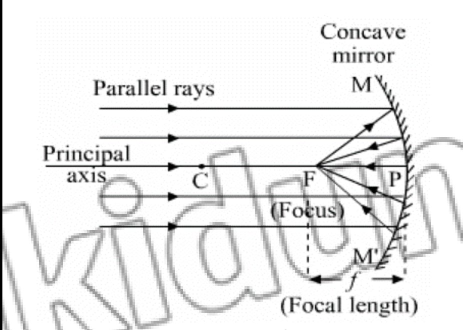


Figure: Principal Focus of Concave Mirror

Principal Focus of 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. In other words rays of light appear to diverge from **F**. This point is called the **principal focus** of the convex mirror. Convex mirrors are also called **diverging mirrors**. 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 (as shown in figure).

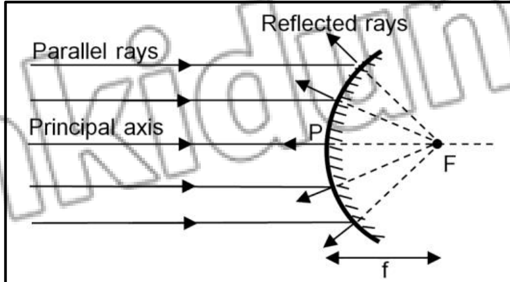


Figure: Principal Focus of Convex Mirror

12.2 SHORT QUESTIONS

Q.1 What are spherical mirrors? *(K.B)* **(FSD-G2)-2015 / (MTN-G2),(DGK-G2)-2016**

Ans: Given on page # 87

Q.2 What is the relation between focal length and radius of a spherical mirror? *(K.B + U.B)*

(FSD-G2)-2017

Ans: **RELATIONSHIP**

Focal Length:

Definition:

"It is the distance from the pole to the principal focus measured along the principal axis**"**.

Relation with Radius:

The focal length is related to the radius of curvature by $f = R/2$. This means that as the radius of curvature is reduced, so too is the **focal length** of the reflecting surface.
It is denoted by f.

Q.3 What are the characteristics of focus of a concave and a convex mirror? *(K.B)*

(RWP-G1)-2016 / (RWP-G2)(DGK-G1)-2017

Ans: **CHARACTERISTIFCS OF FOCUS**

In case of Concave Mirror:

Following are the characteristics of focus of concave mirror:

- The focus lies in front of the concave mirror.
- The focus is real as the rays of light after reflection converge at the focus.

In case of convex mirror:

Following are the characteristics of focus of convex mirror:

- The focus lies behind the mirror.
- The focus is virtual as the rays of light after reflection appears to come from the focus.

Q.4 Explain the reflection of light by spherical mirrors with the help of diagram.

***(K.B+A.B)* (LHR-G2)-2015**

Ans: **REFLECTION OF LIGHT BY SPHERICAL MIRORRS**

Like plane surfaces, spherical surfaces also reflect light following are the two laws of reflection as stated for plane surfaces.

Figure shows how light is reflected by the spherical surfaces of concave and convex mirrors according to the two laws of reflection.

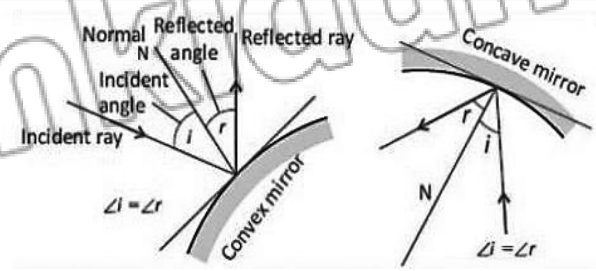


Figure: Reflection of Light by Spherical Mirrors

Q.5 Differentiate between concave and convex mirrrors. ***(K.B)***
(FSD-G1)(MTN-G2)(DGK-G2)-2014 / (LHR-G2)(SDG-G1)(SGD-G2)(AJK-G2) -2015 / (LHR-G1)-16

Ans: Given on page # 88

Q.6 Differentiate between the focus of a concave & convex mirror? ***(K.B)***
(FSD-G1)(MTN-G2)(DGK-G2)-2014 / (LHR-G2)(SGD-G1),(SGD-G2)(AJK-G2)-2015 / (LHR-G1)-2016

Ans: **DIFFERENTIATION**

The differences between the focus of a concave and a convex mirror are given as follows:

Focus of Convex Mirror	Focus of Concave Mirror
Position	
The focus lies behind the mirror.	The focus is in front of the mirror.
Nature	
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.

Q.7 Through which phenomenon of physics the image of a lion is formed inside the pond water? ***(U.B)*** **(Can you tell Pg. # 39)**

Ans: **IMAGE INSIDE THE POND WATER**

In the picture below, a clear image of lion formed inside the pond water due to the phenomenon of reflection of light.

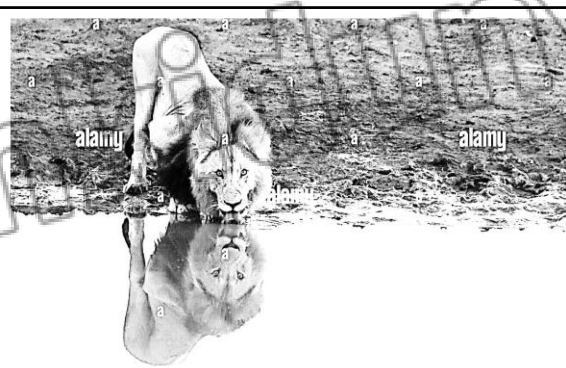


Figure: Image of Lion

Q.8 Which mirrors are used in headlights? (A.B) **(For your Information Pg. # 39)**

Ans: **PARABOLIC MIRRORS**

Parabolic mirrors are used in headlights.

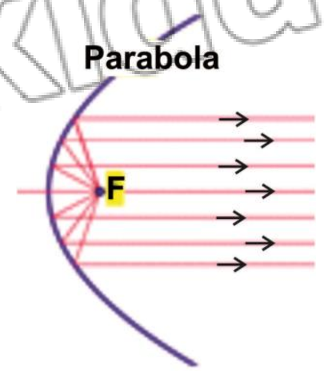


Figure: Parabolic Mirrors

Q.9 Write down the nature of image of a pencil holded in front of well-polished spoon (using the outside of the spoon with the convex surface bulging outward). Also tell whether the image will move closer or father from the focus? *(U.B)* (Activity 12.1 Text Book Pg. # 40)

Ans: **WELL POLISHED SPOON**

Take a well-polished spoon (using outside of the spoon, with the convex surface bulging outward), and hold it in one hand, hold the pencil with its tip in the upright position in the other hand.

IMAGE NATURE

When we look at its image in the well-polished spoon, it seems to be erect, virtual and smaller and the image moves farther from the focus.

12.2 MULTIPLE CHOICE QUESTIONS

1. **In convex mirror focus is: *(K.B)*** **(RWP-G2)-14**
   (A) Centre of mirror (B) In front of mirror
   (C) On the mirror (D) Behind the mirror
2. **The formula for focal length is: *(U.B + A.B)*** **(LHR-G2),(RWP-G1)-2015 / (SWL-G2)-2017**
   (A) $f = \frac{R}{2}$ (B) $f = \frac{R}{4}$
   (C) $f = \frac{R}{3}$ (D) $f = \frac{R}{5}$
3. **In concave mirror which surface is reflecting? *(K.B)***
   (A) Outer surface (B) Outer curved
   (C) Inner curved surface (D) Side of the mirror
4. **Which statement is incorrect about concave mirror? *(K.B)***
   (A) Size of image depends upon position of the object
   (B) Both virtual and real images can form
   (C) Inner surface of spherical mirror is reflecting
   (D) Only virtual images are formed
5. **A spherical mirror whose outer curved surface is reflecting is called: *(K.B)***
   (A) Concave mirror (B) Convex mirror
   (C) Concave lens (D) Convex lens
6. **Which statement is correct about convex mirror? *(K.B)***

(A) Size of image is smaller than object (B) Only virtual & erect image is formed
(C) Outer curved surface is reflecting (D) All of the given statements are true

7. Vertex is the midpoint of the curved surface of spherical mirror and is also called: *(K.B)*
(A) Radius of curvature (B) Principal axis
(C) Pole (D) Principal focus

8. A line joining centre of curvature and pole of the spherical mirror is: *(K.B)*
(A) Principal axis (B) Principal focus
(C) Centre of curvature (D) Pole

9. The distance from the pole to the principal focus measured along the principal axis is: *(K.B)*
(A) Principal focus (B) Radius of curvature
(C) Focal length (D) Diameter

12.3 IMAGE LOCATION BY SPHERICAL MIRROR FORMULA

LONG QUESTIONS

Q.1 What is spherical mirror formula? *(K.B + U.B + A.B)*
OR How can we tell about the nature of image and the size of the image compared with the size of the object formed by the mirror with the help of mirror formula?

Ans: **SPHERICAL MIRRORS**

Definition:
"Mirror formula is the relationship between **object distance** p, **image distance** q from the mirror and **focal length** f of the mirror".

Explanation:
We use the spherical mirror formula to tell about the nature of image (whether image is real or imaginary) inverted or erect formed by a mirror. It also tells the size of the image in comparison with the size of the object.

Mirror Formula:
Thus, we can write mirror formula as:

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

- By using mirror formula, we can tell about the nature of image (whether image is real or imaginary or erect) and also about be the size of image compressed with the size of the object, formed by a mirror.

Validity:
Spherical mirror formula is true/valid for both concave and convex mirrors.

12.3 SHORT QUESTIONS

Q.1 What is meant by mirror formula? *(A.B)* **(RWP-G2)-2016**

Ans: **MIRROR FORMULA**

Definition:
"Relationship between object distance p, image distance q, from the mirror and focal length of the mirror is called mirror formula".

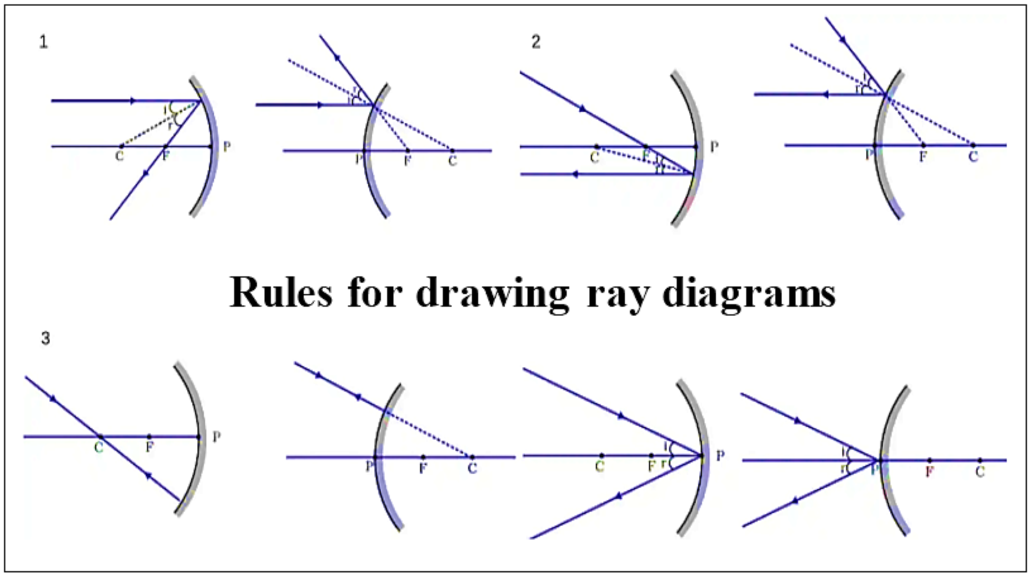
Formula:

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

Q.2 Rules of light for image formation through mirror? ***(K.B+A.B)***

Ans: **Concave/Convex Mirror Image Formation Rules**

1. **Parallel Rays**: Light rays parallel to the principal axis are reflected through the focus of the mirror.
2. **Focus Rays:** Light rays through the focus of the mirror are reflected parallel to the principal axis.
3. **Chief Rays:** Light rays through the center of curvature of the mirror are reflected back along the same path.
4. **Vertex Rays:** Light rays that strike the mirror at its vertex leave at the same angle that it entered.



Q.3 Write down the sign conventions for concave and convex mirror. ***(U.B+A.B)***

Ans: **SIGN CONVENTIONS FOR SPHERICAL MIRRORS**

The sign conventions of concave and convex mirrors are as follows:

Quantity	When Positive (+)	When Negative (–)
Object distance (p)	Real object	Virtual object
Image distance (q)	Real image	Virtual image
Focal length (f)	Concave mirror	Convex mirror

Q.4 Spoon acts as which types of mirrors? ***(U.B)*** **(Spoon as mirror Pg. # 40)**

Ans: **SPOON AS A SPHERICAL MIRROR**

A well-polished spoon acts as convex (right) and concave (left) mirror.

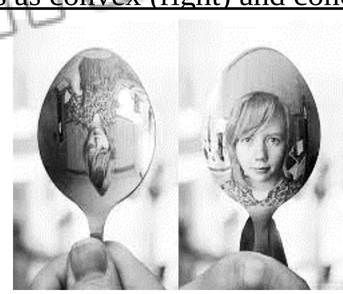


Figure: **Spoon as a Spherical Mirror**

Q.5 Where does focus and centre of curvature lies for convex mirror? *(K.B)*
(Physics insight Pg. # 40)

Ans: **POSITION OF FOCUS AND CENTRE OF CURVATURE**

For a convex mirror focus and center of curvature lies behind the mirror.

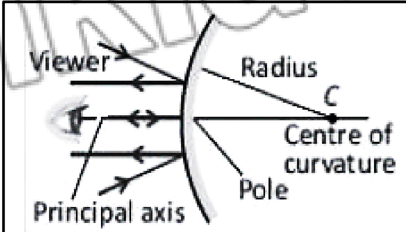


Figure: **Spoon as a Spherical Mirror**

Q.6 Why convex mirrors are used in shopping mall? *(A.B)* **(Point to ponder Pg. # 40)**

Ans: **CONVEX MIRROR IN SHOPPING MALL**

In large shopping malls convex mirrors are used for security purpose.

Figure: **Convex Mirror in Shopping Mall**

Q.7 Why the focal length of a convex mirror is taken as negative? *(U.B)* **(LHR-G2)-2015**
(For Your Information Pg. # 41)

Ans: **FOCAL LENGTH OF CONVEX MIRROR**

The focal length of spherical mirror is one half of the radius of curvature i.e. $\mathbf{f = \frac{R}{2}}$.
However, we take the focal length of a convex mirror as negative. It is because the rays appear to come from focal point behind the mirror. Therefore, for a convex mirror, $\mathbf{f = -\frac{R}{2}}$

Q.8 Why the term magnification is different from the term enlargement in optics? *(K.B)*
(Physics insight Pg. # 41)

Ans: **MAGNIFICATION VS ENLARGEMENT**

The word magnification as used in optic does not only mean always enlargement because the image could be smaller than the object.

Q.9 Draw the ray diagram for the virtual image in a plane mirror? *(K.B+U.B)*
(For Your Information Pg. # 41)

Ans: **RAY DIAGRAM**

For the virtual image formation in a plane mirror, the ray diagram is given below:

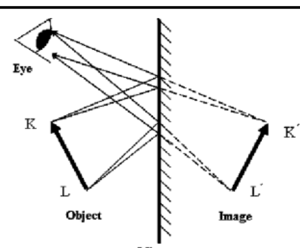


Figure: **Virtual Image in a Plane Mirror**

Q.10 How does convex mirror increase the view of observer? *(K.B+U.B)*

(Do you know Pg. # 41)

Ans: **INCREASE IN VIEW**

Convex mirrors produces images that are smaller than objects. This increase the view for the observer.

Figure: Convex Mirror

Q.11 Why does the position of fish inside the water seem to be at less depth than that of its actual position? *(K.B+U.B)* **(Point to Ponder Pg. # 41)**

Ans: **POSITION OF FISH IN WATER**

The position of fish inside the water seems to be at less depth than that of its actual position due to refraction of light. Because of refraction, water (or glass) looks less deep than it really is. Its apparent depth is less than its real depth. This diagram shows why.

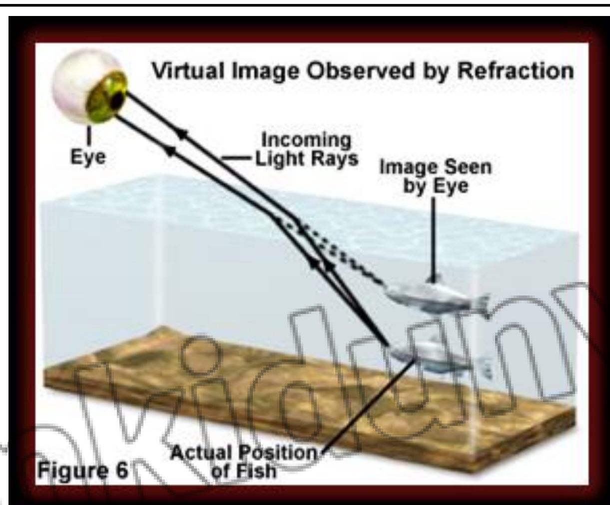


Figure: Position of Fish in Water

Q.12 Can you measure the distance of the screen from the mirror or a well-polished spoon (using inside of the spoon with concave surface bulging inward), using a metre scale? Can you find out the rough focal length of the focal length of the concave mirror? Also draw the ray diagram to show the image formation in this situation. *(K.B+U.B)*

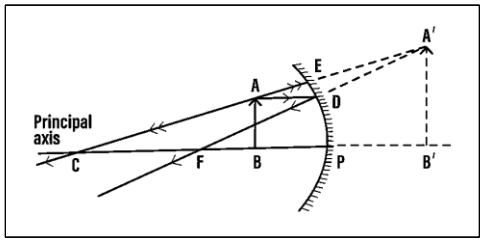
(Activity 12.2 Pg. # 41)

Ans: **CONCAVE MIRROR OR WELL POLISHED SPOON**

Take a concave mirror or a well-polished spoon (using inside of the spoon with concave surface bulging inward). Hold it in hand towards a distant object, such as the sun, a building, a tree or a pole. Try to get a sharp, well focused image of the distant object on the wall or a screen. Measure the distance of the screen from the mirror using a meter scale. By applying the spherical mirror formula and by putting the values of distance of object and distance of image from the mirror, we can find out the focal length of the concave mirror.

Q.13 How virtual image can be formed by concave mirror?

Ans: If object is placed between focus and pole of concave mirror than image formed by this mirror will be virtual erect and enlarge. This mirror used for shaving and makeup purpose.



12.3 MULTIPLE CHOICE QUESTIONS

1. **The relationship between object distance p, image distance q from the mirror and focal length of the mirror is called: (K.B)**
   (A) Mirror focal length (B) Distance from mirror
   (C) Mirror formula (D) Lens formula
2. **Mirror formula is: (K.B)**
   (A) $\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$ (B) $\frac{1}{f}=\frac{1}{p}-\frac{1}{q}$
   (C) $\frac{1}{f}=\frac{1}{p}-\frac{q}{p}$ (D) $\frac{1}{f}=\frac{1}{q}+\frac{p}{q}$
3. **Focal length of spherical mirror is: (K.B)** **(LHR 2016)**
   (A) $\frac{R}{4}$ (B) $\frac{R}{2}$
   (C) $\frac{R}{3}$ (D) $\frac{R}{9}$
4. **Convex mirror produce images: (K.B)**
   (A) Larger than object (B) Smaller than object
   (C) Equal to object (D) Very large in size

EXAMPLE 12.1

A convex mirror is used to reflect light from an object placed 66 cm in front of the mirror. The focal length of the mirror is 46 cm. Find the location of the image.(U.B + A.B)

Solution:

Given Data:

Distance of object from mirror = p = 66 cm

Focal length of convex mirror = f = – 46 cm

Formula:

Or $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

$$\frac{1}{q}=-\frac{1}{46\text{cm}}-\frac{1}{66\text{cm}}$$

$$=\frac{-66\text{cm}-46\text{cm}}{3036\text{cm}^2}=\frac{-112\text{cm}}{3036\text{cm}^2}$$

$$\frac{1}{q}=-\frac{1}{27\text{cm}}\Rightarrow q=-27cm$$

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

Calculation:

By using formula, we have

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

Result:

Hence, the location of image is 27 cm from the convex mirror. Here, negative sign indicates that the image is behind the mirror and, therefore, is a virtual image.

EXAMPLE 12.2

An object is placed 6 cm in front of a concave mirror that has focal length 10 cm. Determine the location of the image.

Solution:

Given Data:

Object distance from mirror = p = 6 cm

Focal length of concave mirror = f =10 cm

To Find:

Location of the image = q = ?

Formula:

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

Calculations:

Using the mirror formula, we have

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

OR $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

OR $$\frac{1}{q}=\frac{1}{10\text{cm}}-\frac{1}{6\text{cm}}$$

$$=\frac{3-5}{30}$$

$$=\frac{-2}{30}$$

$$\frac{1}{q}=-\frac{1}{15\text{cm}}\Rightarrow q=-15\text{cm}$$

Hence, the image is located at 15cm from the concave mirror. Here, negative sign indicates that the image is virtual i.e., behind the mirror.

Result:

12.4 REFRACTION OF LIGHT

LONG QUESTIONS

Q.1 Define refraction of light. ***(K.B+U.B+A.B)*** **(SGD-G1)(DGK-G2)-2016**

Ans: **REFRACTION OF LIGHT**

Definition:

“The process of bending of light as it passes from one transparent medium into another is called refraction**”**.

Explanation:

Refraction of light can be explained with the help of figure. A ray of light IO traveling from air falls on the surface of a glass block. At the air-glass interface, the ray of light IO changes direction and bends towards the normal and travels along the path OR inside the glass block. The rays IO and OR are called the incident ray and the refracted ray respectively. The angle '*i*' made by the incident ray with the normal is called angle of incidence. The angle '*r*' made by the refracted ray with the normal is called angle of refraction. When refracted ray leaves the glass, it bends away from the normal and travels along a path ME.

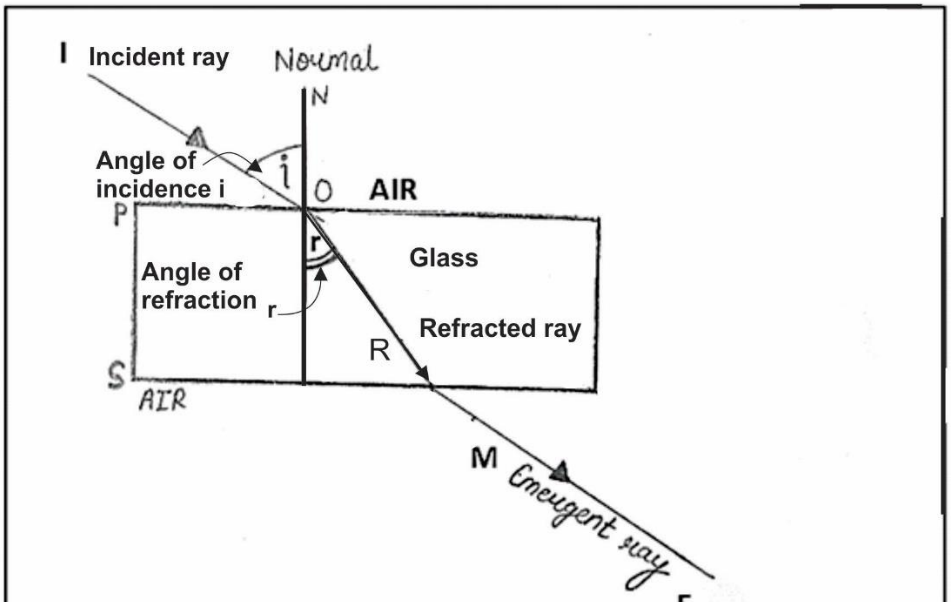


Figure: Refraction of Light

Q.2 What are the laws of refraction? Also describe Snell's law and cause of refraction of light. *(K.B + U.B + A.B)* **(RWP-G1)-2016**

Ans: **LAWS OF REFRACTION**

The laws of refraction are:

- The incident ray, the refracted ray, and the normal at the point of incidence all lie in the same plane.
- 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 i.e., $\sin i / \sin r = \text{constant} = n$

Snell's Law:

Statement:

The ratio sin i / sin r is known as the refractive index of the second medium with respect to the first medium. So we have

$$\frac{\sin\angle\hat{i}}{\sin\angle\hat{r}} = n$$

Cause of Refraction of Light:

Refraction of light is caused by the difference in speed of light in different media. For example, the speed of light in air is approximately $\mathbf{3.0 \times 10^{8}\ ms^{-1}}$. However, when light travels through a medium, such as water or glass, its speed decreases. The speed of light in water is approximately $\mathbf{2.3 \times 10^{8} ms^{-1}}$, while in glass, it is approximately $\mathbf{2.0 \times 10^{8} ms^{-1}}$. To describe the change in the speed of light in a medium, we use the term **index of refraction or refractive index.**

Refractive Index:

With respect to the speed of light in different media, refractive index can also be defined as:

Definition:

"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**"**.

Formula:

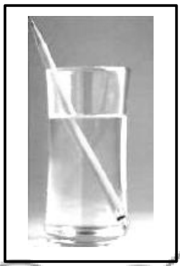
$$\text{Refractive Index} = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$$

Or $$\mathbf{n = \frac{c}{v}}$$

12.4 SHORT QUESTIONS

Q.1 Describe the passage of light through parallel sided transparent material. ***(K.B)***

Ans: **REFRACTION OF LIGHT**



If we dip one end of a pencil or some other object into water at an angle to the surface, the submerged part looks bent as shown in figure. Its image is displaced because the light coming from the underwater portion of the object changes direction as it leaves the water.

Q.2 What is meant by refraction of light? ***(K.B)***

(BWP-G2)-2014 / (LHR-G1)(FSD-G2)-2015 / (RWP-G2)-2017

Ans: Given on Page # 97

Q.3 State law of refraction? ***(K.B)***

(SWL-G1)-2014 / (RWP-G1)-2015 / (GRW-G2)-2016 / (FSD-G1)(LHR-G1)(SGD-G2)-2017

Ans: Given on Page # 98

Q.4 State Snell's law? ***(K.B + A.B)***

(BWP-G2)(DGK-G2)(LHR-G2)-2014 / (SGD-G1)-2015 / (BWP-G2)(BWP-G1)-2017

Ans: Given on Page # 98

Q.5 Define refractive index. ***(K.B)*** **(LHR-G1)-2014 / (BWP-G2)-2015 / (SGD-G2)(BWP-G2)(AJK- G1)-201**

Ans: Given on Page # 99

Q.6 Why do we see the bending of pencil in water? *(K.B + A.B)*

Ans: **BENDING OF PENCIL IN WATER**

As, the refractive index or index of refraction describe the change in the speed of light in a medium so that, the medium through which, the speed of light is less than the speed of light in air will have high refractive index and hence will have more bending due to the phenomenon of refraction.

Q.7 Which quantities change during refraction of light? *(K.B)* **(Physics insight Pg. # 42)**

Ans: **CHANGES DURING REFRACTION**

In refraction, the speed of light changes due to change in the wavelength. But frequency and hence the colour of light does not changes.

Q.8 Write the refractive index of the following substances. *(K.B)* **(For your info. Pg. # 43 Table)**

Ans: **REFRACTIVE INDEX OF SUBSTANCES (Table for MCQs)**

The refractive index of following substances are:

Substance	Index of Refraction (n)	Substance	Index of Refraction (n)
Diamond	2.42	Ethyl Alcohol	1.36
Cubic Zirconia	2.21	Ice	1.31
Glass (flint)	1.66	Water	1.33
Glass (crown)	1.52	Air	1.00

Q.9 How dispersion of light occurs? *(K.B + U.B)* **(Do you know Pg. # 43)**

Ans: **DISPERSION OF LIGHT**

Dispersion of light is due to the variation in the refractive index with the color. Dispersion in drops of water separates the colors of sunlight into rainbow. And this dispersion of light can also be experienced by prism.

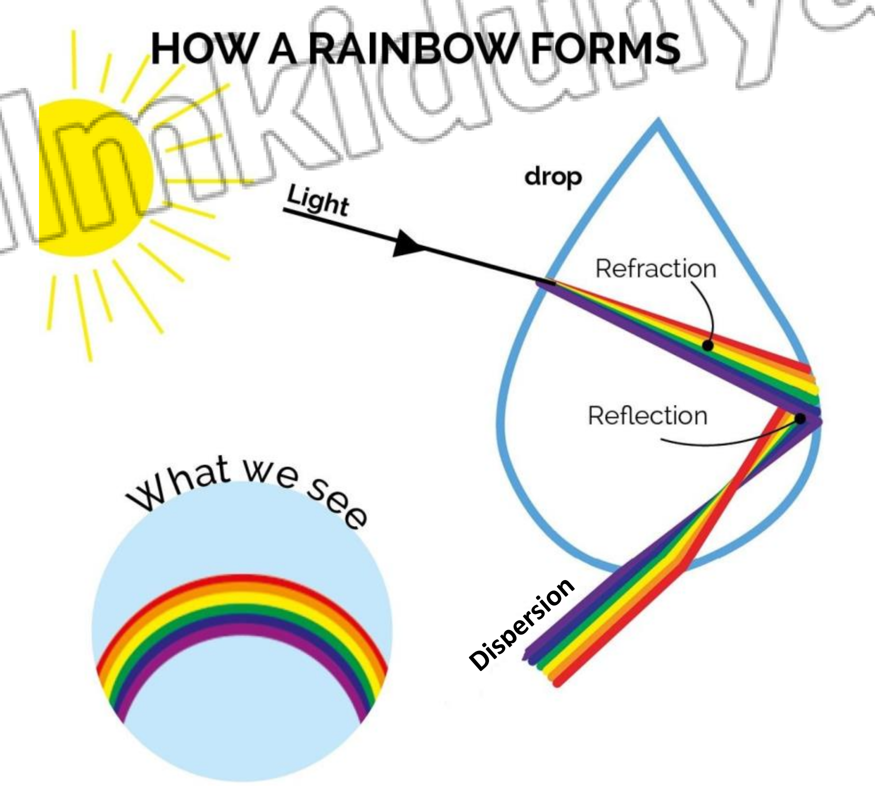


Figure: Dispersion of Light

Q.10 Whether the bending of light be more or less for a medium with high refractive index. ***(K.B)***

(Self Assessment Pg. # 43)

Ans: **BENDING WITH HIGH REFRACTIVE INDEX**

The bending of light will be more for a medium with high refractive index.

Q.11 Why light express the phenomena of refraction? ***(A.B+C.B)***

Or

Why light bend tours normal when it moves from rare medium to denser medium?

Ans: Light is made up of tiny waves. This travel more slowly in glass (or water) than in air. When a light pass from air into glass, one side of the beam is slowed before the other. This makes the beam 'bend'.

12.4 MULTIPLE CHOICE QUESTIONS

1. The bending of light as it passes from one transparent medium into another is: ***(K.B)***

(A) Reflection (B) Refraction

(C) Reverberation (D) Incidence

2. According to law of refraction: ***(U.B)***

(A) $\frac{\sin i}{\sin r} > i$ (B) $\frac{\sin r}{\sin i} > r$

(C) $\frac{\sin i}{\sin r} = constant$ (D) $\frac{\sin r}{\sin i} > n$

3. $\frac{\sin i}{\sin r} = n = \frac{n_2}{n_1}$ **is called:** ***(U.B)*** **(GRW 2013)**

(A) Boyl's law (B) Charless's law

(C) Snell's law (D) Newton's law

4. **Speed of light in air is approximately:** ***(K.B)***

(A) 3.0×10^8 ms^{-1} (B) 4×10^9 ms^{-1}

(C) 4×10^{14} ms^{-1} (D) 3×10^7 ms^{-1}

5. **The speed of light is greater in:** ***(K.B)***

(A) Air (B) Water

(C) Solid (D) Glass

6. **The speed of light in water is approximately:** ***(K.B)***

(A) 2.0×10^8 ms^{-1} (B) 2.3×10^8 ms^{-1}

(C) 3×10^8 ms^{-1} (D) 3×10^7 ms^{-1}

7. **? =** $\frac{\textbf{speed of light in vacuum}}{\textbf{speed of light in medium}}$ ***(K.B)***

(A) Reflective index (B) Snell's law

(C) Refractive index (D) Critical angle

EXAMPLE 12.3

A ray of light enters from air into glass. The angle of incidence is 30°. If the refractive index of glass is 1.52, then find the angle of refraction '*r*'. *(U.B + A.B)*

Solution:

Give Data:

Angle of incidence $= i = 30°$

Refractive index of glass = n = 1.52

Required:

Angle of refraction = r = ?

Formula:

$n = \frac{\sin i}{\sin r}$

Calculations:

Using Snell's law, we have

$1.52 \times \sin r = \sin 30°$

Or $\sin r = \sin 30° / 1.52$

$\sin r = 0.33$

$r = \sin^{-1}(0.33)$

$r = 19.3°$

Result:

Hence angle of refraction is 19.3°.

12.5 TOTAL INTERNAL REFLECTION

LONG QUESTIONS

12.5 Q.1 What is meant by total internal reflection? Write its conditions. Explain it with the help of ray diagram. ***(K.B+U.B+A.B)*** **(SGD-G2)(RWP-G2)-2015 / (DGK-G1)-2016**

Ans: **TOTAL INTERNAL REFLECTION**

Definition:

"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**"**.

OR

"When the value of **angle of incidence** becomes **greater** than the **critical angle**, then the ray does not enter into second medium, but reflects back into same medium such reflection of light is called total internal reflection**"**.

Conditions for Total Internal Reflection:

- The ray of light should travel from denser medium to rare medium.
- The angle of incidence should be greater than the critical angle.

Explanation:

When a ray of light travelling in denser medium enters into a rarer medium, it bends away from the normal. If the angle of incidence '***i***' increases, the angle of refraction '***r***' also increases. For a particular value of the angle of incidence, the angle of refraction becomes 90°.

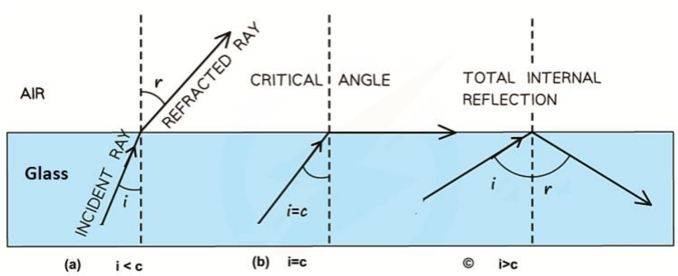


Figure: **Condition for Total Internal Reflection**

Critical Angle:

Definition:

"The angle of incidence that causes the refracted ray in the rarer medium to bend through **90°** is called critical angle**"**.

OR

"The angle of incidence for which the corresponding angle of reflection becomes 90°, that angle of incidence is called as critical angle**"**.

12.5 SHORT QUESTIONS

Q.1 Define Critical angle. ***(K.B+U.B)***
(BWP-G1)(SWL-G2)(SGD-G1)-2014 / (DGK-G1)(SWL-G1 / G2)-2015 / (GRW-G2)(FSD-G2)(LHR-G2)(RWP-G1)(MTN-G1)-2017

Ans: **CRITICAL ANGLE**

Definition:

"The angle of incidence that causes the refracted ray in the rarer medium to bend through 90° is called critical angle**"**.

Formula Derivation:

$$n = \frac{\sin r}{\sin i}$$

Here, $r = 90°$ $\therefore i = c$

$$n = \frac{\sin 90^\circ}{\sin c}$$

$$n = \frac{1}{\sin c}$$

$$\sin c = \frac{1}{n} \Rightarrow c = \sin^{-1}\left[\frac{1}{n}\right]$$

Q.2 Define total internal reflection. ***(K.B)***
(GRW-G2)(SWL-G2)(DGK-G2)-2014 / (LHR-G2)(SGD-G1)(DGK-G2)-2015 / (RWP-G1)(FSD-G1)-2016

Ans: *Given on Page # 102*

Q.3 Write conditions of total internal reflection. ***(K.B+U.B)*** **(DGK-G2)-2014 / (FSD-G1)-2016**

Ans: **TOTAL INTERNAL REFLECTION**

There are two conditions of total internal reflection.

- Angle of incidence is greater than the critical angle i.e. **i > c.**
- Ray of light enters form denser to rare medium.

12.5 MULTIPLE CHOICE QUESTIONS

1. When a ray of light enters from a denser medium to a rarer medium: ***(K.B)***
(A) It bends toward the normal (B) It bends away from the normal
(C) It bends towards inside (D) None of these

2. The angle of incidence that causes the refracted ray in the rarer medium to bend through 90º is called: ***(K.B)***
(A) Critical angle (B) Angle of incidence
(C) Angle of reflection (D) Angle of refraction

3. No refraction occurs when the angle of incidence is: ***(K.B + U.B)***
(A) Smaller than the critical angle (B) Larger than the critical angle
(C) Equal to the critical angle (D) Very small than the critical angle

4. The critical angle of water is: ***(K.B)*** **(BWP-G1 / G2)-2014 / (BWP-G1)-2015**
(A) 48.8° (B) 488°
(C) 90° (D) 95°

5. Conditions for total internal reflection are: ***(K.B)*** **(BWP-G2)-2014**
(A) 2 (B) 3
(C) 4 (D) 5

6. If a ray of light in glass is incident on an air, surface at an angle greater than the critical angle, the ray will be: ***(K.B)*** **(RWP-G1)-2017**
(A) Refract only (B) Reflect only
(C) Partially refract and reflect (D) Diffract only

7. Critical angle is equal to: ***(U.B + A.B)***
(A) $c = \sin\frac{1}{n}$ (B) $c = \sin^{-1}\frac{1}{n}$
(C) $c = \frac{\sin i}{\sin r}$ (D) None

8. Which is the refractive index of diamond? ***(K.B)***
(A) 1000 (B) 1.003
(C) 1.33 (D) 2.42

9. Which r represents Snell's law? ***(A.B + U.B)***
(A) $n = \frac{\sin i}{\sin r}$ (B) $niSinr = n_2$

(C) $n = \frac{1}{q}$ (D) $n = v \times \lambda$

10. Speed of light in glass is: *(K.B)*

(A) $3\times10^{8}ms^{-1}$ (B) $2\times10^{8}ms^{-1}$

(C) $3\times10^{8}ms^{-1}$ (D) $4\times10^{8}ms^{-1}$

11. The angle of incidence in the denser medium for which the corresponding angle of refraction is 90° in the rare medium is called: *(K.B)*

(A) Angle of deviation (B) Critical angle

(C) Angle of reflection (D) Angle of refraction

EXAMPLE 12.4

Find the value of critical angle for water (refracted angle=90°). The refractive Index of water is 1.33 and that of air is 1. *(U.B + A.B)*

Solution:

Given Data:

Angle of refraction = r = 90°

Refractive index of water = n = 1.33

Required:

Critical angle of water = C = ?

Formula:

Critical angle = C $= \sin^{-1}\left(\frac{1}{n}\right)$

Calculations:

As, the angle of incidence for which the corresponding angle of refraction become 90° is called as critical angle. So, by using Snell's law, when light enters in air from water, we have.

$\frac{\sin r}{\sin i} = n$

Or $n\sin i = \sin$

$n\sin i = \sin 90°$

$n\sin i = 1$

But $n = 1.33$

Therefore,

$\sin i = 1/1.33$

Or $i = \sin^{-1}[1/1.33]$

Critical angle C=48.8°

Result:

Hence the critical angle of water is 48.8°.

12.6 APPLICATIONS OF TOTAL INTERNAL REFLECTION

LONG QUESTIONS

12.6 Q.1 What are totally reflecting prisms? Also write its uses. *(K.B + A.B +U.B)*

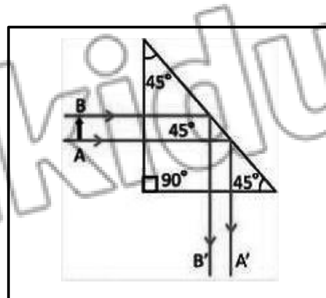
Ans: **TOTALLY INTERNAL REFLECTING PRISM**

Definition:

"Such prisms which reflect a beam of light through 90° or 180° by total internal reflection are called totally internal reflecting prisms".

Working:

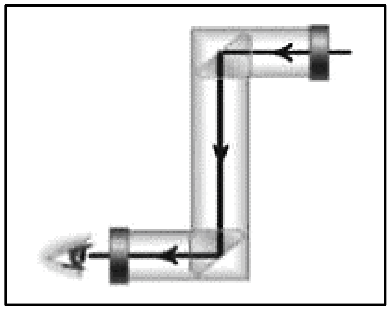
One of the angles of a right-angled prism is 90°. When a ray of light strikes a face of prism perpendicularly, it enters the prism without deviation and strikes the hypotenuse at an angle of 45° (As shown in Fig.).



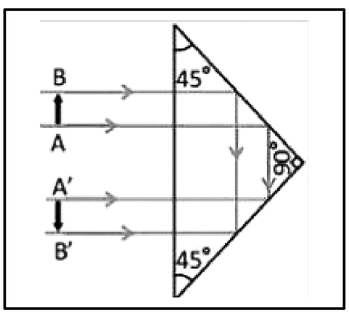
Since the angle of incidence 45° is greater than critical angle of the glass which is 42°, the light is totally reflected by the prism through an angle of 90°.

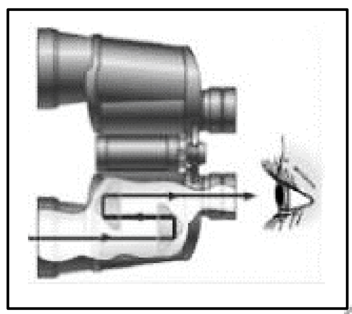
Uses:

- Two such prisms are used in periscope (As shown in Fig.).



- When the light is totally reflected by the prism by an angle of 180°.Two such prisms are used in binoculars.





12.6 Q.2 What do you know about optical fibre? Also describe how light totally reflected through an optical fibre. ***(K.B + A.B +U.B)*** **(FSD-G2)-2015 / (SGD-G2)(LHR-G1)-2016**

Ans: **OPTICAL FIBRE**

Introduction:

Total internal reflection is used in fiber optics which has number of advantages in telecommunication field.

Definition:

"Optical fibre or fibre optic is a hair size thread made up of glass or plastic through which light can travel by total internal reflection**"**.

PARTS OF OPTICAL FIBRE

Following are the parts of optical fibre:

- Core

- Cladding

Core:
The inner part of the fiber optics is called core that carries the light.
Cladding:
An outer concentric shell is called cladding.
Core:
The core is made of glass or plastic of relatively **high index of refraction**.
Cladding:
The core is made of glass or plastic, but of relatively low refractive index of refraction.

Phenomenon:
Light entering from one end of the core strikes the core-cladding boundary at an angle of Incidence greater than critical angle and is reflected back into the core. In this way, light travels many kilometers with small loss of energy. In this way light travels many kilometers with small loss of energy (as shown in figure).

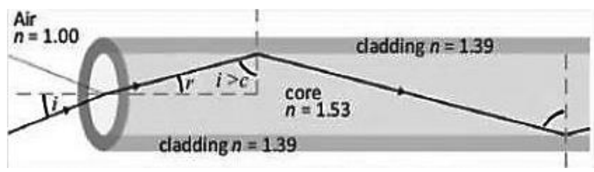


Figure: Passage of Light through Optical Fibre

Uses:
- In Pakistan, optical fiber is being used in telephone and advanced telecommunication systems.
- We can listen thousands of phone calls without any disturbance.

Q.1 What do you know about endoscope and endoscopy? Describe the types of an endoscope. *(K.B + A.B +U.B)*

Ans: **ENDOSCOPE**

Definition:
"An endoscope is a medical instrument used for exploratory diagnostics, and surgical purposes".
Use:
An endoscope is used to explore the interior organs of the body. Due to its small size, it can be inserted through the mouth and thus eliminates the invasive surgery.

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

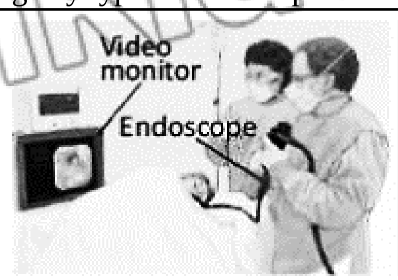


Figure: The Doctors are Examining are Examining a Patient with Endoscope

Construction:

An endoscope uses two fiber-optic tubes through a pipe.

Types:

Its types are as follows:

- Gastroscope
- Cystoscope
- Bronchoscope

Gastroscope:

The gastroscope is used to examine the stomach, bladder and throat.

Cystoscope:

The cystoscope is used to examine bladder.

Bronchoscope:

The bronchoscope is used to view the throat.

Phenomenon:

The light shines on the organ of patient to be examined by entering through one of the fiber tubes of the endoscope. Then light is transmitted back to the physician's viewing lens through the other fiber tube by total internal reflection.

Flexible endoscopes:

Flexible endoscopes have a tiny camera attached to the end. Doctor can see the view recorded by the camera on a computer screen.

12.6 SHORT QUESTIONS

Q.1 What is a light pipe? Write down its (medical) use? *(K.B + A.B)*

Ans: **LIGHT PIPE**

Definition:

"Light pipe is a bundle of thousands of optical fibers bounded together".

Uses:

- They are used to illuminate the inaccessible places by the doctors or engineers.
- Doctors view inside the human body. They can also be used to transmit images from one place to another.

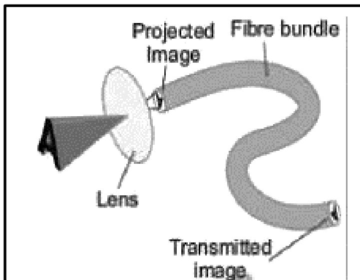


Figure: Light Pipe

Q.2 Define optical fibre. *(K.B)* **(FSD-G1)-2015 / (GRW-G2)(BWP-G1)-2016 / (GRW-G2)(SWL-G2)-2017**

Ans: **OPTICAL FIBRE**

It is a hair size thread made up of glass or plastic through which light can be travelled.

- The inner part of fibre optic is called core that carries light.
- The outer part is concentric shell caused cladding.

Q.3 Differentiate between core and cladding of a optical fibre. *(K.B)* **(MTN-G1)-2017**

Ans: **DIFFERENTIATE**

The differences between core and cladding of a optical fibre are as follows:

The differences between the frequency and pitch are as follows:

Core	Cladding
• The inner part of the fibre optics is called	• An outer concentric shell is called

core that carries the light. • The core is made from glass or plastic of relatively high index of refraction.	cladding. • The cladding is made of glass or plastic, but of relatively low refractive index.

Q.4 How light travels with the use of total internal reflection in optical fibre. *(K.B)*
(RWP-G1)-2014 / (SWL-G2)-2017

Ans: **REFLECTION THROUGH OPTICAL FIBRE**

In optical fibre light entering from one end of the core strikes the core-cladding boundary at an angle of incidence greater than critical angle and is reflected back into the core. In this way light travels many kilometres with small loss of energy.

Q.5 What is meant by endoscopy? *(K.B)* **(BWP-G1)-2016 / (SWL-G2)-2017**

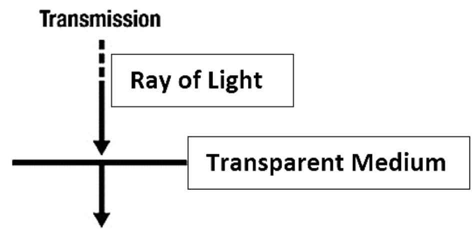
Ans: *Given on Page # 107*

Q.6 Define Cystoscope and Gastroscope. *(K.B)* **(RWP-G1)-2014 / (SWL-G2)-2017**

Ans: *Given on Page # 107*

Q.7 What is transmission of light? *(C.B+A.B)*

Ans: The Phenomenon of light in which when light from one medium falls perpendicularly on the surfaces of another transparent medium it does not change its path.



12.6 MULTIPLE CHOICE QUESTIONS

1. **To see from submarine and the ship at the surface of water, we use: *(A.B)***
(A) Telescope (B) Microscope
(C) Periscope (D) Prism

2. **In totally reflecting prism one angle is of: *(K.B)***
(A) 45° (B) 90°
(C) 180° (D) 120°.

3. **In totally reflecting prism one angle is of 90°, and other two angles are of: *(K.B)***
(A) 30°,30° (B) 45°,90°
(C) 45°,45° (D) 40°,40°

4. **Totally reflecting prism is used in: *(A.B)***
(A) Periscope (B) Binoculars
(C) Periscope and binocular (D) Telescope

5. **Totally reflecting prism turns the incident ray at an angle of: *(K.B + U.B)***
(A) 90° (B) 60°
(C) 75° (D) 45°

6. **The refractive index of internal coating of optical fibre is: *(K.B)***
(A) 1.56 (B) 1.51
(C) 1.53 (D) 1.58

7. **Optical fibres are: *(K.B)***
(A) Cheap (B) Flexible
(C) Lighter (D) All of these

8. **Optical fibre works on the principal of: *(K.B + U.B)***

(A) Reflection (B) Refraction
(C) Total internal reflection (D) Diffraction

9. Which pipe is a bundle of thousands of optical fibres bounded together? *(K.B)*
(A) Light pipe (B) Telescope
(C) Microscope (D) Projector

10. It is used to explore the interior organs of the body? *(K.B + A.B)* **(GRW 2013)**
(A) Telescope (B) Endoscope
(C) Microscope (D) Projector

11. Endoscope used to diagnose the stomach is; *(K.B + A.B)*
(A) Cystoscope (B) Gastroscope
(C) Bronchoscope (D) Pancreoscope

12. Endoscope which is used to diagnose throat is; *(K.B + A.B)*
(A) Gastroscope (B) Cystoscope
(C) Bronschoscope (D) None of these

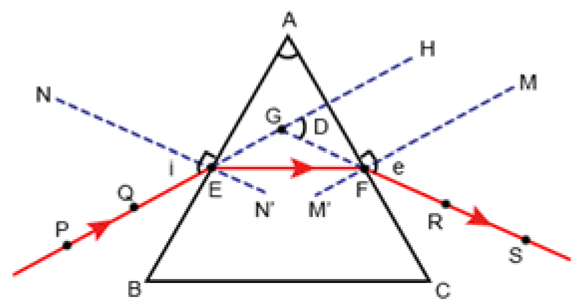
12.7 REFRACTION THROUGH PRISM

Q.1 What are totally reflecting prisms? Also write its uses. *(K.B+A.B+U.B)*

Ans: **TOTALLY INTERNAL REFLECTING PRISM**

Definition:

"Prism is a transparent object (made of optical glass) with at least two smooth plane faces Inclined towards each other from which light is refracted**"**.



Explanation:

In case of triangular prism (as shown in figure), the emergent ray is not parallel to the incident ray. It is deviated by the prism from its original path. The **incident ray PE** makes an angle of incidence **'*i*'** at point **E** and is refracted towards the normal **N** as **EF**. The refracted ray **EF** makes an angle **'*r*'** with the normal inside the prism and travels to the other face of the prism. This ray emerges out from prism at point ***F*** making an angle **'*e*'.** Hence the emerging ray **FS** is not parallel to the incident ray PE but is deviated by an angle ***D*** which is called angle of deviation.

Angle of Deviation:

"Light rays after refraction through a glass prism deviate through an angle. This angle is called angle of deviation**"**. This is denoted by D.

12.7 SHORT QUESTIONS

Q.1 What is prism? *(K.B)* **(LHR-G2)-2015 / (GRW-G2)-2017**
Ans: *Given on Page # 109*

Q.2 Angle of deviation. *(K.B)*
Ans: *Given on Page # 109*

12.7 MULTIPLE CHOICE QUESTIONS

1. Angle opposite to the base of triangle of prism is called: *(K.B)*
(A) Angle of incidence (B) Angle of refraction
(C) Angle of refraction (D) Emerging angle

2. The refracted light striking to the side of prims is called: *(K.B)*
(A) Refracted ray (B) Incident ray
(C) Reflected ray (D) Emergent ray

3. The minimum value of angle of deviation is called: *(K.B)*

(A) Minimum angle (B) Incident angle
(C) Angle of minimum deviation (D) None of these

4. The angle at which prism deviates the incident ray is called: *(K.B)*
(A) Angle of incident (B) Angle of reflection
(C) Angle of deviation (D) Angle of minimum deviation

5. It is a transparent body (made of optical glass) with at least two polished plane faces inclined towards each other from which light is refracted: *(K.B)*
(A) Prism (B) Camera
(C) Lens (D) Mirror

12.8 LENSES

LONG QUESTIONS

Q.1 Define lens. Also describe its uses and types. *(K.B+U.B+A.B)* **(FSD-G1)-2015**

Ans:

LENS

Definition:

"A lens is any transparent material having two surfaces, of which at least one is curved. Lenses refract light in such a way that an image of the object is formed**"**.

Uses:

- Lenses of many different types are used in optical devices such as cameras, eyeglasses, microscopes, telescopes, and projectors.
- They also enable millions of people to see clearly and read comfortably.

Types of Lenses:

There are different types of lenses, which are given below:

- Convex mirror
- Concave mirror

Convex Lens / Converging Lens:

Definition:

"The lens which causes incident parallel rays to converge at a point is known as convex or converging lens**"**.

Formation:

This lens is thick at the center but thin at the edges.

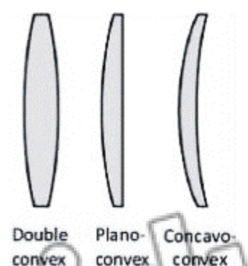


Figure: Convex Lens

Concave Lens / Diverging Lens:

Definition:

"The type of lens which causes the parallel rays of light to diverge from a point is called concave or diverging lens**"**.

Formation:

This lens is thin at the center and thick at the edges.

Figure: Concave Lens

12.8 Q.2 Describe the following lens terminologies. ***(K.B)***

- **Principal axis**
- **Optical Centre**
- **Focal length**
- **Principal focus of convex & concave lens**

Ans: **LENS TERMINOLOGIES**

Principal Axis:

Definition:

"Each of the two surfaces of a spherical lens is a section of a sphere. The line passing through the two centre of curvatures of the lens is called principal axis".

Optical Center:

Definition:

"A point on the principal axis at the centre of lens is called optical centre".

Symbol:

It is denoted by C.

Principal Focus of Convex Lens:

The light rays travelling parallel to the principal axis of a convex lens after refraction meet at a point on the principal axis, called principal focus or focal point F. Convex lens is also called converging lens.

Symbol:

It is denoted by F (as shown in figure).

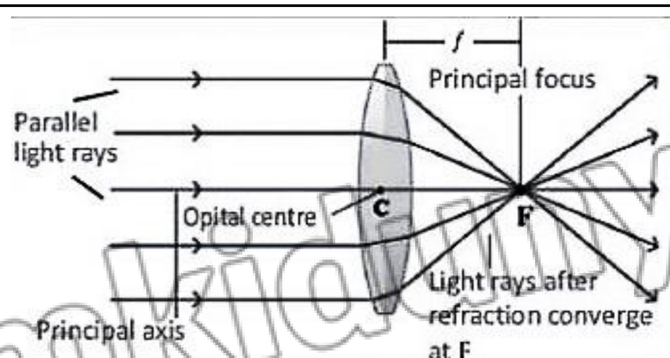


Figure: Convex Lens

Principal Focus of Concave Lens:

For a concave lens, the parallel rays appear to come from a point behind the lens called principal focus F. Hence concave lens is also called diverging lens.

Symbol:

It is denoted by f (as shown in figure).

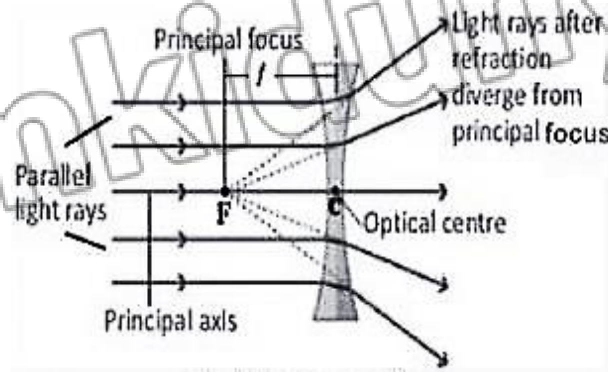


Figure: Concave Lens

Focal Length:

Definition:

"The distance between the optical centre and the principal focus is called **focal length** of lens".

Symbol:

It is denoted by f.

Q.3 Define power of the lens. Also define the unit of power of lens. *(K.B + U.B)*

Ans: **POWER OF LENS**

Definition:

"Power of a lens is defined as the reciprocal of its **focal length** in **metres**".

Formula:

The formula of power of lens is:

Power of a lens **= P =1 / focal length in metre**

Unit:

The SI unit of power of a lens is "Dioptre", denoted by a symbol D.

12.8 SHORT QUESTIONS

Q.1 Define lens. *(K.B)*

Ans: *Given on Page # 110*

Q.2 Write down the uses of lens. *(A.B)*

Ans: *Given on Page # 110*

Q.3 Define convex lens and concave lens. *(K.B)*

Ans: *Given on Page # 110*

Q.4 What do you know about principal axis and principal focus of lens? *(K.B)*

Ans: *Given on Page # 111*

Q.5 Define optical centre and focal length of lens? *(K.B + U.B)*

Ans: *Given on Page # 112*

Q.6 What do you know about power of lens? *(K.B + U.B)*

Ans: *Given on Page # 112*

Q.7 Define unit of power of lens. *(K.B + U.B)*

Ans: **DIOPTRE**

Definition:

"1 Dioptre is the power of lens whose focal length is 1 metre".

Formula:

If f is expressed in metres so that,

$1D=1m^{-1}$

Power of Convex Lens:

Because the focal length of a convex lens is positive. Therefore, its power is also positive.

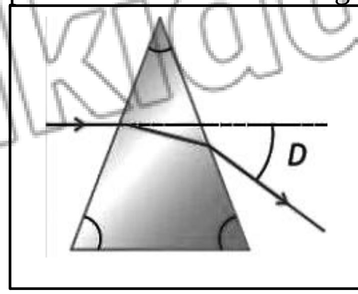
Power of Concave Lens:

The power of a concave lens is negative, for it has negative focal length.

Q.8 What happens when light passes through prism? *(K.B)* **(Refraction through prism Pg. # 48)**

Ans: **REFRACTION THROUGH PRISM**

When light passes through prism it deviates from original path due to refraction.



Q.9 How does the combination of two triangular prisms resemble a concave or convex lens? ***(K.B + U.B)***

Ans: **COMBINATION OF TWO PRISMS**

When Bases Combined:

If the base of two triangular prisms are joined together then it resembles a convex lens.

When Cones Combined:

If two triangular prisms are joined in such a way that their bases held opposite to each other and cones are joined together then it resembles a concave lens.

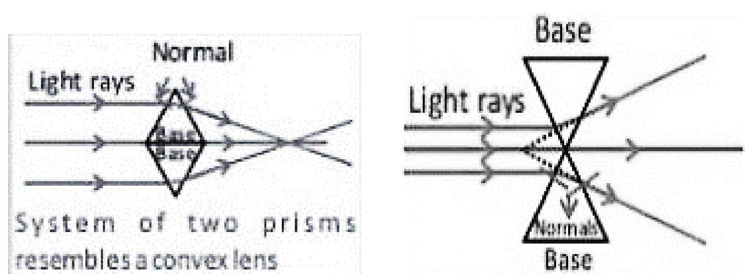


Figure: Combination of Two Prisms

Q.10 Why diopters are handy to use? Explain with the help of an example. ***(K.B)***

(For your information Pg. # 49)

Ans: **HANDY TO USE**

Diopters are handy to use because if two thin lenses are placed side by side, the total power is simply the sum of the individual powers.

Example:

An ophthalmologist places a 2.00 dioptre lets next to 0.25 dioptre lens and immediately knows that the power of combination is 2.25 dioptre.

Q.11 What is the critical point which must be kept in mind while dealing with diverging lenses? ***(K.B)***

(Remember it Pg. # 49)

Ans: **DIVERGING LENSES**

When dealing with diverging lenses, be careful not to omit the negative sign associated with the focal length and the image position.

Q.12 How length and curvature of lens if act the power of lens? (Conceptual Base)

Ans: When the length of lens increase its focal length become large then its power will decrease but when the length decrease then its curvature increase and its focal length also decrease. So when the focal length decreases, power of length increases.

$$\text{Power} = \frac{1}{\text{Focal Length in meter}}$$

12.8 MULTIPLE CHOICE QUESTIONS

1. **The line passing through the two centres of curvatures of the lens is called: *(K.B)***
(A) Principal focus (B) Optical centre
(C) Principal axis (D) Focal length

2. **Optical centre is represented by: *(K.B)***
(A) A (B) f
(C) F (D) C

3. **For a concave lens, the parallel rays appear to come from a point behind the lens is called: *(K.B)***
(A) Principal focus (B) Principal axis
(C) Focal length (D) Optical length

4. **The distance between the optical centre and the principal focus is: *(K.B)***
(A) Principal focus (B) Principal axis
(C) Focal length (D) Optical length

5. **In a lens, number of curved surfaces will be at least: *(K.B)***
(A) Two (B) Three
(C) One (D) Four

6. **Lenses are used in optical devices: *(A.B)***
(A) Camera (B) Eyeglasses
(C) Microscope (D) All given

7. **The lens which causes incident parallel rays to converge at a point is: *(K.B)***
(A) Convex lens (B) Converging lens
(C) Both a & b (D) Concave lens

8. **Lens thick at the centre but thin at the edges is: *(K.B)***
(A) Concave (B) Convex
(C) Diverging (D) Plane

9. **SI unit of power of lens is: *(K.B)***
(A) Meter (B) Diopter
(C) Centimeter (D) Millimeter

10. **1D = ? *(U.B + K.B)***
(A) $1m^{-1}$ (B) m^{-2}
(C) m^{-3} (D) cm^{-1}

11. **It has positive focal length: *(K.B)***
(A) Simple lens (B) Concave lens
(C) Convex lens (D) None of above

12.9 IMAGE FORMATION BY LENSES

LONG QUESTIONS

Q.1 Explain the image formation by lenses. ***(K.B + U.B + A.B)*** **(AJK-G1)(BWP-G2)-2015**

Ans: **IMAGE FORMATION BY LENSES**

In mirrors images are formed through reflection, but lenses form images through refraction.

Image Formation in Convex Lens:

Image formation in convex lens can be explained with the help of ray diagram of three principal rays (as shown in figure).

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

Ray Diagram:

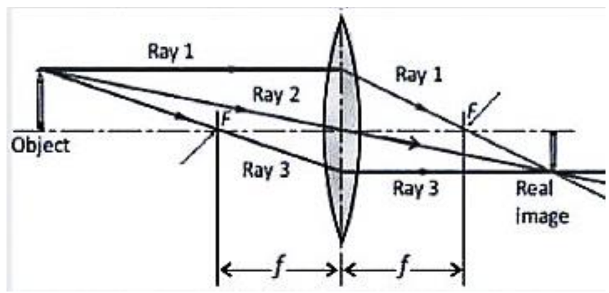


Figure: Image Formed By Convex Lens

Image Formation in Concave Lens:

Image formation in concave lens can be explained with the help of ray diagram of three principal rays (as shown in figure).

- The ray parallel to the principal axis diverged outside after refraction by the lens.
- The ray passing through the optical centre passes straight through the lens and remains undeviated.
- The ray parallel to the principal axis diverged after refraction by the lens.

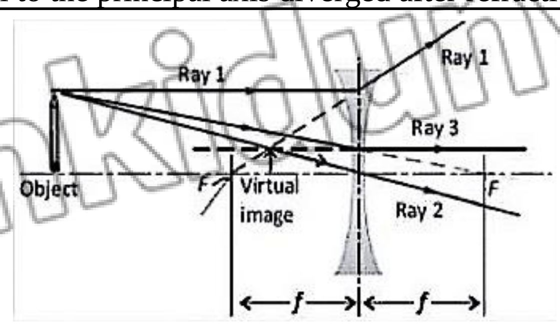


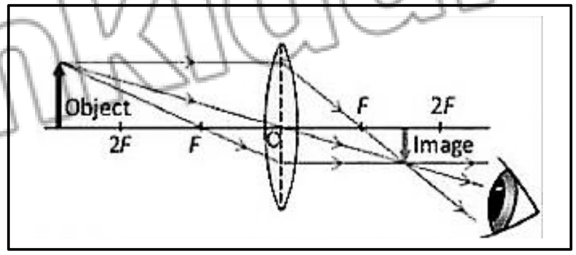
Figure: Image Formed By Convex Lens

12.8 Q.2 Explain the image formation in convex lens with the help of ray diagram. Also describe the natur

Ans: **IMAGE FORMATION IN CONVEX LENS**

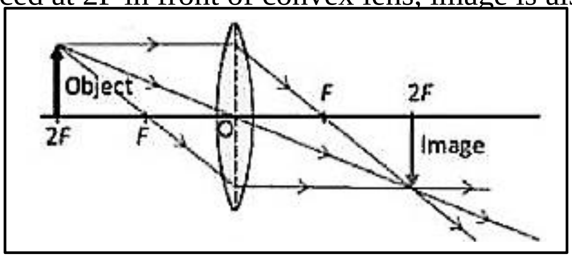
Images formed by the convex lens, depending upon the location of object are given as follows:

Object beyond 2F:
When the object is placed beyond 2F in front of convex lens, image is formed between F and 2F.



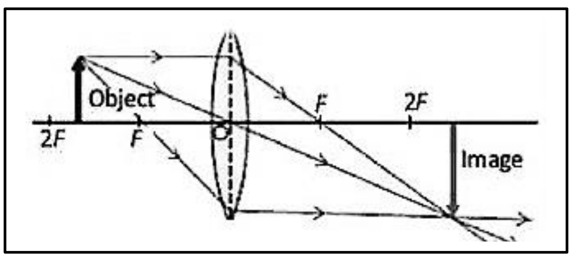
Nature:
The image is between F and 2F, real, inverted, smaller than the object.

Object at 2F:
When the object is placed at 2F in front of convex lens, image is also formed at 2F.



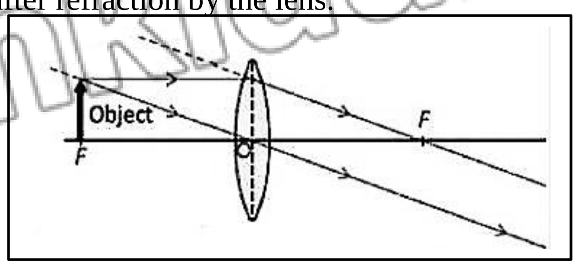
Nature:
The image is at 2F, real, inverted, the same size as the object.

Object between F and 2F:
When the object is placed between F and 2F in front of convex mirror, image is formed beyond 2F.



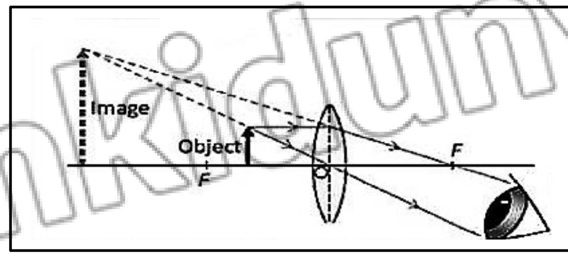
Nature:
The image is beyond 2F, real, inverted, larger than the object.

Object at F:
When the object is placed at E in front of convex lens, image will not be formed. Because rays become parallel after refraction by the lens.



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

Object between Lens and F:
When the object is placed between lens and F, image is formed behind the object.



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

12.9 SHORT QUESTIONS

Q.1 Write down the characteristics of three principal rays, passing through the convex lens. *(K.B)*

Ans: *Given on Page # 115*

Q.2 Draw the ray diagram of three principal rays passing through the concave lens. *(K.B+U.B)*

Ans: *Given on Page # 115*

Q.3 What is the nature of image formed in convex lens at following different locations of object in front of convex lens? *(K.B + U.B)*

Ans: *Given On Page # 116* (See Topic 12.9, Long Question-2)

Q.4 Write down the ways to compare lenses simply by looking at them. *(K.B)*
(For your information Pg. # 50)

Ans: **WAYS TO COMPARE LENSES**

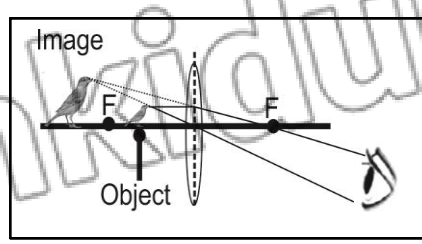
The ways of comparing lenses are:

- Lenses can be compared simply by looking at them.
- A lens with a long focal length is thin; its surfaces are not very strongly curved.
- A lens with a short focal length is fatter; its surfaces are more strongly curved.

Q.5 How can we make a converging lens into magnifying glass? *(K.B + A.B)*
(Physics Insight Pg. # 50)

Ans: **CONVERGING LENS AS MAGNIFYING GLASS**

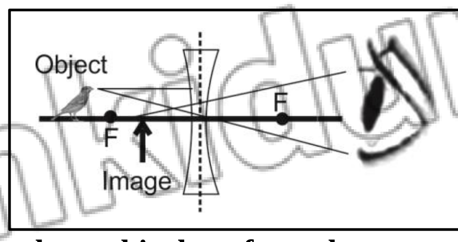
A converging lens becomes a magnifying gals when an object is located inside the lens's focal length.



Q.6 When do we have the same ray diagram of diverging lens as that of converging lens? *(K.B)*
(Physics Insight Pg. # 50)

Ans: **RAY DIAGRAM OF DIVERGING LENS**

A diverging lens always forms a smaller image.



Q.7 What can we assume about thin lens formula compared with the thick lens when objects and images are far away? *(K.B + U.B)* **(Approximations Pg. # 51)**

Ans: **THICK AND THIN LENS**

The thin lens formula assumes the lenses have no thickness. This is a good assumption when objects and images are far away compared with the thickness of a lens.

12.9 MULTIPLE CHOICE QUESTIONS

1. In mirrors images are formed through reflection, but lenses form images through; *(K.B)*

(A) Refraction (B) Incidence
(C) Diffraction (D) Reflection

2. In case of convex lens when object is placed beyond 2F,the image is formed; *(K.B + U.B)*

(A) Between F and 2F (B) Real, inverted
(C) Smaller than object (D) All of these

3. The image with convex lens is formed at 2F, real , inverted, the same size as the object when the object is placed at: *(K.B + U.B)*

(A) 2F (B) Between F and 2F
(C) F (D) C

4. When object is at F the image is; *(K.B + U.B)*

(A) Inverted (B) Real
(C) Small (D) Not formed

12.10 IMAGE LOCATION BY LENS EQUATION

LONG QUESTIONS

12.10 Q.1 What is lens equation? How can we locate the image by lens equation? *(K.B + U.B +A.B)* **(Example 12.6)(AJK-G1)-2016 / (GRW-G1)(FSD-G2)(BWP-G2)-2017**

Ans: **LENS EQUATION**

Definition:

"The relation between the object and Image distance from the lens In terms of the focal length of the lens is called lens formula".

Formula:

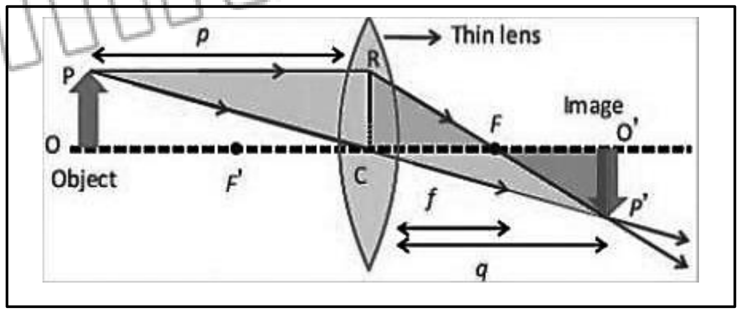
$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

Validity:

The lens equation is valid for both concave and convex lenses.

Explanation:

In figure, let an object OP be placed in front of a convex lens at a distance p. A ray PR parallel to the principal axis after refraction passes through focus F. Another ray PC meets the first ray at point P' after passing through the optical center C. If this process is repeated for the other points of the object, a real and inverted image O'P' is formed at a distance q from the lens.



Sign Conventions for Lenses:

The sing conventions for lenses are:

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.

12.10 SHORT QUESTIONS

Q.1 What is Lens formula? *(K.B + U.B)*

Ans: *Given on Page # 118.*

Q.2 What are the sign conventions for focal length in lenses? *(K.B)*

Ans: *Given on Page # 119.*

Q.3 What are the sign conventions for object distance in lenses? *(K.B)*

Ans: *Given on Page # 119.*

Q.4 What are the sign conventions for image distance in lenses? *(K.B)*

Ans: *Given on Page # 119.*

Q.5 Define optics and geometrical optics. How much is it useful in other branches of sciences? *(K.B + A.B)*

(For your information Pg. # 51)

Ans: **OPTICS AND GEOMETRICAL OPTICS**

Optics:

Definition:

"The study of behavior of light behavior is called optics".

Geometrical Optics:

Definition:

"The branch of optics that focuses on the creation of images is called geometrical optics" because it is based on relationships between angles and lines that describe light rays.

Uses in other Branches of Science:

Optics also includes the study of the eye itself because the human eye forms an image with a lens.

Q.6 Write down the names of objects / devices of daily life in which lenses are used. *(K.B + A.B)*

Ans: **NAMES OF OBJECTS**

The objects in which lenses are used that are:

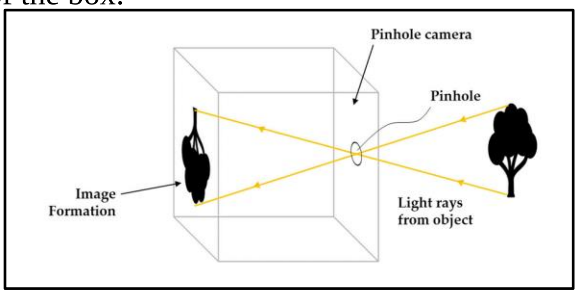
- Spectacles
- Magnifying glass
- Microscope
- Slide projector
- Binoculars
- Camera

Q.7 What is a pinhole camera? How can we make pinhole camera without lens? *(K.B + U.B)*

(A camera without lens Pg. # 53)

Ans: **PINHOLE CAMERA**

Even simpler than a camera with one lens is a pinhole camera. To make a pinhole camera, a tiny pinhole is made in one side of a box. An inverted, real image is formed on the opposite side of the box.



12.10 MULTIPLE CHOICE QUESTIONS

1. Lens formula is *(U.B + A.B)*

(A) $\frac{1}{p}=\frac{1}{f}+\frac{1}{q}$ (B) $\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$

(C) $\frac{1}{f}=\frac{q}{p}+\frac{1}{q}$ (D) $\frac{1}{f}=\frac{1}{p}-\frac{1}{q}$

2. For a converging lens f is; *(K.B)*

(A) Negative (B) Positive

(C) Sometime negative and sometime positive (D) Smaller

3. The study of behaviour of light is called; *(K.B)*

(A) Optics (B) Geometry

(C) Plasma (D) Geometrical optics

4. If the object is on the right side of the lens then p is; *(K.B)*

(A) Positive (B) Negative

(C) Smaller (D) Larger

EXAMPLE 12.5

A person 1.7 m tall is standing 2.5 m in front of a camera. The camera uses a convex lens whose focal length is 0.05 m. Find the image distance (the distance between the lens and the film) and determine whether the image is real or virtual.

Solution:

Given Data:

Focal length of convex lens = f = 0.05 m

Distance of person from lens = p = 2.5 m

Required:

Distance of image = q = ?

Nature of image = ?

Formula:

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

Calculations:

By using formula, we have

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

Or $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

$$\frac{1}{q}=\frac{1}{0.05m}-\frac{1}{2.5m}$$

$$\frac{1}{q}=19.6m^{-1}$$

Or $q = 0.05m$

Image Nature:

Since the image distance is positive, so a real image is formed on the film at the focal point of the lens.

Result:

Hence, the image distance is 0.05 m from the lens. Since the image distance is positive, so a real image is formed on the film at the focal point of the lens

EXAMPLE 12.6

A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also find the magnification of the lens.

Solution:

Given Data:

Distance of image from concave lens = q = –10 cm

Focal length of concave lens = f = –15 cm

Required:

(a) Distance of object from lens = p = ?

(b) Magnification of the lens = m = ?

Formula:

(a) $\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$

(b) $m=\frac{q}{p}$

Calculations:

By using formula, we have

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

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

$$=-\frac{1}{(-10cm)}+\frac{1}{(-15cm)}$$

$$=\frac{1}{10cm}-\frac{1}{15cm}$$

$$\frac{1}{p}=\frac{3cm-2cm}{30cm^2}$$

$$\frac{1}{p}=-\frac{1}{30cm}$$

$$p=-30cm$$

(b) Magnification of the lens is = $m=\frac{q}{p}$

$$m=\frac{q}{p}=\frac{10cm}{30cm}=\frac{1}{3}$$ (Ignore negative sign)

Result:

Hence, the object is 30cm, on the left side from the concave lens and the image is reduced to one-third in size than the object.

12.11 APPLICATIONS OF LENSES

LONG QUESTIONS

12.11 Q.1 Describe the application of lenses in camera with ray diagram. ***(A.B)***

Ans: **CAMERA**

Definition:

"A device for recording visual images in the form of photographs, movie films or video signals".

Construction:

A simple camera consists of a light-proof box with a converging lens in front and a light sensitive plate or film at the back. The lens focuses images to be photographed onto the film. In simple lens camera, the distance between lens and film is fixed which is equal to the focal length of the lens.

Position of Object:

In camera, object is placed beyond **2F**.

Nature of Image:

A **real**, **inverted** and **diminished** image is formed (as shown in figure).

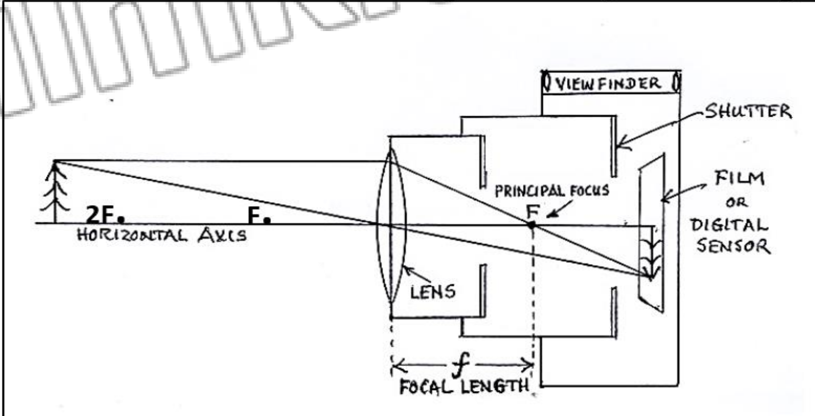


Figure: Camera

12.11 Q.2 Explain the working of slide projector with the ray diagram to describe the application of lens. ***(A.B)***

Ans: **SLIDE PROJECTOR**

Definition:

"An optical instrument that projects on enlarged image of individual slides into a screen or wall**"**.

Construction and Working:

The light source is placed at the centre of curvature of a converging or concave mirror. The concave mirror is used to reflect light back in fairly parallel rays. The condenser is made up of 2 converging lenses that refract the light so that part of slide are illuminated with parallel rays.

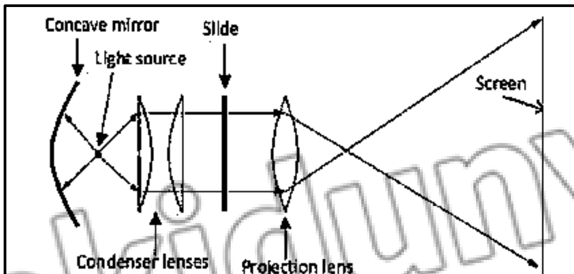


Figure: Slide Projector

The projection or converging lens provides a real, large and inverted image. It must be real to be projected on a screen.

Object Position:

The slide (object) must be placed between **F** and **2F** of projection lens.

Nature:

Lens produces a **real, large,** and **inverted** image.

Placement of Slide:

Because the image is inverted, the slide must be placed upside down and laterally inverted so the erect Image can be seen properly.

12.11 Q.3 Describe the working of photograph enlarger with the ray diagram. ***(A.B)***

Ans: **PHOTOGRAPH ENLARGER**

Definition:

An optical instrument for making enlarged photographic prints in which a negative is brightly illuminated and its enlarged image is focuses onto a sheet of sensitized paper.

Construction:

It uses a convex lens to produce a real, magnified and inverted image of the film on photographic paper.

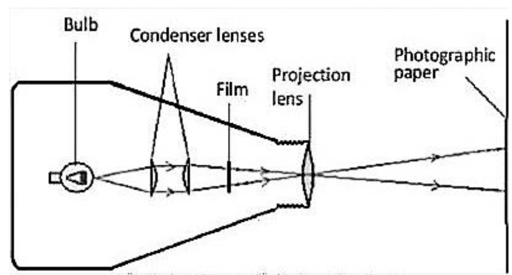


Figure: Photograph Enlarger

Working Principle:

The working principle of photograph enlarger is basically the same as that of a slide projector.

Position of Object:

In the case of photograph enlarger object is placed at distance of more than **F** but less than **2F**.

Nature of Image:

We get a **real, inverted** and **enlarged image**.

12.11 SHORT QUESTIONS

Q.1 What is the construction of camera? ***(K.B)***

Ans: *Given on Page # 122*

Q.2 What is the working principle of photograph enlarger? ***(K.B)***

Ans: **WORKING PRINCIPLE OF PHOTGRAPH ENLARGER**

The working principle of photograph enlarger is basically the same as that of a slide projector. It uses a convex lens to produce a real, magnified, inverted image of the film on photographic paper.

12.11 MULTIPLE CHOICE QUESTIONS

1. **Optical device is;** ***(K.B)***
   (A) Camera (B) Slide projector
   (C) Photograph enlarger (D) All of given
2. **Which statement is correct about image formed by camera?** ***(K.B)***
   (A) Real image is formed (B) Inverted image is formed
   (C) Diminished image is formed (D) All options are true
3. **In case of photograph enlarger, the object is placed at distance;** ***(U.B)***
   (A) More than F (B) Less than 2F
   (C) Both (A) and (B) (D) More than 3F
4. **The working principle of photograph enlarger is the same as;** ***(U.B)***
   (A) Slide projector (B) Camera
   (C) Telescope (D) Endoscope

12.12 SIMPLE MICROSCOPE

LONG QUESTIONS

12.12 Q.1 How does image formation take place in simple microscope? Also derive the formula of magnifying power.

Ans: SIMPLE MICROSCOPE

Definition:

"A magnifying glass is a convex lens which is used to produce magnified images of small objects. Hence, it is also called simple microscope".

Object Position to Lens:

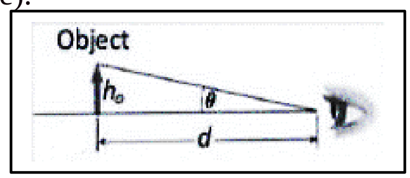
The object is placed nearer to the lens than the principal focus such that an upright, virtual and magnified image is seen clearly at 25cm from the normal eye.

Magnifying Power:

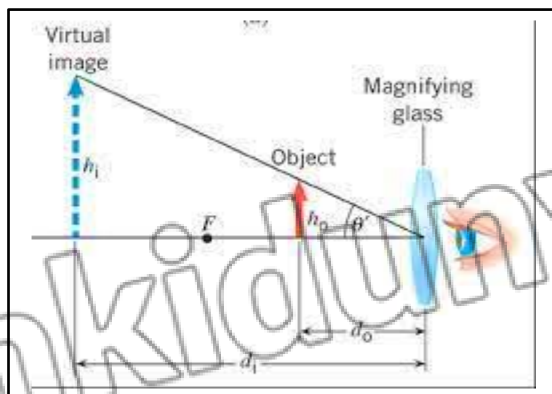
It is ratio of angular size of final image produced by magnifying glass to the angular size of object seen without magnifying glass.

Explanation:

Let θ be the angle subtended at the eye by a small object when it is placed at near point of the eye (as shown in figure).



If the object is now moved nearer to the eye (as shown in figure), the angle on the eye will increase and becomes θ', but the eye will not be able to see it clearly. In order to see the object clearly, we put a convex lens between the object and the eye, so that the lens makes a large virtual image of the object at near point of the eye. In this way, the object appears magnified.



Mathematical Equation:

The magnifying power in this case will be:

$$M = \frac{\theta'}{\theta} = \frac{\text{Angular size of final image produced by magnifying glass}}{\text{Angular size of object seen without magnifying glass}}$$

It can be shown that the magnifying power is given by the relation:

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

Where *f* is the focal length of lens and *d* is near point of eye. It is clear from this relation that a lens of shorter focal length will have greater magnifying power.

12.12 SHORT QUESTIONS

Q.1 What do you mean by resolving power of an instrument? *(K.B)*

Ans: **RESOLVING POWER**

Definition:

"The resolving power of an instrument is its ability to distinguish between two closely placed objects or point sources".

High Resolving Power:

- In order to see objects that are close together, we use an instrument of high resolving power.

Example:

We use high resolving power microscope to see tiny organisms and telescope to view distant stars.

Q.2 What is a simple microscope? *(K.B)* **(FSD-G1)-2016**

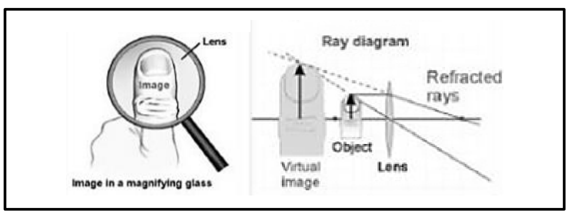
Ans: **SIMPLE MICROSCOPE**

A magnifying glass is a convex lens which is used to produce magnified image of small objects. Hence it is also called a simple microscope.

Q.3 What is a magnifying glass? *(K.B)*

Ans: **IMAGE OF MAGNIFYING GLASS**

Magnifying glass is a lens that forms a virtual image that is larger than object and appears behind the lens.



Q.4 What do you mean by linear magnification? *(K.B+U.B)*

Ans: **LINEAR MAGNIFICATION**

Definition:

"The ratio of the size of image to that of the size of object is called linear magnification".

Mathematical Formula:

$$m = \frac{\text{image height}}{\text{object height}} = \frac{h_i}{h_o} = \frac{q}{p}$$

Unit:

It has no unit because it is a ratio of two same quantities.

12.12 MULTIPLE CHOICE QUESTIONS

1. A magnifying glass is a convex lens which is used to produce magnified images of small objects. It is also called: *(K.B)*

(A) Compound microscope (B) Simple microscope
(C) Electron microscope (D) Light microscope

2. For seeing tiny objects we use microscope of: *(A.B)*

(A) Low resolving power (B) High resolving power
(C) Electron microscope (D) Light microscope

12.13 COMPOUND MICROSCOPE

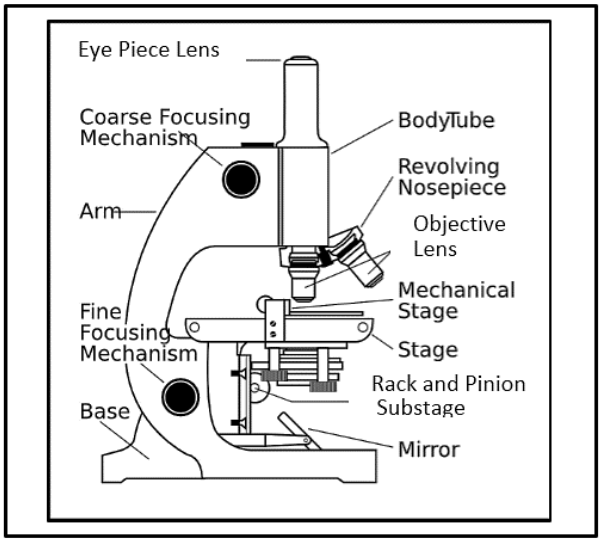
LONG QUESTIONS

12.13 Q.1 Describe compound microscope. Also describe its magnification. ***(K.B+U.B+A.B)***
(MTN-G2) (DGK-G2)-2015 / (GRW-G2)(BWP-G1)-2016

Ans: **COMPOUND MICROSCOPE**

Definition:

"Compound microscope has two converging lenses, the objective and the eyepiece and is used to investigate structure of small objects**"**.



Features:

Following are some features of compound microscope:

- It gives greater magnification than a single lens.
- The objective lens has a short focal length , $\mathbf{f_o < 1cm}$.
- The eyepiece has larger focal length, f_e of a few cm..

Magnification of the Compound Microscope:

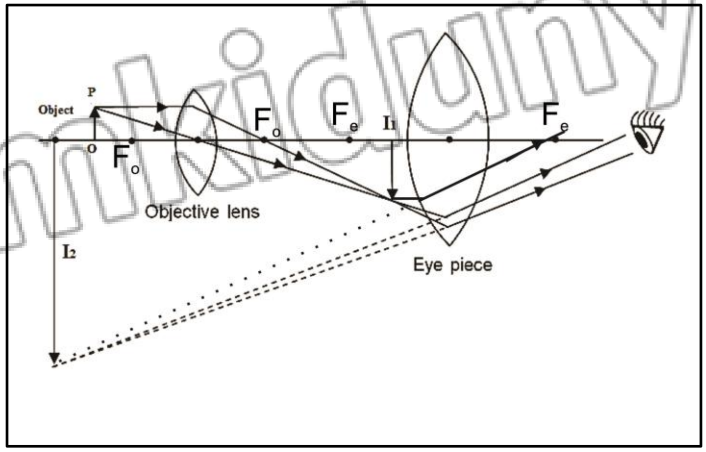
Objective forms a small image I_1, inside the focal point of eyepiece. This image acts as an object for the eyepiece and the final larger image I_2 is formed outside the focal point of the objective.

Mathematical Equation:

The magnification of compound microscope is given by

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

Where L is the length of compound microscope which is equal to the distance between objective and eye piece, d is distance of final image from eye, f_0, and f_e, are the focal lengths of objective and eye piece respectively.



Uses of Compound Microscope:

- A compound microscope is used to study bacteria and other micro objects.
- It is also used for research in several fields of sciences like Microbiology, Botany, Geology and Genetics.

12.13 SHORT QUESTIONS

Q.1 Define compound microscope. *(K.B)* **(GRW-G1)-2017**

Ans: **COMPOUND MICROSCOPE**

Definition:

"Compound microscope has two converging lenses, the objective and the eyepiece and is used to investigate structure of small object.**"**

Q.2 What are the features of compound microscope? *(K.B)* **(AJK-G1)-2014**

Ans: **FEATURES OF COMPOUND MICROSCOPE**

The features of compound microscope are:

- It gives greater magnification than a single lens.
- The eyepiece has larger focal length f_e of a few cm.

Q.3 What are the uses of compound microscope? *(A.B)* **(Compound microscope Pg. # 57)**

Ans: **USES OF COMPOUND MICROSCOPE**

The uses of compound microscope are:

- To study bacteria and other micro objects.

It is also used for research in several fields of sciences like microbiology, botany, geology and genetics.

Q.4 Compare the focal length of objective lens and eyepiece of compound microscope. *(K.B+U.B)*

Ans: **COMPOUND MICROSCOPE**

Objective lens has smaller focal length, than the eyepiece. Distance between the objective lens and the eyepiece is greater than $\mathbf{f_o + f_e}$. It is used to see very small objects.

Q.5 What do you know about astronomical telescope? *(K.B+A.B)*

(Astronomical Telescope Pg. # 57)

Ans: **ASTRONOMICAL TELESCOPE**

Objective lens has larger focal length than the eyepiece. Distance between the objective lens and the eyepiece is equal to $\mathbf{f_o + f_e}$. It is used to see distant astronomical objects.

12.13 MULTIPLE CHOICE QUESTIONS

1. **Which statement is correct about compound microscope? *(K.B)*** **(RWP-G2)-2015**
(A) Focal length of objective lens is smaller than eyepiece.
(B) Distance between objective lens and eyepiece is greater than $f_0 + f_e$.
(C) It is used to see very small object
(D) All given statements are true

2. **The magnification of compound microscope is; *(A.B+U.B)***
(A) $M = \frac{L}{f_0}\left(1+\frac{d}{f_e}\right)$ (B) $M = \frac{L}{f_0}$
(C) $M = \left(1+\frac{d}{f_e}\right)$ (D) $M = \frac{L}{f_e}\left(1+\frac{d}{f_e}\right)$

12.14 TELESCOPE

LONG QUESTIONS

12.14 Q.1 Describe the working and magnification of telescope.*(K.B+A.B+U.B)*(BWP-G2)-2016

Ans: **TELSECOPE**

Definition:

"Telescope is an optical instrument which is used to observe distant objects using lenses or mirrors".

Refracting Telescope:

A telescope that uses two converging lenses is called refracting telescope (as shown in figure). In refracting telescope, an objective lens forms *a* real image of the distant object, while an eyepiece forms a virtual image that is viewed by the eye.

Working of Refracting Telescope:

When parallel rays from a point on a distant object pass through objective lens, a real image I_1, is formed at the focus $F_\circ$, of the objective lens. This image acts as an object for the eyepiece. A large virtual image I_2, of I_1, is formed by the eyepiece at a large distance from the objective lens. This virtual image makes an angle 0 at the eyepiece.

Magnification of Telescope:

Magnification of a refracting telescope can be determined by $M = \frac{f_0}{f_e}$

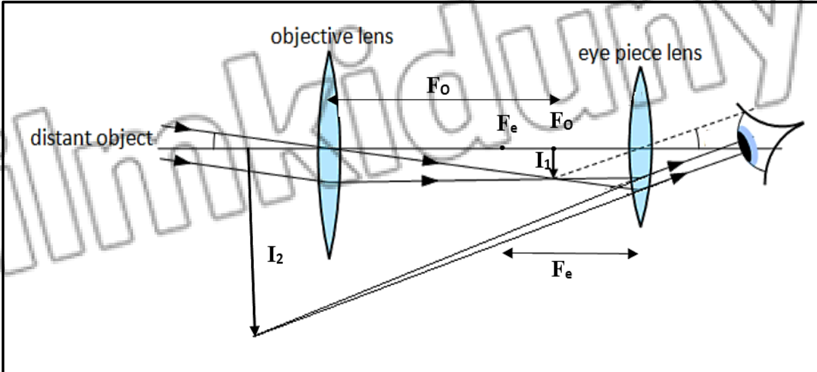


Figure: Ray Diagram of Refracting Telescope

12.14 SHORT QUESTIONS

Q.1 What is telescope? *(K.B)* **(SGD-G1)-2014**

Ans: **TELESCOPE**

Definition:

Telescope is an optical instrument which is used to observe distant object using lenses or mirrors.

Q.2 What is refracting telescope? *(K.B)* **(MTN-G2)-2016**

Ans: **REFRACTING TELESCOPE**

Definition:

"A telescope that uses two converging lenses is called refracting telescope**"**.

Q.3 What do you know about terrestrial telescope? *(K.B)*

(For your information Pg. # 58)

Ans: **TERRESTRIAL TELESCOPE**

Terrestrial telescope is similar to refracting telescope except with an extra lens between objective and eyepiece.

Q.4 What will be the magnification of combination of lenses? *(K.B)*

(For your information Pg. # 58)

Ans: **MAGNIFICATION OF COMBINATION OF LENSES**

The magnification of a combination of lenses is equal to the product of the magnification of each lens.

Q.5 What is the importance of telescope in astronomy? *(K.B)*

(For your information Pg. # 58)

Ans: **PURPOSE OF TELESCOPE**

A telescope cannot make stars look bigger, because they are too far away. But there is something important the telescope can do– it makes stars look brighter. Dim stars look bright, and stars that are too faint to see come into view. Without a telescope, we can see up to 3000 individual stars in the night sky; a small telescope can increase this by a factor of at least 10. So a telescope is better than the naked eye for seeing dim stars. The reason is that the telescope gathers more light than the eye.

Q.6 Write two differences between telescope and microscope. *(K.B)*

(SWL-G2)-2017

Ans: **DIFFERENTIATION**

The differences between telescope and microscope are as follows:

Telescope	Microscope
• It is optical instrument which is used to observe distant object using lenses or mirrors. • Telescope is used to see distant astronomical objects.	• Microscope is used to investigate structure of small objects. • A microscope is used to study bacteria and other micro objects.

12.14 MULTIPLE CHOICE QUESTIONS

1. It is an optical instrument which is used to observe distant objects using lens or mirror.*(K.B)*

(A) Microscope (B) Kaledoscope
(C) Telescope (D) Light microscope

2. Magnification of telescope can be determined by using formula: *(K.B)*

(A) $M = \frac{f_0}{f_e}$ (B) $M = \frac{f_0}{f_0}$
(C) $M = \frac{F}{L}$ (D) $M = \frac{L_0}{f_0}$

12.15 THE HUMAN EYE

LONG QUESTIONS

Q.1 Describe the structure and image formation in human eye? *(K.B+U.B+A.B)*

(LHR-G1)-2015

Ans: **THE HUMAN EYE**

Definition:

"Eye is an organ of a human body used for vision".

Image Formation:

The image formation in human eye is shown in figure. Human eye acts like a camera.

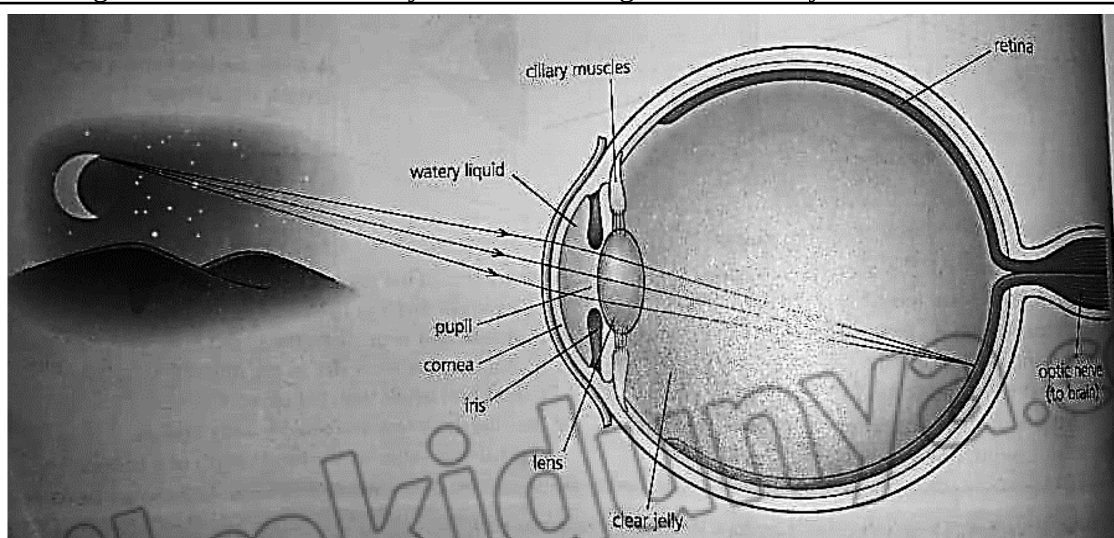


Figure: Image Formation in Human Eye

Parts of Human Eye:

The parts of human eye which plays an important role in the image formation are described as below:

Retina:

Human eye acts like a camera. In place of the film, the retina records the picture. The eye has a refracting system containing a converging lens. The lens forms an image on the retina which is a light sensitive layer at the back of the eye.

Lens:

In the camera, the distance of lens from film is adjusted for proper focus but in the eye, the lens changes focal length.

Cornea:

Light enters the eye through a transparent membrane called the cornea.

Iris:

The iris is the colored portion of the eye and controls the amount of light reaching the retina.

Pupil:

Iris has an opening at its center called the pupil. The iris controls the size of the pupil.

Image Formation (Function of Cilliary muscles):

In bright light, Iris contracts the size of the pupil while in dim light pupil is enlarged. The lens of the eye is flexible and accommodates objects over a wide range of distances.

Q.2 What do you know about accommodation? Also describe the mechanism for focusing in eye. *(K.B)*

Ans:

ACCOMODATION

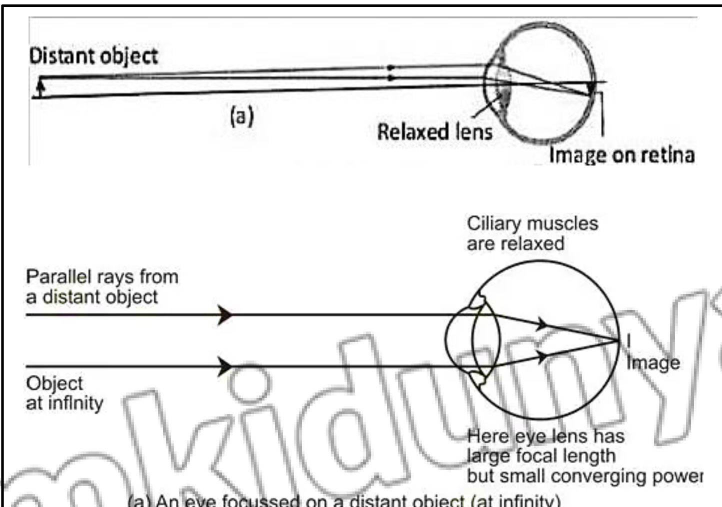
Definition:

"The variation of focal length of eye lens to form a sharp image on retina is called accommodation".

- It is large in young people while it goes on decreasing with age.

For Distant Objects:

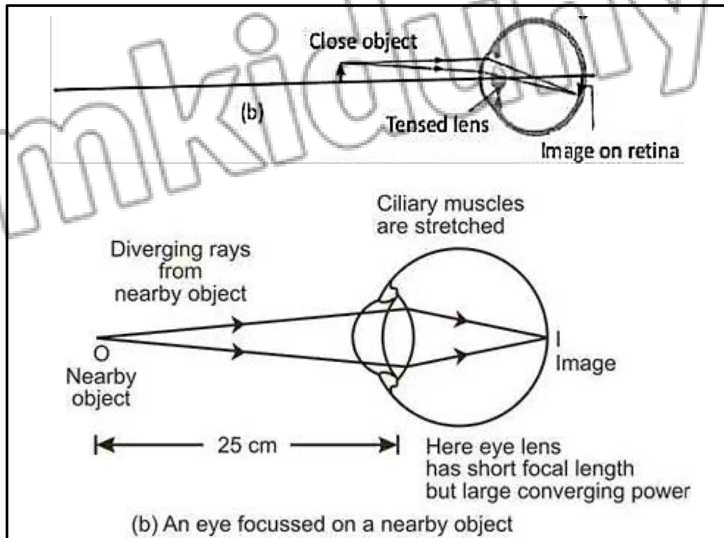
If an object is far away from the eye, the deviation of light through the lens must be less. To do this, the ciliary muscles relax and decrease the curvature of the lens, thereby, increasing the focal length. The rays are thus focused onto the retina producing a sharp image of the distant object (as shown in figure).



(a) An eye focussed on a distant object (at infinity)

For Close Objects:

If an object is close to the eye, the ciliary muscles increase curvature of the lens, thereby, shortening the focal length. The divergent rays from the nearer object are thus bent more so as to come to a focus on the retina (as shown in figure).



(b) An eye focussed on a nearby object

Correction:

Defects in accommodation may be corrected by using different type of lenses in eyeglasses.

Focusing Mechanism of Eye:

- The camera focuses the image of an object at a given distance from it by moving the lens towards or away from the film.
- The eye has different adjusting mechanism for focusing the image of an object onto the retina. Its ciliary muscles control the curvature and thus the focal length of the lens, and allow objects at various distances to be seen.

Q.3 Describe the near point and far point of an eye. ***(K.B)***

Ans:

NEAR POINT

Definition:

"The near point of the eye is the minimum distance of an object from the eye at which it produces a sharp image on the retina".

- This distance is also called the least distance of distinct vision.

Explanation:

When we hold a book too close, the print is blurred because the lens cannot adjust enough to bring the book into focus. An object closer to the eye than the near point appears blurred. For people in their early twenties with normal vision, the near point is located about 25 cm from the eye. It increases to about 50 cm at the age 40 years and to roughly 500 cm at the age of 60 years.

FAR POINT

Definition:

"The far point of the eye is the maximum distance of a distant object from the eye on which the fully relaxed eye can focus".

Explanation:

A person with normal eyesight can see objects very far away, such as the planets and stars, and thus has a far point located at infinity. Majority of people do not have "normal eyes" in this sense.

12.15 SHORT QUESTIONS

Q.1 Define accommodation. ***(K.B)***

Ans: **ACCOMODATION**

Deficiency:

"The variation of focal length of eye lens to form a sharp image on retina is called accommodation".

Q.2 How do we see? ***(K.B)*** **(For your information Pg. # 59)**

Ans: **SEEING OBJECT**

We see because the eye forms images on the retina at the back of the eyeball.

Q.3 How the size of the pupil of our eye will change? ***(K.B)*** **(Quick quiz Pg. # 59)**

- In dim light
- In bright light

Ans: **SIZE OF PUPIL**

In Dim Light:

In dim light pupil is enlarged.

In Bright Light:

In bright light, iris contracts the size of the pupil.

Q.4 Define near point and far point. ***(K.B)***

Ans: **NEAR POINT**

Definition:

"The near point of the eye is the minimum distance of an object from the eye at which it produces a sharp image on the retina".

- This distance is also called the least distance of distinct vision.

FAR POINT

Definition:

"The far point of the eye is the maximum distance of a distant object from the eye on which the fully relaxed eye can focus".

12.15 MULTIPLE CHOICE QUESTIONS

1. **Human eye acts like:** ***(K.B)***
   (A) Camera (B) Telescope
   (C) Kaledoscope (D) Microscope
2. **Light enters the eye through transparent membrane called:** ***(K.B)***
   (A) Retina (B) Cornea
   (C) Iris (D) Pupil
3. **The coloured portion of eye controls the amount of light reaching the retina.** ***(K.B)***
   (A) Iris (B) Pupil
   (C) Cornea (D) Eye lens
4. **The variation of focal length of eye lens is called:** ***(K.B)***
   (MTN-G2)-2014 / (BWP-G2)-2016 / (LHR-G1)-2017
   (A) Variation (B) Accommodation
   (C) Magnification (D) Resolution

12.16 DEFECTS OF VISION

LONG QUESTIONS

Q.1 What do you mean by defects of vision? Describe he main defects of vision and how as minimized

Ans: **DEFECTS OF VISION**

Definition:

"The Inability of the eye to see the image of objects clearly is called defect of vision".

Causes of Defects of vision:

The defects of vision arise when the eye lens is unable to accommodate effectively.

Effect:

The images formed are therefore blurred.

Nearsightedness (myopia):

Definition:

"Some people cannot see distant objects clearly without the aid of spectacles. This defect of vision is known as short sight or nearsightedness".

Reason:

It may be due to the eyeball being too long. Light rays from a distant object are focused in front of the retina and *a* blurred image is produced.

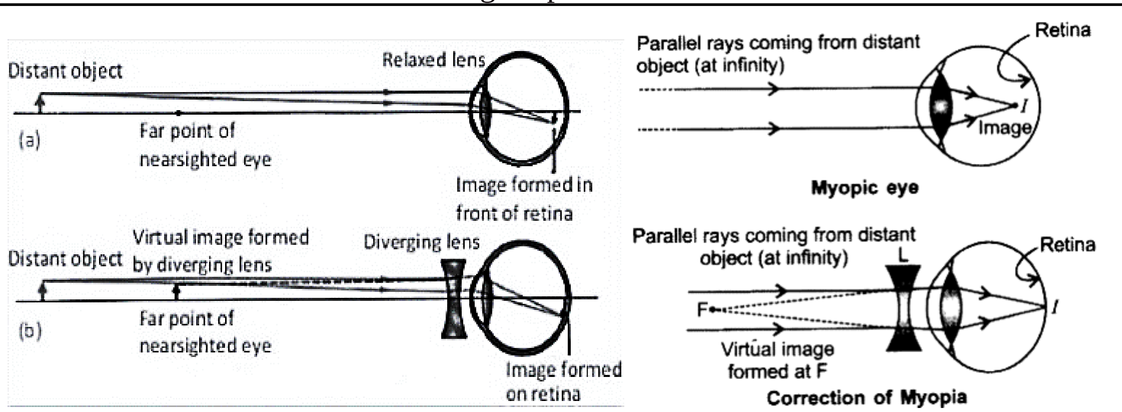


Figure: Correction of Nearsightedness

Correction:

The nearsighted eye can be corrected with glass or contact lenses that use diverging lenses. Light rays from the distant objects are now diverged by this lens before entering the eye. To the observer, these light rays appear to come from far point and are therefore focused on the retina, thus forming a sharp image.

Farsightedness (hypermetropia):

Definition:

"The disability of the eye to form distinct images of nearby objects on its retina is known as farsightedness".

Reason:

IT may be due to eye ball being too short.

Correction:

When a farsighted eye tries to focus on a book held closer than the near point, it shortens its focal length as much as it can. However, even at its shortest, the focal length is longer than it should be. Therefore, the light rays from the book would form a blurred image behind the retina (as shown in figure).

This defect can be corrected with the aid of a suitable converging lens. The lens refracts the light rays and they converge to form an Image on the retina. To an observer, these rays appear to come from near point to form a sharp virtual image on the retina (as shown in figure)

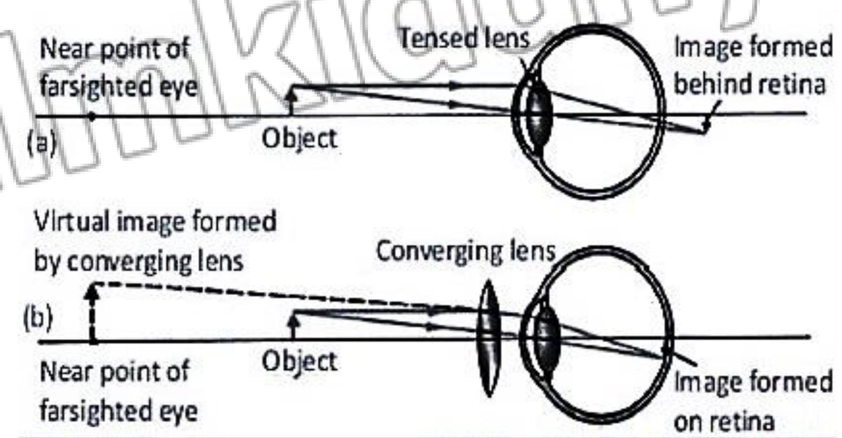


Figure: Correction of Farsightedness

12.16 SHORT QUESTIONS

Q.1 Compare the contact lenses with the eyeglasses? *(K.B + U.B)*

Ans: **CONTACT LENSES**

Contact lenses produces the same results as eyeglasses do. These small, thin lenses are placed directly on the corneas. A thin layers of tears between the cornea and lens keeps the lens in the place. Most of the refraction occurs at the air-lens surface, where the difference in indices of refraction is greatest.

Q.2 Which animals can move their eye lenses forward or backward? *(K.B)*

(Interesting information Pg. # 61)

Ans: **MOVING EYE LENSES**

Some animals like fish has the ability to move their eye lenses forward or backward and hence, are able to see clearly objects around them.

Q.3 How can we prevent the glare of reflected light from an eye? *(K.B)*

(Interesting information Pg. # 61)

Ans: **PREVENTION**

A thin film can be placed on the lenses of eyeglasses to keep them from reflecting wavelengths of light that are highly visible to the human eye. This prevents the glare of reflected light.

Q.4 Define nearsightedness and farsightedness. *(K.B)*

(GRW-G1)(MTN-G2)-2016 / (FSD-G1)(LHR-G1)-2017

Ans: **NEARSIGHTEDNESS (MYOPIA)**

Definition:

"Some people cannot see distant objects clearly without the aid of spectacles. This defect of vision is known as short sight or nearsightedness".

FARSIGHTEDNESS (HYPERMETROPIA)

Definition:

"The disability of the eye to form distinct images of nearby objects on its retina is known as farsightedness".

Q.5 Why doctor check the eyes of patient with torch light at last stage? *(Conceptual Base)*

Ans: The doctor check the eyes of patient with torch light at last stage whether the patient is dead or alive because the lens of eye of a alive person is sensitive to the light and it change its curvature and length one the light fall. But the lens of dead person does not change its curvature and length when light fall. So doctor declare the patient is died.

12.16 MULTIPLE CHOICE QUESTIONS

1. **When people cannot see distant objects clearly without the aid of spectacles the defect of vision is called as: *(K.B)***
   (A) Short-sighted (B) Near-sightedness
   (C) Both (A) & (B) (D) Farsightedness
2. **Short sighted may be due to eyeball being: *(K.B)***
   (A) Too long (B) Too short
   (C) Too thick (D) Too thin
3. **Which animal has the ability to move eye lens forward or backward? *(K.B)***
   (A) Fish (B) Human
   (C) Birds (D) Dog
4. **The nearsighted eye can be corrected by using; *(K.B)***
   (A) Diverging lens (B) Converging lens
   (C) Both (A) & (B) (D) Concave mirror
5. **The disability of the eye to form distinct images of nearby object on retina is called foresightedness or: *(K.B)***
   (A) Short sightedness (B) Isometropia
   (C) Hypermetropia (D) Myopia
6. **Farsightedness can be corrected by using: *(A.B)***
   (A) Converging lens (B) Diverging lens
   (C) Concave mirror (D) Convex mirror
7. **Power of concave lens is: *(K.B)***
   (A) Greater (B) Less
   (C) Positive (D) Negative
8. **Long sightedness is caused due eye ball being. *(K.B)***
   (A) Too thick (B) Too thin
   (C) Too short (D) Too long
9. **Near point of a normal human being is: *(K.B)*** **(GRW 2013)**
   (A) 25 cm (B) 50 cm
   (C) 100 cm (D) Infinity
10. **Long sightedness can be corrected by: *(A.B)***
   (A) Convex mirror (B) Concave mirror
   (C) Convex lens (D) Concave lens

MCQ'S ANSWER KEY (TOPIC WISE)

12.1 REFLECTION OF LIGHT

1	2	3	4	5	6	7	8	9
A	C	B	A	A	B	D	A	B

12.2 SPHERICAL MIRRORS

1	2	3	4	5	6	7	8	9
D	A	C	D	B	B	C	A	C

12.3 IMAGE LOCATION BY SPHERICAL MIRROR FORMULA

1	2	3	4
C	A	B	A

12.4 REFRACTION OF LIGHT

1	2	3	4	5	6	7	8
B	C	C	A	C	B	C	B

12.5 TOTAL INTERNAL REFLECTION

1	2	3	4	5	6	7	8
B	B	B	A	A	B	B	D

12.6 APPLICATION OF TOTAL INTERNAL REFLECTION

1	2	3	4	5	6	7	8	9	10	11	12
C	B	C	C	A	C	D	C	A	B	B	C

12.7 REFRACTION THROUGH PRISM

1	2	3	4	5
D	A	C	C	A

12.8 LENSES

1	2	3	4	5	6	7	8	9	10	11
C	D	A	C	C	D	C	B	B	A	C

12.9 IMAGE FORMATION BY LENSES

1	2	3	4
A	A	A	D

12.10 IMAGE LOCATION BY LENSES

1	2	3	4
B	B	D	B

12.11 APPLICATION OF LENSES

1	2	3	4
D	D	C	A

12.12 SIMPLE MICROSCOPE

1	2

B	B

12.13 COMPOUND MICROSCOPE

1	2
D	A

12.14 TELESCOPE

1	2
C	A

12.15 THE HUMAN EYE

1	2	3	4
A	B	A	B

12.16 DEFECTS OF VISION

1	2	3	4	5	6	7	8	9	10
C	A	A	A	C	A	D	C	A	D

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. **Which of the following quantity is not changed during refraction of light? *(K.B)***
(a) its direction (b) its speed
(c) its frequency (d) its wavelength

ii. **A converging mirror with a radius of 20cm creates a real image 30cm from the mirror. What is the object distance? *(U.B+A.B)***
(a) –5.0cm (b) –7.5cm
(c) –15cm (d) –20cm

iii. **An object is placed at the centre of curvature of a concave mirror. The image produced by the mirror is located: *(K.B)***
(a) out beyond the centre of curvature
(b) at the centre of curvature
(c) between the centre of curvature and the focal point
(d) at the focal point

iv. **An object is 14cm in front of a convex mirror. The image is 5.8cm behind the mirror. What is the focal length of the mirror? *(U.B+A.B)***
(a) –4.1cm (b) –8.2cm
(c) –9.9cm (d) –20cm

v. **The index of refraction depends on: *(K.B)***
(a) the focal length (b) the speed of light
(c) the image distance (d) the object distance

vi. **Which type of image is formed by a convex lens on a screen? *(K.B)***
(a) inverted and real (b) inverted and virtual
(c) upright and real (d) upright and virtual

vii. Which type of image is produce by the converging lens of human eye if it views a distant object? *(K.B)*
(a) real, erect same size (b) real, inverted, diminished
(c) virtual, erect, diminished (d) virtual, inverted, magnified

viii. Image formed by a camera is: *(K.B)*
(a) real, inverted and diminished (b) virtual, upright and diminished
(c) virtual, upright and magnified (d) real, inverted and magnified

ix. If a ray of light in glass is incident on an air surface at an angle greater than the critical angle, the ray will: *(K.B)*
(a) refract only (b) reflect only
(c) partially refract and partially reflect (d) diffract only

x. The critical angle for a beam of light passing from water into air is 48.8 degrees. This means that all light rays with an angle of incidence greater than this angle will be: *(K.B)*
(a) absorbed (b) totally reflected
(c) partially reflected and partially transmitted (d) totally transmitted

ANSWER KEY

i	ii	iii	iv	V	vi	vii	viii	ix	x
C	C	B	C	B	A	B	A	B	B

REVIEW QUESTIONS

12.1 What do you understand by reflection of light? Draw a diagram to illustrate reflection at a plane surface. *(K.B)*
Ans: (See Topic 12.1, Short Question-1)

12.2 Describe the following terms used in reflection: *(K.B)*
(i) Normal (ii) Angle of incidence (iii) Angle of reflection
Ans:
ANGLE OF INCIDENCE
Definition:
“The angle between the incident ray and normal is called as angle of incidence (i)**”**
ANGLE OF REFLECTION
Definition:
“The angle between normal and reflected ray at the point of incidence is called as angle of reflection (r)**”**
NORMAL
Definition:
“A line (imaginary) at right angle to the plan (surface) is called normal to the surface**”**

12.3 State laws of reflection. Describe how they can be verified graphically. *(K.B+U.B)*
Ans: (See Topic 12.1, Long Question-1)

12.4 Define refraction of light. Describe the passage of light through parallel-sided transparent material. *(K.B)*
Ans: (See Topic 12.4, Long Question-1)

12.5 Define the following terms used in refraction: *(K.B)*
(i) Angle of incidence (ii) Angle of refraction
Ans:
ANGLE OF INCIDENCE
Definition:
“Incidence ray makes an angle with normal line is called angle of incidence**”**
ANGLE OF REFRACTION
Definition:

"The angle made by refracted ray with normal line is called angle of refraction"

12.6 What is meant by refractive index of a material? How would you determine the refractive index of a rectangular glass slab? *(K.B+U.B+A.B)*

Ans: (See Topic 12.4, Long Question-2)

12.7 State the laws of refraction of light and show how they may be verified using rectangular glass slab and pins. *(K.B+U.B+A.B)*

Ans: (See Topic 12.4, Long Question-2)

12.8 What is meant by the term total internal reflection? *(K.B)*

Ans: (See Topic 12.5, Short Question-2)

12.9 State the conditions for total internal reflection. *(K.B)*

Ans: (See Topic 12.5, Short Question-3)

12.10 What is critical angle? Derive a relationship between the critical angle and the refractive index of a substance. *(K.B+A.B+U.B)*

Ans: (See Topic 12.5, Long Question-1)

12.11 What are optical fibres? Describe how total internal reflection is used in light propagating through optical fibres. *(K.B+A.B+U.B)*

Ans: (See Topic 12.6, Long Question-2)

12.12 Define the following terms applied to a lens: *(K.B)*
(i) Principal axis (ii) Optical centre (iii) Focal length

Ans: (See Topic 12.8, Long Question-4)

12.13 What is meant by the principal focus of a (a) convex lens (b) concave lens? Illustrate your answer with ray diagrams. *(K.B +U.B)*

Ans: (See Topic 12.8, Long Question-4)

12.14 Describe how light is refracted through convex lens. *(K.B +U.B)*

Ans: (See Topic 12.9, Long Question-1)

12.15 With the help of a ray diagram, how can you show the use of thin converging lens as a magnifying glass? *(K.B)*

Ans: (See Topic 12.12, Short Question-3)

12.16 A coin is placed at a focal point of a converging lens. Is an image formed? What is its nature? *(K.B)*

Ans: (See Topic 12.9, Long Question-2) (object at F)

12.17 What are the differences between real and virtual images? *(K.B)*

Ans:

DIFFERENCE

Real Image	Virtual Image
• The image that can be obtained on screen is called real image • In real image, rays of light actually converge to form image • Image is inverted	• The image that can not be obtained on screen is called virtual image. • In virtual image, rays of light appear to diverge • Virtual image is erect

12.18 How does a converging lens form a virtual image of a real object? How does a diverging lens form a real image of a real object? *(K.B)*

Ans:

CONVERGING LENS

- Converging lens form a virtual image of real object when the object is placed between optical centre and principal focus. The image is formed behind the object, virtual and larger in size than object.

DIVERGING LENS

- Diverging lens form a virtual image of real objects therefore, it is not possible for a diverging or concave lens to form a real image of real object.

12.19 Define power of a lens and its units. ***(K.B)***

Ans: (See Topic 12.8, Short Question-6)

12.20 Describe the passage of light through a glass prism and measure the angle of deviation. ***(K.B+U.B+A.B)***

Ans: (See Topic 12.7, Long Question-1)

12.21 Define the terms resolving power and magnifying power. ***(K.B)***

Ans: (See Topic 12.12, Long & Short Question-1)

12.22 Draw the ray diagrams of ***(U.B+K.B)***

(i) Simple microscope (ii) Compound microscope (iii) Refracting telescope

Ans: *Given on previous pages 125,127,129*

12.23 Mention the magnifying powers of the following optical instruments ***(K.B)***

(i) Simple microscope (ii) Compound microscope (iii) Refracting telescope

Ans:

SIMPLE MICROSCOPE

Magnifying Power:

Magnifying power of simple microscope can be determined by using formula:

$$M = \frac{\theta'}{\theta} = \frac{\text{Angular size of final image produced by magnifying glass}}{\text{Angular size of object seen without glass}}$$

OR $$M = \frac{\theta'}{\theta} = 1 + \frac{d}{f}$$

COMPOUND MICROSCOPE

Magnifying Power:

Magnifying power of compound microscope can be determined by using formula:

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

TELESCOPE

Magnifying Power:

Magnifying power of telescope can be determined by using formula.

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

12.24 Draw ray diagrams to show the formation of images in the normal human eye. ***(K.B)***

Ans:

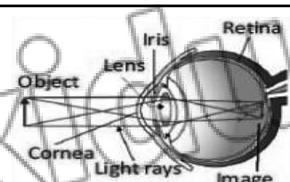


Figure: Image Formation in Human Eye

12.25 What is meant by the terms nearsightedness and farsightedness? How can these defects be corrected? ***(K.B+U.B+A.B)***

Ans: (See Topic 12.6, Long Question-1)

CONCEPTUAL QUESTIONS

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

Ans:

IMAGE BY PLANE MIRROR

Images produced by the plane mirror are virtual, upright, left-right reversed, the same distance from the mirror and of same size as object.

A plane mirror produces virtual image. If we view an image of our self in a plane mirror, we will quickly notice that there is an apparent left right reversal of the image. That's why if we raise our left hand, the image facing him raising his right hand due to the left-right reversal of the orientation.

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

Ans: **REFRACTION OF LIGHT WAVES**

When light rays enter from one transparent medium into another medium the speed of light changes due to change in wavelength. The speed of light is different in different materials due to difference in densities so light rays are refracted at the boundary between two materials.

12.3 Explain why a fish under water appears to be at a different depth below the surface than it actually is. Does it appear deeper or shallower?

Ans: **FISH IN WATER**

A fish under water appears to be at different depth below the surface, it appears to be shallower because apparent depth is always less than the real depth and image is formed after the refraction of light in water at the apparent depth.

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

Ans: **CONCAVE MIRRORS FOR MAKEUP**

Concave mirrors are suitable for make up because when a person stands between principal focus and pole of mirror, he sees an enlarge erect and virtual image of his face and it is not suitable, when a person is not with in the focal length of mirror because the image formed will be real and inverted.

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

Ans: **DRIVER'S SIDE MIRROR AS CONVEX**

The image formed by the convex mirror is always virtual, erect and diminished so convex mirrors are used in automobiles which enable the driver to see the automobiles coming behind him.

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.

Ans: **OPTICIAN'S TESTING FORSIGHT**

If the optician's room is small, then for testing the patients eye sight original words are placed at the back side of patient and mirror is placed in front of the patient. So, that the image of words is formed at the distance doubled than the size of room.

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

Ans: **EFFECT OF THICKNESS OF A LENS**

As we know that f=R/2, focal length is half of the radius of curvature. Thickness of lens (or) curvature of lens affect the focal length of lens. A thick lens has short focal length and a thin lens has large local length.

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

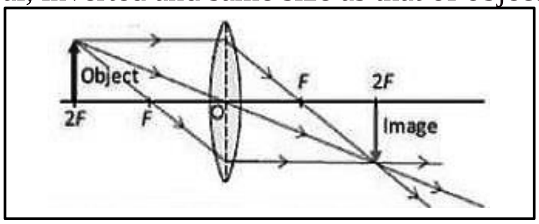
Ans: **VIRTUAL IMAGE BY CONVERGING LENS**

If the object is placed between principal focus and optical centre of converging lens, the image formed will be virtual, erect and large in size than the object.

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

Ans: **REAL & SAME SIZE IMAGE**

If object is placed at a distance of 2F from the optical centre of converging lens, the image formed will be real, inverted and same size as that of object.



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

Ans: **REFRACTIVE TELESCOPE WITH LARGE OBJECTIVE LENS**

In telescope, objective lens of large focal length is used in order to collect information of distant object from infinity. Objective lens forms a real, inverted and diminished image at the principal foucs of objective lens. This image acts as an object for the eye piece lens and this lens forms the large, errects virtual image at a large distance from the objective lens.

NUMERICAL PROBLEMS (U.B + A.B)

12.1 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 Data:

Distance of object = p = 10 cm

Distance of image = q = –5 cm (For convex mirror)

Required:

Focal length f = ?

Formula:

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

Calculations:

By putting the values

$$\frac{1}{f}=\frac{1}{10cm}-\frac{1}{5cm}$$

$$=\frac{1-2}{10cm}$$

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

f = –10 cm

Result:

Hence the focal length of convex mirror is 10 cm. Here, negative sign indicates that image is virtual.

12.2 An object 30.0 cm tall is located 10.5 cm from a concave mirror with focal length 16.0cm. (a) Where is the image located) (b) How high is it?

Solution:

Given Data:

Object height = h_o = 30 cm

Distance of object = p = 10.5 cm

Focal length = f = 16 cm

Required:

(a) Distance of image = q = ?

(b) Image height = h_i = ?

Formula:

(a) Using the formula

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

(b) we know that

$$\frac{image\,height}{object\,height}=\frac{q}{p}$$

Calculations:

(a) By using formula, we have

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

Or $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

$$\frac{1}{q}=\frac{1}{16\,cm}-\frac{1}{10.5\,cm}$$

Or $$\frac{1}{q}=\frac{1}{16\,cm}-\frac{10}{105\,cm}$$

$$=\frac{105-160}{(16)(105)\,cm}$$

$$=-\frac{55}{(16)(105)\,cm}$$

q = –30.54 cm

(b) By using formula, we have

or $$\frac{h_i}{h_o}=\frac{q}{p}$$

by putting the values

$$\frac{h_i}{30\,cm}=\frac{30.54\,cm}{10.5\,cm}$$

$$h_i=\frac{30.54\,cm}{10.5\,cm}\times 30\,cm$$

h_i = 87.26 cm

Result:

Hence the distance of image will be 30.54 cm from concave mirror. Here, negative sign indicates the image is virtual. The height of image formed will be 87.26 cm.

12.3 An object and its image in a concave mirror are of the same height, yet inverted, when the object is 20.0 cm form the mirror. What is the focal length of the mirror?

Solution:

Given Data:

Distance of object = p = 20 cm

Distance of image = q = 20 cm

Required:

Focal length = f =?

Formula:

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

Calculations:

By using the formula, we have

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

$$=\frac{1+1}{20\,\text{cm}}$$

$$=\frac{2}{20\,\text{cm}}$$

$$f=\frac{20\,\text{cm}}{2}$$

$$f = 10\text{ cm}$$

Result:

Hence, the focal length of mirror will be 10 cm.

12.4 Find the focal length of a mirror that form an image 5.66 cm behind a mirror of an object placed at 34.4 cm in front of the mirror

Solution:

Given Data:

Distance of the image form the mirror = q = 5.66

Distance of object form the mirror = p = 34.4 cm

Required:

Find out the focal length of the mirror = f = ?

Formula:

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

Calculations:

By using the above formula

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

As the image is formed behind the mirror, so it would be convex mirror, so q will be taken negative.

q = - 5. 66 cm

p = + 34 .4 cm

By substituting values in above equation, we get;

$$\frac{1}{f}=-\frac{1}{5.66}+\frac{1}{34.4}$$

$$\frac{1}{f}=-0.177+0.029$$

$$\frac{1}{f}=-0.148$$

$$f=-6.77cm$$

Result:

Hence, the focal length of mirror will be 6.77 cm and here, negative sign indicates that the image is virtual.

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

Solution: **(GRW 2014)**

Given Data:

Distance of image = q = –11.5 cm (For convex mirror)

Focal length = f - 13.5 cm

Required:

Distance of object = p = ?

Formula:

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

Calculations:

By using the formula, we have

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

Or $$\frac{1}{p} = \frac{1}{f} - \frac{1}{q}$$

By putting the values

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

$$= \frac{-11.5 + 13.5}{(13.5)\,(11.5)\,cm}$$

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

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

$$p = 77.62 \text{ cm}$$

Result:

Hence the distance of statue from the mirror will be 6.21 cm.

12.6 An image is produced by a concave mirror of focal length 8.70cm. 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:

Given Data:

Focal length f = 8.70 cm

Object height h_o = 13.2 cm

Distance of object p = 19.3 cm

Required:

(a) Location of image = q = ?

(b) Height of image = h_o = ?

Formula:

(a) $$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

(b) $$\frac{h_i}{h_o} = \frac{q}{p}$$

Calculations:

(a) By using the formula, we have

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

Or $$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

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

$$\frac{1}{q} = \frac{19.3 - 8.7}{(8.7)\,(19.3)\,cm}$$

$$\frac{1}{q} = \frac{10.6}{167.9\,cm}$$

$$q = \frac{167.9\,cm}{10.6}$$

$$q = 15.83 \text{ cm}$$

(b) By using the formula, we have

$$\frac{h_i}{h_o} = \frac{q}{p} \Rightarrow h_i = \frac{q}{p} \times h_0$$

By putting the values

$$h_i = \frac{15.84\,cm}{19.3\,cm} \times 13.2 \text{ cm}$$

$$h_i = 10.83 \text{ cm}$$

(b) When the object is twice as far from the mirror, then

p = 19.3 cm × 2 = 38.6 cm

Now, again using the formula

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or $$h_i = \frac{q}{p} \times ho$$

By putting the values

$$h_i = \frac{15.84\,cm}{38.6\,cm} \times 13.2 \text{ cm}$$

$$h_i = 5.42 \text{ cm}$$

Result:

Hence the image formed will be at the distance of 15.83cm and the image height will be 10.83 cm. But if object is at double distance then height will be 5.42 cm.

12.7 Nabeela uses a concave mirror when applying makeup. The mirror has a radius of curvature of 38.0 cm. (a) what is the focal length of the mirror? (b) Nabeela is located 50cm from the mirror. Where will her image appear? (c) Will the image be upright or invited?

Solution:

Given Data:

Radius of curvature = R = 38 cm
Distance of object = p = 50 cm

Required:

(a) Focal length = f = ?
(b) Distance of image = q = ?
(c) Nature of image = ?

Formula:

(a) $f = \frac{R}{2}$

(b) $\frac{1}{f} = \frac{1}{q} + \frac{1}{p}$

Calculations:

(a) By using the formula, we have

$$f = \frac{R}{2}$$

or $f = \frac{38\,cm}{2}$

$f = 19$ cm

(b) Using the formula

$$\frac{1}{f} = \frac{1}{q} + \frac{1}{p} \text{ Or } \frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

$$\frac{1}{q} = \frac{1}{19\,cm} - \frac{1}{50\,cm}$$

$$= \frac{50 - 19}{(19)\,(50)\,cm} = \frac{31}{950\,cm}$$

Therefore, $q = \frac{950\,cm}{31} \Rightarrow q = 30.64$ cm

(c) **Nature of image:**

The image formed will be real, inverted and smaller in size than object.

Result:

Hence, the focal length of mirror will be 19 cm and distance of image will be 30.64 cm. The image formed will be real, inverted and smaller in size than object.

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

Solution:

Given Data:

Height of object = ho = 4cm
Distance of object = p = 12 cm
Focal length = f = 8 cm

Required:

(a) Position of image = q = ?
(b) Size of image = h_i = ?
(c) Nature f the image = ?

Formula:

(a) $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

(b) $\frac{h_i}{h_o} = \frac{q}{p}$

Calculations:

(a) By using the formula, we have

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

By putting the values

$$\frac{1}{q} = \frac{1}{8\,cm} - \frac{1}{12\,cm}$$

$$= \frac{12 - 8}{(8)\,(12)\,cm} = \frac{4}{96\,cm}$$

$$q = \frac{96\,cm}{4} \Rightarrow q = 24 \text{ cm}$$

(b) by using formula, we have

$$\frac{h_i}{h_o} = \frac{q}{p} \Rightarrow h_i = \frac{q}{p} \times h_o$$

By putting the values

$$h_i = \frac{24\,cm}{12\,cm} \times 4cm$$

$$h_i = \frac{96\,cm}{12\,cm} \Rightarrow h_i = 8 \text{ cm}$$

(c) **Image nature:**

Since the lens in convex and size of image is larger than the size of the object, therefore, image formed is real, inverted and magnified.

Result:

Hence, the position of the image will be 24 cm and the size of image will be 8 cm. Since the lens in convex and size of image is larger than the size of the object, therefore, image formed is real, inverted and magnified.

12.9 An object 10cm high is placed at a distance of 20cm from a concave lens of focal length 15cm high is placed at a instance of 20 cm from a concave lens of focal length 15cm. Calculate the position and size of the image. Also state the nature of the image. (LHR 2014)

Solution:

Given Data:

Size of object = ho = 10 cm

Distance of object = p = 20 cm

Focal length = f = –15 cm (for concave lens)

Required:

(a) Politico of image = q = ?

(b) Size of image = h_i = ?

(c) Nature of image = ?

Formula:

Calculations:

(a) By using the formula, we have

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

or

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

By putting the values

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

$$= \frac{-4-3}{60\,cm} = \frac{-7}{60\,cm}$$

$$q = -\frac{60}{7}cm = -8.57\text{ cm}$$

(b) By using formula, we have

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or $h_i = \frac{q}{p} \times h_o$

By putting the values

$$h_i = \frac{8.57\,cm}{20\,cm} \times 10cm \Rightarrow h_i = 4.28\text{ cm}$$

(c) **Image nature:**

Since the lens is concave and object is larger in size than the size of the image, tTherefore, the image in virtual, erect and diminished.

Result:

Hence, the position of image will be 8.57 cm. Here negative sign indicates that image is virtual. The size of image will be 4.28 cm. Image will be virtual erect and diminished.

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

Solution:

Given Data:

Focal length = f = 6 cm (For virtual image)

Distance of image = q = –3p

Required:

Distance of object p = ?

Formula:

By using the formula, we have

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

Calculations:

By putting the values,

$$\frac{1}{6\,cm} = \frac{1}{p} - \frac{1}{3p}$$

$$\frac{1}{6\,cm} = \frac{3-1}{3p}$$

$$\frac{1}{6\,cm} = \frac{2}{3p}$$

Or 3p = 12 cm

$$p = \frac{12\,cm}{3}$$

p = 4cm

Result:

Hence, the distance of object will be 4 cm form convex lens.

12.11 A ray of light from air is incident on a liquid surface at an angle of incidence 35°. Calculate the angle refraction if the refractive index of the liquid is 12.5. Also calculate the critical angle between the liquid air inter-face.

Solution:

Given Data:

Angle of incidence i = 35°

Refractive index n = 1.25

Required:

(a) Angle of refraction r = ?

(b) Critical angle = C = ?

Formula:

(a) $n = \frac{\sin \hat{i}}{\sin \hat{r}}$

(b) $\sin C = \left(\frac{1}{n}\right)$

Calculations:

(a) Using Snell's law

$$n = \frac{\sin \hat{i}}{\sin \hat{r}}$$

Or $\sin r = \frac{\sin i}{n}$

By putting the values

$$\sin r = \frac{\sin(35^o)}{1.25}$$

$$\sin r = \frac{0.57}{1.25}$$

$$= 0.456$$

$$r = \sin^{-1}(0.456)$$

$$r = 27.13^o$$

(b) For critical angle. We know that

$$\sin C = \left(\frac{1}{n}\right)$$

or $C = \sin^{-1}\left(\frac{1}{n}\right)$

By putting the values

$$C = \sin^{-1}\left(\frac{1}{1.25}\right)$$

$$= \sin^{-1}(0.8)$$

$$C = 52.13^o$$

Result:

Hence, the angle of reflection of light from air to liquid will be 27.12° and critical angle between liquid air inter-face will be 52.13°.

12.12 The power of a convex lens is 5D. At what distance the object should be placed from the lens so that its real and 2 times larger image is formed. (LHR 2013, LHR 2016)

Solution:

Given Data:

Power of the lens p = 5D

Size of image = q = 2p

Required:

Distance of object = p = ?

Formula:

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

Calculations:

To find the distance object from convex lens, first we have to find the focal length of lens. So that by using formula, we have

Power of lens $p = \frac{1}{f}$

or $5 = \frac{1}{f}$

or $f = \frac{1}{5}$

or $f = 0.2\text{m}$

$$= \frac{2}{10} \times 100 \text{ cm} = 20 \text{ cm}$$

Now using the formula

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

By putting the values

$$\frac{1}{20\,\text{cm}} = \frac{1}{p} + \frac{1}{2p}$$

$$\frac{1}{20\,\text{cm}} = \frac{2+1}{2p}$$

$$\frac{1}{20\,\text{cm}} = \frac{3}{2p}$$

$$2p = 60 \text{ cm}$$

$$p = \frac{60\,\text{cm}}{2}$$

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

Result:

Hence, the distance of object from the convex

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. In a convex mirror the size of the image:
(A) Is smaller than the size of the object (B) Is greater than the size of the object
(C) Depends upon the position of the object (D) Is equal to the size of the object

2. The index of refraction depends on:
(A) The focal length (B) The speed of light
(C) The image distance (D) The object distance

3. An object is 14 cm in front of a convex mirror. The image is 5.8 cm behind the mirror. What is the focal length of the mirror?
(A) 4.1 cm (B) 8.2 cm
(C) 9.9 cm (D) 20 cm

4. After refraction from a convex lens, rays of light parallel to the principal axis converge at a point, this point of convex lens is called:
(A) Principal focus (B) Pole
(C) Focal length (D) Optical centre

5. The focal length is related to radius of curvature by the formula:
(A) $f = \frac{R}{2}$ (B) $f = 2R$
(C) $f = R2$ (D) $f = 3R$

6. Optical fibers work on the principle of:
(A) Refraction (B) Continuous refraction
(C) Total internal reflection (D) Both B & C

Q.2 Give short answers to following questions. **(5×2=10)**

i. State laws of reflection.
ii. What are the characteristics of focus of a concave and convex mirror?
iii. What is meant by total internal reflection?
iv. Define power of a lens. Give its mathematical form and SI unit.
v. Illustrate the image formation in a convex lens with the help of a ray diagram when the object is place beyond 2F.

Q.3 Answer the following questions in detail. **(4+5=9)**

a) What is meant by total internal reflection? Explain in detail.
b) An object 10 cm high is placed at a distance of 20 cm from a concave lens of focal length 15 cm. Calculate position and size of the image. Also, state the nature of the image.

<u>Note</u>:
Parents or guardians can conduct this test in their supervision in order to check the skill of students.

UNIT 12

GEOMETRICAL OPTICS

12.1 REFLECTION OF LIGHT

LONG QUESTIONS

Q.1 Define reflection of light. Also describe the laws and types of reflection.
(LHR-G2)-2015 / (BWP-G1),(FSD-G1),(LHR-G1 / G2),(MTN-G1 / G2)-2014 / (GRW-G1 / G2),(SGD-G2),(FSD-G1),(MTN-G2),(SWL-G1)-2015 / (SGD-G1),(RWP-G2),(AJK-G1)-2016 / (LHR-G2),(GRW-G2),(MTN-G1),(GRW-G2),(RWP-G2),(SGD-G1)-2017

Ans: **REFLECTION OF LIGHT**

Definition:

"When light travelling in a certain medium falls on the surface of another medium, a part of it turns back in the same medium. This is called reflection of light**"**.

Explanation:

When a ray of light from air along the path AO falls on a plane mirror M, it is reflected along the path OB. The ray AO is called incident ray while the ray OB is called reflected ray. The angle between incident ray AO and normal N, i.e., $\angle$ AON is called the **angle of incidence** represented by i. The angle between the normal and the reflected ray OB, i.e., $\angle$ NOB is called **angle of reflection** represented by r. (As shown in figure)

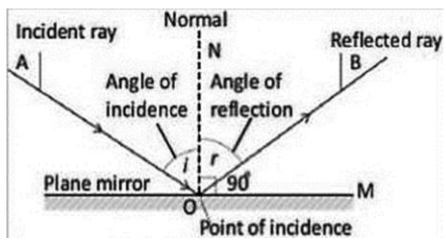


Figure: Reflection of Light

LAWS OF REFLECTION

Following are the laws of reflection:

- The incident ray, the normal, and the reflected ray at the point of incidence all lie in the same plane.
- The angle of incidence is equal to the angle of reflection i.e., $\angle\hat{i} = \angle\hat{r}$

TYPES OF REFLECTION

Nature of reflection depends on smoothness of the surface. On the basis of nature of surface there are two following types of reflection.

- Regular reflection
- Irregular reflection

Regular Reflection:

Definition:

"The reflection by smooth surfaces is called regular reflection**"**.

Example:

A smooth surface of silver reflects parallel rays of light in one direction only.
(As shown in figure)

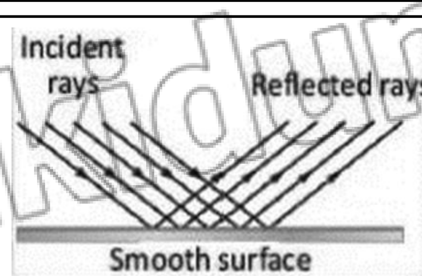


Figure: Regular Reflection

- Most of the objects in everyday life are not smooth on the microscopic level.

Irregular Reflection:

Definition:

"The reflection by rough surfaces is called irregular reflection".

Example:

The rough surfaces of objects reflect the ray of light in many directions.
(As shown in figure)

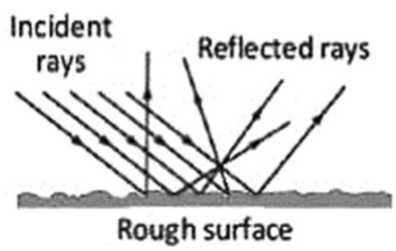


Figure: Irregular Reflection

SHORT QUESTIONS

Q.1 What is meant by reflection of light? **(GRW-G1),(SWL-G2)-2014 / (RWP-G1)-2016**

Ans: **REFLECTION OF LIGHT**

Definition:

"When light travelling in a certain medium falls on the surface of another medium, a part of it turns back in the same medium. This is called reflection of light".

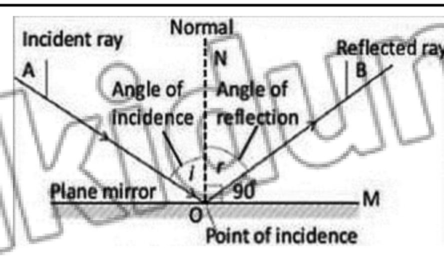


Figure: Reflection of Light

Q.2 State laws of reflection.
(BWP-G1),(FSD-G1),(LHR-G1 / G2),(MTN-G1 / G2)-2014 / (GRW-G1 / G2),(SGD-G2),(FSD-G1),(MTN-G2),(SWL-G

Ans: See Long Question.1 (Heading: Laws of reflection)

Q.3 What are the types of reflection? **(SGD-G2),(MTN-G2)-2016**

Ans: See Long Question. 1 (Heading: Types of Reflection)

Q.4 Difference between regular and irregular reflection.
(GRW-G2),(LHR-G1 / G2)-2014 / (BWP-G1)-2017

Ans: **DIFFERENTIATION**

The differences between regular and irregular reflection are as follows:

Regular Reflection	Irregular Reflection
Definition	
• In regular reflection smooth surfaces reflect the light in one direction only. This reflection is called regular reflection.	• In irregular reflection the rough surfaces reflect the rays of light in many directions. This reflection is called irregular reflection.

Q.5 Differentiate between angle of incidence and angle of reflection. **(MTN-G2)-2017**

Ans: **DIFFERENTIATION**

The differences between angle of incidence and angle of reflection are as follows:

Angle of Incidence	Angle of Reflection
Definition	
• The angle between incidence ray and normal is called angle of incidence.	• The angle between normal and reflected ray is called angle of reflection.
Symbol	
• Angle of incidence is denoted by i.	• Angle of reflection is denoted by r.

Q.6 How are we able to see a page of a book? **(Physics of Light Pg. # 37)**

OR Why do we see printed words as black area on a page?

Ans: **PHYSICS OF LIGHT**

We can see a page of a book because light reflects from each part of page in all directions, so that some of the light rays from each part of the page enter our eye because almost no light is reflected by the printed words, therefore, we "see" then as black areas.

Figure: Physics of Light

Q.7 What were the main ideas about the nature of light in early 1700 S?

(For your information Pg # 37)

Ans: **NATURE OF LIGHT IN EARLY 1700 S**

In the early 1700 S, there were two main ideas about the nature of light:

- Particle nature
- Wave nature

Q.8 What theories were given by following scientists about the nature of light?

(For your information Pg # 37)

Ans: **THEORIES ABOUT THE NATURE OF LIGHT**

Newton:

Newton put forward the idea of corpuscular nature of light. According to him, light consist of, fast moving particles.

Maxwell:

He formulated the wave theory of light.

Thomas Young:

In 1802, Thomas Young proved the wave nature of light experimentally.

Planck:

In 1990, Planck suggested that light consist of small packets of energy called photons. Later on, the idea of photons was confirmed by experiments.

Q.9 Why do we see an inverted image in a plane mirror? **(For Your Information Pg. # 38)**

Ans: **INVERTED IMAGE**

Light rays can reflected in a plane mirror, causing us to see an inverted image.

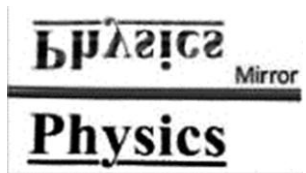


Figure: Plane Mirror

Q.10 What will be the nature of images formed by a flat mirror?
(For Your Information Pg. # 38)

Ans: **NATURE OF IMAGE**

The image you see in a flat mirror is at the same distance behind the mirror as you are in front of it.

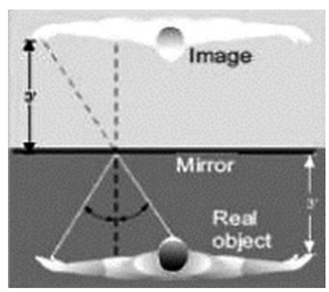


Figure: Flat Mirror

MULTIPLE CHOICE QUESTIONS

1. Laws of reflection are: **(BWP-G2)-2015**

(A) 2 (B) 3
(C) 4 (D) 5

2. Plank suggested that light consists of small packets of energy called:

(A) Electrons (B) Neutrons
(C) Photons (D) Positrons

3. The angle between incident ray and normal N is:

(A) Angle of reflection (B) Angle of incidence
(C) Angle of refraction (D) Normal angle

4. Angle of incidence is represented by:

(A) i (B) e
(C) R (D) p

5. The angle between the normal and the reflected ray is called angle of:

(A) Angle of reflection (B) Angle of refraction
(C) Angle of incidence (D) Diffraction

6. The incident ray, the normal, and the reflected ray at the point of incidence all lie in the:

(A) Opposite direction (B) Same plane
(C) x and y axis (D) y & z - axis

7. According to law of reflection:
(A) i > r (B) i < r
(C) r > i (D) i = r

8. Regular reflection is reflection by the:
(A) Rough surface (B) Smooth surface
(C) Irregular surface (D) Smooth and rough surfaces

9. The rough surfaces of object reflect the rays of light in many directions which is called:
(A) Regular reflection (B) Irregular reflection
(C) Refraction (D) Interference

12.2 SPHERICAL MIRRORS

LONG QUESTIONS

Q.1 What do you know about spherical mirrors? Also describe the types of spherical mirrors.

Ans: **SPHERICAL MIRRORS**

Definition:

"A mirror whose polished, reflecting surface is a part of a hollow sphere of glass or plastic is called a spherical mirror".

Construction:

In a spherical mirror, one of the two curved surfaces is coated with a thin layer of silver followed by a coating of red lead oxide paint. Thus, one side of the spherical mirror is opaque and the other side is a highly polished reflecting surface.

TYPES OF SPHERICAL MIRRORS

Depending upon the nature of reflecting surface, there are two types of spherical mirrors (as shown in figure)

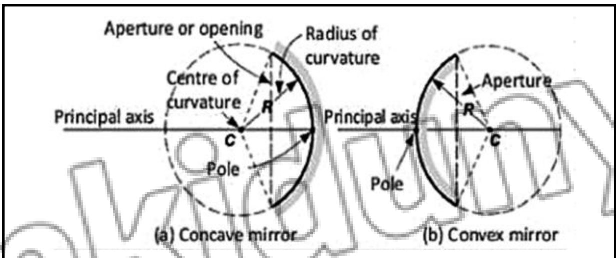


Figure: Types of Spherical Mirrors

Concave mirror:

Definition:

"A spherical mirror whose Inner curved surface is reflecting is called concave mirror".

Size of image:

In concave mirror the size of the image depends on the position of the object.

Nature of image:

Both virtual and real images can be formed by a concave mirror.

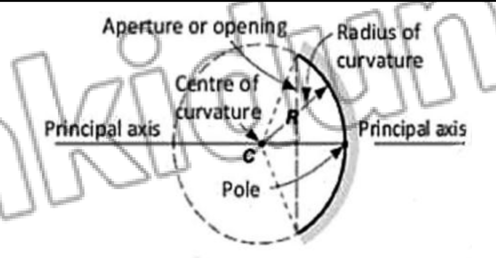


Figure: **Concave Mirror**

Convex Mirror:

Definition:

“A spherical mirror whose outer curved surface is reflecting is called convex mirror**”**.

Size of image:

In convex mirror the size of the image is always smaller than the object.

Nature of image:

Only virtual and erect image is formed by a convex mirror.

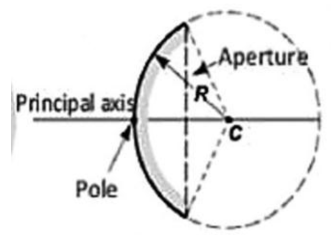


Figure: **Convex Mirror**

Q.2 Describe the following terms associated with spherical mirrors.

(MTN-G1)-2016, (FSD-G2)-2014 / (SGD-G2),(BWP-G1)-2016 / (DGK-G2)-2017, (BWP-G1)-2014 / (BWP-G1),(DGK-G

- **Pole**
- **Center of Curvature**
- **Radius of Curvature**
- **Principal Axis**

Ans: **TERMS ASSOSIATED WITH MIRRORS**

Pole:

Definition:

“It is the midpoint of the curved surface of spherical mirror. It is also called vertex**”**.

Centre of Curvature:

Definition:

“A spherical mirror is a part of a sphere. The centre of this sphere is called centre of curvature**”**. It is denoted by C.

Radius of Curvature (R):

Definition:

“It is the radius of the sphere of which spherical mirror is a part**”**. It is denoted by R.

Principal Axis:

Definition:

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

Q.3 Define the principal focus. How is different from principal focus of convex mirror?

Ans: **PRINCIPAL FOCUS**

Definition:

“After reflection from concave / convex mirror rays of light parallel to the principal axis converge to a point F or appeared to come from a point F. This point is called the principal focus of the mirror**”**.

Principal Focus of 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 concave mirror. (As shown in Figure). Hence, Concave mirrors are also called **converging mirrors**. Since rays actually pass through this point, therefore, it is called **real focus**. It is denoted by F.

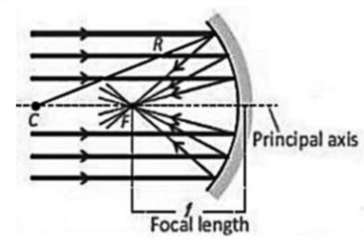


Figure: Principal Focus of Concave Mirror

Principal Focus of 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. In other words rays of light appear to diverge from F. This point is called the principal focus of the convex mirror. Convex mirrors are also called **diverging mirrors**. 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 (as shown in figure).

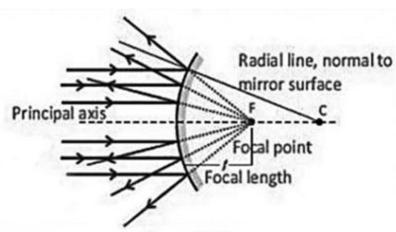


Figure: Principal Focus of Convex Mirror

SHORT QUESTIONS

Q.1 What are spherical mirrors? **(FSD-G2)-2015 / (MTN-G2),(DGK-G2)-2016**

Ans: **SPHERICAL MIRRORS**

Definition:

"A mirror whose polished, reflecting surface is a part of hollow sphere of glass or plastic is called a spherical mirror**"**.

Types:

There are two types of spherical mirrors:

- Concave mirror
- Convex mirror

Q.2 What is the relation between focal length and radius of a spherical mirror?
(FSD-G2)-2017

Ans: **RELATIONSHIP**

Focal Length:

Definition:

"It is the distance from the pole to the principal focus measured along the principal axis**"**.

Relation with Radius:

The focal length is related to the radius of curvature by $f = R/2$. This means that as the radius of curvature is reduced, so too is the focal length of the reflecting surface.

It is denoted by f.

Q.3 What are the characteristics of focus of a concave and a convex mirror?

(RWP-G1)-2016 / (RWP-G2)(DGK-G1)-2017

Ans: CHARACTERISTIFCS OF FOCUS

In case of Concave Mirror:

Following are the characteristics of focus of concave mirror:

- The focus lies in front of the concave mirror.
- The focus is real as the rays of light after reflection converge at the focus.

In case of convex mirror:

Following are the characteristics of focus of convex mirror:

- The focus lies behind the mirror.
- The focus is virtual as the rays of light after reflection appears to come from the focus.

Q.4 Explain the reflection of light by spherical mirrors with the help of diagram.

(LHR-G2)-2015

Ans: REFLECTION OF LIGHT BY SPHERICAL MIRORRS

Like plane surfaces, spherical surfaces also reflect light following the two laws of reflection as stated for plane surfaces.

Figure shows how light is reflected by the spherical surfaces of concave and convex mirrors according to the two laws of reflection.

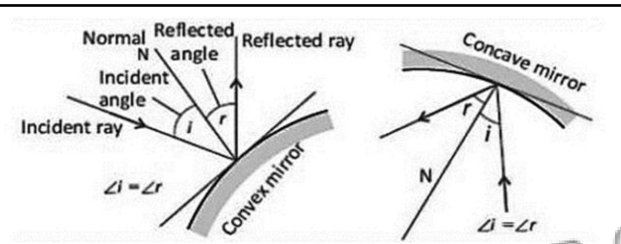


Figure: Reflection of Light by Spherical Mirrors

Q.5 Differentiate between concave and convex mirrrors.

(FSD-G1)(MTN-G2)(DGK-G2)-2014 / (LHR-G2)(SDG-G1)(SGD-G2)(AJK-G2) -2015 / (LHR-G1)-16

Ans: DIFFERENTIATION

The differences between concave and convex mirrors are as follows:

Concave Mirror	Convex Mirror
Definition	
• A mirror whose inner curved surface is reflecting is called concave mirror.	• A spherical mirror, whose outer curved surface is reflecting is called convex mirror.
Size of Image	
• In concave mirror, the size of image depends on the object position.	• In convex mirror, the size of image is always smaller than object.

Nature of Image	
• Both virtual and real images can be formed.	• Only virtual and erect images are formed.

Q.6 Differentiate between the focus of a concave & convex mirror?
(FSD-G1)(MTN-G2)(DGK-G2)-2014 / (LHR-G2)(SGD-G1),(SGD-G2)(AJK-G2)-2015 / (LHR-G1)-2016

Ans: **<u>DIFFERENTIATION</u>**

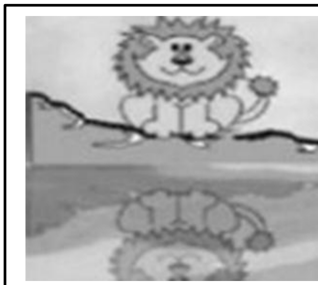
The differences between the focus of a concave and a convex mirror are given as follows:

Focus of Convex Mirror	Focus of Concave Mirror
Position	
• The focus lies behind the mirror.	• The focus is in front of the mirror.
Nature	
• 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.

Q.7 Through which phenomenon of physics the image of a lion is formed inside the pond of water? **(Can you tell Pg. # 39)**

Ans: **<u>IMAGE INSIDE THE POND WATER</u>**

In the picture below, a clear image of lion formed inside the pond water due to the phenomenon of reflection of light.



Q.8 Which mirrors are used in headlights? **(For your Information Pg. # 39)**

Ans: **<u>PARABOLIC MIRRORS</u>**

Parabolic mirrors are used in headlights.

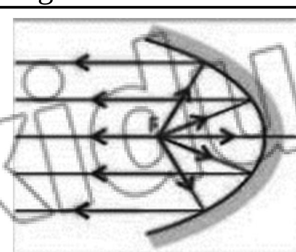


Figure: **<u>Parabolic Mirrors</u>**

Q.9 Write down the nature of image a pencil holded in front of well-polished spoon (using the outside of the spoon with the convex surface bulging outward). Also tell whether the image will move closer or father from the focus? **(Activity 12.1 Text Book Pg. # 40)**

Ans: **<u>IMAGE NATURE</u>**

Take a well-polished spoon (using outside of the spoon, with the convex surface bulging outward), and hold it in one hand, hold the pencil with its tip in the upright position in the other hand.

IMAGE NATURE

When we look at its image in the well-polished spoon, it seems to be erect, virtual and smaller and the image moves farther from the focus.

MULTIPLE CHOICE QUESTIONS

1. In convex mirror focus is: **(RWP-G2)-14**

(A) Centre of mirror (B) In front of mirror
(C) On the mirror (D) Behind the mirror

2. The formula for focal length is: **(LHR-G2),(RWP-G1)-2015 / (SWL-G2)-2017**

(A) $f = \frac{R}{2}$ (B) $f = \frac{R}{4}$
(C) $f = \frac{R}{3}$ (D) $f = \frac{R}{5}$

3. In concave mirror which surface is reflecting?

(A) Outer surface (B) Outer curved
(C) Inner curved surface (D) Side of the mirror

4. Which statement is incorrect about concave mirror?

(A) Size of image depends upon position of the object
(B) Both virtual and real images can form
(C) Inner surface of spherical mirror is reflecting
(D) Only virtual images are formed

5. A spherical mirror whose outer curved surface is reflecting is called:

(A) Concave mirror (B) Convex mirror
(C) Concave lens (D) Convex lens

6. Which statement is correct about convex mirror?

(A) Size of image is smaller than object (B) Only virtual & erect image is formed
(C) Outer curved surface is reflecting (D) All of the given statements are true

7. Vertex is the midpoint of the curved surface of spherical mirror and is also called:

(A) Radius of curvature (B) Principal axis
(C) Pole (D) Principal focus

8. A line joining centre of curvature and pole of the spherical mirror is:

(A) Principal axis (B) Principal focus
(C) Centre of curvature (D) Pole

9. The distance from the pole to the principal focus measured along the principal axis is:

(A) Principal focus (B) Radius of curvature
(C) Focal length (D) Diameter

12.3 IMAGE LOCATION BY SPHERICAL MIRROR FORMULA

LONG QUESTIONS

Q.1 What is spherical mirror formula?

OR How can we tell about the nature of image and the size of the image compared with the size of the object formed by the mirror with the help of mirror formula?

Ans: **SPHERICAL MIRRORS**

Definition:

"Mirror formula is the relationship between object distance p, image distance q from the mirror and focal length f of the mirror".

Explanation:

We use the spherical mirror formula to tell about the nature of image (whether image is real or imaginary) inverted or erect formed by a mirror. It also tells the size of the image in comparison with the size of the object.

Mirror Formula:

Thus, we can write mirror formula as:

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

- By using mirror formula, we can tell about the nature of image (whether image is real or imaginary or erect) and also about be the size of image compressed with the size of the object, formed by a mirror.

Validity:

Spherical mirror formula is true/valid for both concave and convex mirrors.

SHORT QUESTIONS

Q.1 What is meant by mirror formula? **(RWP-G2)-2016**

Ans: **MIRROR FORMULA**

Definition:

"Relationship between object distance p, image distance q, from the mirror and focal length of the mirror is called mirror formula".

Formula:

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

Q.2 Write down the sign conventions for concave and convex mirror.

Ans: **SIGN CONVENTIONS FOR SPHERICAL MIRRORS**

The sign conventions of concave and convex mirrors are as follows:

Quantity	When Positive (+)	When Negative (–)
Object distance (p)	Real object	Virtual object
Image distance (q)	Real image	Virtual image
Focal length (f)	Concave mirror	Convex mirror

Q.3 Spoon acts as which types of mirrors? **(Spoon as mirror Pg. # 40)**

Ans: **SPOON AS A SPHERICAL MIRROR**

A well-polished spoon acts as convex (left) and concave (right) mirror.

Figure: Spoon as a Spherical Mirror

Q.4 Where does focus and centre of curvature lies for convex mirror?

(Physics insight Pg. # 40)

Ans: **POSITION OF FOCUS AND CENTRE OF CURVATURE**

For a convex mirror focus and center of curvature lies behind the mirror.

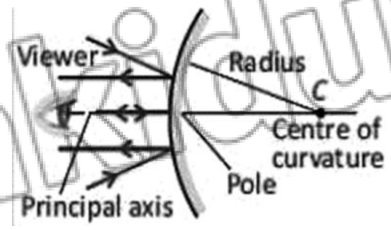


Figure: Spoon as a Spherical Mirror

Q.5 Why convex mirrors are used in shopping mall? **(Point to ponder Pg. # 40)**

Ans: **CONVEX MIRROR IN SHOPPING MALL**

In large shopping malls convex mirrors are used for security purpose.

Figure: Convex Mirror in Shopping Mall

Q.6 Why the focal length of a convex mirror is taken as negative? **(LHR-G2)-2015**
(For Your Information Pg. # 41)

Ans: **FOCAL LENGTH OF CONVEX MIRROR**

The focal length of spherical mirror is one half of the radius of curvature i.e. $f = \frac{R}{2}$.

However, we take the focal length of a convex mirror as negative. It is because the rays appear to come from focal point behind the mirror. Therefore, for a convex mirror, $f = -\frac{R}{2}$

Q.7 Why the term magnification does is different from the term enlargement in optics?
(Physics insight Pg. # 41)

Ans: **MAGNIFICATION VS ENLARGEMENT**

The word magnification as used in optic does not only mean enlargement because the image could be smaller than the object.

Q.8 Draw the ray diagram for the virtual image in a plane mirror?
(For Your Information Pg. # 41)

Ans: **RAY DIAGRAM**

For the virtual image formation in a plane mirror, the ray diagram is given below:

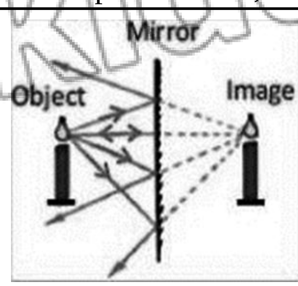


Figure: Virtual Image in a Plane Mirror

Q.9 How does convex mirror increase the view of observer? **(Do you know Pg. # 41)**

Ans: **INCREASE IN VIEW**

Convex mirrors produces images that are smaller than objects. This increase the view for the observer.

Figure: Convex Mirror

Q.10 Why does the position of fish inside the water seem to be at less depth than that of its actual position? **(Point to Ponder Pg. # 41)**

Ans: **POSITION OF FISH IN WATER**

The position of fish inside the water seems to be at less depth than that of its actual position due to refraction of light.

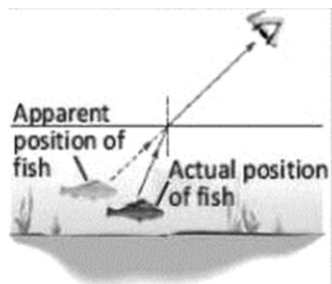


Figure: Position of Fish in Water

Q.11 Can you measure the distance of the screen from the mirror or a well-polished spoon (using inside of the spoon with concave surface bulging inward), using a metre scale? Can you find out the rough focal length of the focal length of the concave mirror? Also draw the ray diagram to show the image formation in this situation.

(Activity 12.2 Pg. # 41)

Ans: **CONCAVE MIRROR OR WELL POLISHED SPOON**

Take a concave mirror or a well-polished spoon (using inside of the spoon with concave surface bulging inward). Hold it in hand towards a distant object, such as the sun, a building, a tree or a pole. Try to get a sharp, well focused image of the distant object on the wall or a screen. Measure the distance of the screen from the mirror using a meter scale. By applying the spherical mirror formula and by putting the values of distance of object and distance of image from the mirror, we can find out the focal length of the concave mirror.

MULTIPLE CHOICE QUESTIONS

1. The relationship between object distance p, image distance q from the mirror and focal length of the mirror is called:

(A) Mirror focal length (B) Distance from mirror
(C) Mirror formula (D) Lens formula

2. Mirror formula is:

(A) $\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$ (B) $\frac{1}{f}=\frac{1}{p}-\frac{1}{q}$

(C) $\frac{1}{f}=\frac{1}{p}-\frac{q}{p}$ (D) $\frac{1}{f}=\frac{1}{q}+\frac{p}{q}$

3. Focal length of spherical mirror is: **(LHR 2016)**

(A) $\frac{R}{4}$ (B) $\frac{R}{2}$

(C) $\frac{R}{3}$ (D) $\frac{R}{9}$

4. Convex mirror produce images:

(A) Larger than object (B) Smaller than object

(C) Equal to object (D) Very large in size

EXAMPLE 12.1

A convex mirror is used to reflect light from an object placed 66 cm in front of the mirror. The focal length of the mirror is 46 cm. Find the location of the image.

Solution:

Given Data:

Distance of object from mirror = p = 66 cm

Focal length of convex mirror = f = – 46 cm

Formula:

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

Calculation:

By using formula, we have

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

Or $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

$$\frac{1}{q}=-\frac{1}{46\mathrm{cm}}-\frac{1}{66\mathrm{cm}}$$

$$\frac{1}{q}=-\frac{1}{27\mathrm{cm}}\Rightarrow q=-27cm$$

Result:

Hence, the location of image is 27 cm from the convex mirror. Here, negative sign indicates that the image is behind the mirror and, therefore, is a virtual image.

EXAMPLE 12.2

An object is placed 6 cm in front of a concave mirror that has focal length 10 cm. Determine the location of the image.

Solution:

Given Data:

Object distance from mirror = p = 6 cm

Focal length of concave mirror = f =10 cm

To Find:

Location of the image = q = ?

Formula:

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

Calculations:

Using the mirror formula, we have

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

OR $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

OR $$\frac{1}{q}=\frac{1}{10\text{cm}}-\frac{1}{6\text{cm}}$$

$$=\frac{3-5}{30}$$

$$=\frac{-2}{30}$$

$$\frac{1}{q}=-\frac{1}{15\text{cm}}\Rightarrow q=-15\text{cm}$$

Result:

Hence, the image is located at 15cm from the concave mirror. Here, negative sign indicates that the image is virtual i.e., behind the mirror.

12.4 REFRACTION OF LIGHT

LONG QUESTIONS

Q.1 Define refraction of light. **(SGD-G1)(DGK-G2)-2016**

Ans: **REFRACTION OF LIGHT**

Definition:

"The process of bending of light as it passes from one transparent medium into another is called refraction**"**.

Explanation:

Refraction of light can be explained with the help of figure. A ray of light IO traveling from air falls on the surface of a glass block.

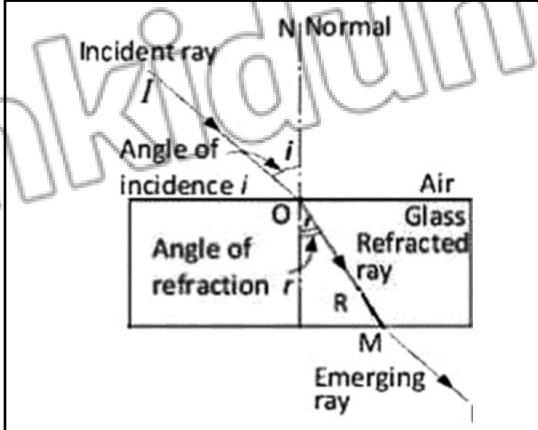


Figure: Refraction of Light

At the air-glass interface, the ray of light IO changes direction and bends towards the normal and travels along the path OR inside the glass block. The rays IO and OR are called the incident ray and the refracted ray respectively. The angle '*i*' made by the incident ray with the normal is called angle of incidence.

The angle '*r*' made by the refracted ray with the normal is called angle of refraction. When refracted ray leaves the glass, it bends away from the normal and travels along a path ME.

Q.2 What are the laws of refraction? Also describe Snell's law and cause of refraction of light.

(RWP-G1)-2016

Ans: **LAWS OF REFRACTION**

The laws of refraction are:

- The incident ray, the refracted ray, and the normal at the point of incidence all lie in the same plane.
- 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 i.e., $\sin i / \sin r = \text{constant} = n$

Snell's Law:

Statement:

The ratio sin i / sin r is known as the refractive index of the second medium with respect to the first medium. So we have

$$\frac{\sin\angle\hat{i}}{\sin\angle\hat{r}} = n = \frac{n_2}{n_1}$$

Cause of Refraction of Light:

Refraction of light is caused by the difference in speed of light in different media. For example, the speed of light in air is approximately 3.0×10^8 ms^{-1}. However, when light travels through a medium, such as water or glass, its speed decreases. The speed of light in water is approximately 2.3×10^8ms^{-1}, while in glass, it is approximately 2.0×10^8ms^{-1}. To describe the change in the speed of light in a medium, we use the term **index of refraction or refractive index.**

Refractive Index:

With respect to the speed of light in different media, refractive index can also be defined as:

Definition:

"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**"**.

Formula:

$$\text{Refractive Index} = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$$

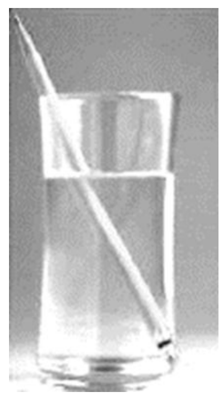
Or $$n = \frac{c}{v}$$

SHORT QUESTIONS

Q.1 Describe the passage of light through parallel sided transparent material.

Ans: **REFRACTION OF LIGHT**

If we dip one end of a pencil or some other object into water at an angle to the surface, the submerged part looks bent as shown in figure. Its image is displaced because the light coming from the underwater portion of the object changes direction as it leaves the water.



Q.2 What is meant by refraction of light?

(BWP-G2)-2014 / (LHR-G1)(FSD-G2)-2015 / (RWP-G2)-2017

Ans: **REFRACTION OF LIGHT**

Definition:

"The process of bending of light as it passes from one medium to another is called refraction of light".

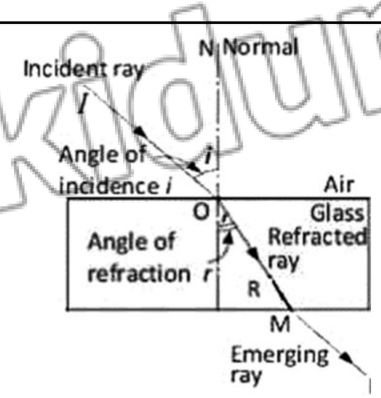


Figure: Refraction of Light

Q.3 State law of refraction?

(SWL-G1)-2014 / (RWP-G1)-2015 / (GRW-G2)-2016 / (FSD-G1)(LHR-G1)(SGD-G2)-2017

Ans: **LAW OF REFRACTION**

The law of refraction are:

- The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane.
- The ratio of the sin of the angle of incidence 'i' to the sine of angle of refraction 'r' is always equal to a constant i.e. $\frac{\sin i}{\sin r} = \text{constant} = n$

Q.4 State Snell's law?

(BWP-G2)(DGK-G2)(LHR-G2)-2014 / (SGD-G1)-2015 / (BWP-G2)(BWP-G1)-2017

Ans: **SNELL'S LAW**

Definition:

"The ratio of sin of angle of incidence "i" to the sine of angle of refraction "r" is always equal to a constant where the ratio $\frac{\sin \hat{i}}{\sin \hat{r}}$ is known as the refractive index of the second medium with respect to the first medium. It is called snell's law**"**.

Mathematical Expression:

$$\frac{\sin \hat{i}}{\sin \hat{r}} = n$$

Q.5 Define refractive index. **(LHR-G1)-2014 / (BWP-G2)-2015 / (SGD-G2)(BWP-G2)(AJK-G1)-2016**

Ans: **REFRACTIVE INDEX**

Definition:

"The ratio of speed of light in air 'c' to the speed of light in the medium 'v' is called the refractive index 'n' of the medium".

Mathematical Expression:

$$\text{Refractive index} = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$$

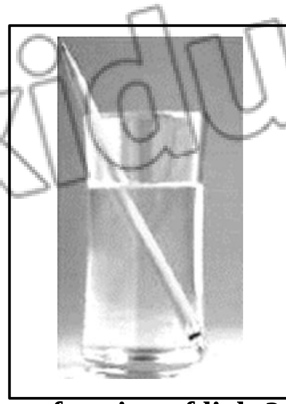
$$n = \frac{c}{v}$$

Where n is constant, c is speed of light in air and v is speed of light in medium.

Q.6 Why do we see the bending of pencil in water?

Ans: **BENDING OF PENCIL IN WATER**

As, the refractive index or index of refraction describe the change in the speed of light in a medium so that, the medium through which, the speed of light is less than the speed of light in air will have high refractive index and hence will have more bending due to the phenomenon of refraction.



Q.7 Which quantities change during refraction of light? **(Physics insight Pg. # 42)**

Ans:

CHANGES DURING REFRACTION

In refraction, the speed of light changes due to change in the wavelength. But frequency and hence the colour of light does not changes.

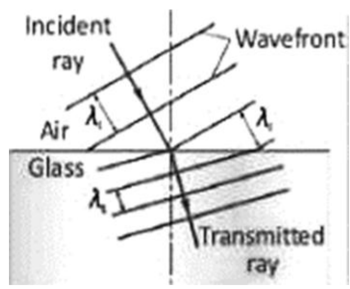


Figure: Changes during Refraction

Q.8 Write the refractive index of the following substances. **(For your info. Pg. # 43 Table)**

Ans:

REFRACTIVE INDEX OF SUBSTANCES

The refractive index of following substances are:

Substance	Index of Refraction (n)	Substance	Index of Refraction (n)
Diamond	2.42	Ethyl Alcohol	1.36
Cubic Zirconia	2.21	Ice	1.31
Glass (flint)	1.66	Water	1.33
Glass (crown)	1.52	Air	1.00

Q.9 How dispersion of light occurs? **(Do you know Pg. # 43)**

Ans:

DISPERSION OF LIGHT

Dispersion of light is due to the variation in the refractive index with the color.

Dispersion in drops of water separates the colors of sunlight into rainbow.

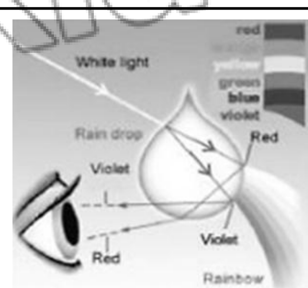


Figure: Dispersion of Light

Q.10 Whether the bending of light be more or less for a medium with high refractive index.

(Self Assesment Pg. # 43)

Ans: **BENDING WITH HIGH REFRACTIVE INDEX**

The bending of light will be more for a medium with high refractive index.

MULTIPLE CHOICE QUESTIONS

1. The bending of light as it passes from one transparent medium into another is:
(A) Reflection (B) Refraction
(C) Reverberation (D) Incidence

2. According to law of refraction:
(A) $\frac{\sin i}{\sin r} > i$ (B) $\frac{\sin r}{\sin i} > r$
(C) $\frac{\sin i}{\sin r} = constant$ (D) $\frac{\sin r}{\sin i} > n$

3. $\frac{\sin i}{\sin r} = n = \frac{n_2}{n_1}$ is called: **(GRW 2013)**
(A) Boyl's law (B) Charless's law
(C) Snell's law (D) Newton's law

4. Speed of light in air is approximately:
(A) 3.0×10^8 ms^{-1} (B) 4×10^9 ms^{-1}
(C) 4×10^{14} ms^{-1} (D) 3×10^7 ms^{-1}

5. The speed of light is greater in:
(A) Air (B) Water
(C) Solid (D) Glass

6. The speed of light in water is approximately:
(A) 2.0×10^8 ms^{-1} (B) 2.3×10^8 ms^{-1}
(C) 3×10^8 ms^{-1} (D) 3×10^7 ms^{-1}

7. ? = $\frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$
(A) Reflective index (B) Snell's law
(C) Refractive index (D) Critical angle

EXAMPLE 12.3

A ray of light enters from air into glass. The angle of incidence is 30°. If the refractive index of glass is 1.52, then find the angle of refraction '*r*'.

Solution:

Give Data:

Angle of incidence $= i = 30°$

Refractive index of glass = n = 1.52

Required:

Angle of refraction = r = ?

Formula:

$$n = \frac{\sin i}{\sin r}$$

Calculations:

Using Snell's law, we have

$1.52 \times \sin r = \sin 30°$

Or $\sin r = \sin 30° / 1.52$

$\sin r = 0.33$

$r = \sin^{-1}(0.33)$

$r = 19.3°$

Result:

Hence angle of refraction is 19.3°.

12.5 TOTAL INTERNAL REFLECTION

LONG QUESTIONS

Q.1 What is meant by total internal reflection? Write its conditions. Explain it with the help of ray diagram. **(SGD-G2)(RWP-G2)-2015 / (DGK-G1)-2016**

Ans: **TOTAL INTERNAL REFLECTION**

Definition:

"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**"**.

OR

"When the value of angle of incidence becomes greater than the critical angle, then the ray does not enter into second medium, but reflects back into same medium such reflection of light is called total internal reflection**"**.

Conditions for Total Internal Reflection:

- The ray of light should travel from denser medium to rare medium.
- The angle of incidence should be greater than the critical angle.

Explanation:

When a ray of light travelling in denser medium enters into a rarer medium, it bends away from the normal (Fig.12.9-a). If the angle of incidence '*i*' increases, the angle of refraction '*r*' also increases. For a particular value of the angle of incidence, the angle of refraction becomes 90°.

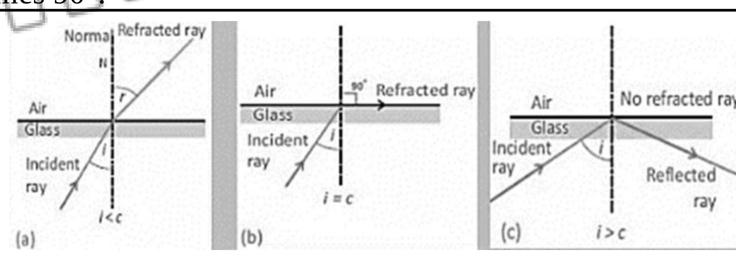


Figure: **Condition for Total Internal Reflection**

Critical Angle:

Definition:

"The angle of incidence that causes the refracted ray in the rarer medium to bend through 90° is called critical angle**"**.

OR

"The angle of incidence for which the corresponding angle of reflection becomes 90°, that angle of incidence is called as critical angle**"**.

SHORT QUESTIONS

Q.1 Define Critical angle.

(BWP-G1)(SWL-G2)(SGD-G1)-2014 / (DGK-G1)(SWL-G1 / G2)-2015 / (GRW-G2)(FSD-G2)(LHR-G2)(RWP-G1)(MTN-G1)-2017

Ans: **CRITICAL ANGLE**

Definition:

"The angle of incidence that causes the refracted ray in the rarer medium to bend through 90° is called critical angle**"**.

Formula Derivation:

$$n = \frac{\sin r}{\sin i}$$

Here, $r = 90°$ $\therefore i = c$

$$n = \frac{\sin 90°}{\sin c}$$

$$n = \frac{1}{\sin c}$$

$$\text{cinc} = \frac{1}{n} \Rightarrow c = \sin^{-1}\left[\frac{1}{n}\right]$$

Q.2 Define total internal reflection.

(GRW-G2)(SWL-G2)(DGK-G2)-2014 / (LHR-G2)(SGD-G1)(DGK-G2)-2015 / (RWP-G1)(FSD-G1)-2016

Ans: **TOTAL INTERNAL REFLECTION**

Definition:

"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**"**.

Q.3 Write conditions of total internal reflection. **(DGK-G2)-2014 / (FSD-G1)-2016**

Ans: **TOTAL INTERNAL REFLECTION**

There are two conditions of total internal reflection.

- Angle of incidence is greater than the critical angle i.e. i > C.
- Ray of light enters form denser to rare medium.

MULTIPLE CHOICE QUESTIONS

1. When a ray of light enters from a denser medium to a rarer medium:

(A) It bends toward the normal (B) It bends away from the normal
(C) It bends towards inside (D) None of these

2. The angle of incidence that causes the refracted ray in the rarer medium to bend through 90^o is called:

(A) Critical angle (B) Angle of incidence
(C) Angle of reflection (D) Angle of refraction

3. **No refraction occurs when the angle of incidence is:**
(A) Smaller than the critical angle
(B) Larger than the critical angle
(C) Equal to the critical angle
(D) Very small than the critical angle

4. **The critical angle of water is:** **(BWP-G1 / G2)-2014 / (BWP-G1)-2015**
(A) 48.8°
(B) 488°
(C) 90°
(D) 95°

5. **Conditions for total internal reflection are:** **(BWP-G2)-2014**
(A) 2
(B) 3
(C) 4
(D) 5

6. **If a ray of light in glass is incident on an air, surface at an angle greater than the critical angle, the ray will be:** **(RWP-G1)-2017**
(A) Refract only
(B) Reflect only
(C) Partially refract and reflect
(D) Diffract only

7. **Critical angle is equal to:**
(A) $c = \sin\frac{1}{n}$
(B) $c = \sin^{-1}\frac{1}{n}$
(C) $c = \frac{\sin i}{\sin r}$
(D) None

8. **Which is the refractive index of diamond?**
(A) 1000
(B) 1.003
(C) 1.33
(D) 2.42

9. **Which r represents Snell's law?**
(A) $n = \frac{\sin i}{\sin r}$
(B) $niSinr = n_2$
(C) $n = \frac{1}{q}$
(D) $n = v \times \lambda$

10. **Speed of light in glass is:**
(A) $3\times10^{8}ms^{-1}$
(B) $2\times10^{8}ms^{-1}$
(C) $3\times10^{8}ms^{-1}$
(D) $4\times10^{8}ms^{-1}$

11. **The angle of incidence in the denser medium for which the corresponding angle of refraction is 90° in the rare medium is called:**
(A) Angle of deviation
(B) Critical angle
(C) Angle of reflection
(D) Angle of refraction

EXAMPLE 12.4

Find the value of critical angle for water (refracted angle=901°). The refractive Index of water is 1.33 and that of air is 1.

Solution:

Given Data:

Angle of refraction = r = 90°

Refractive index of water = n = 1.33

Required:

Critical angle of water = C = ?

Formula:

$$\text{Critical angle} = C = \sin^{-1}\left(\frac{1}{n}\right)$$

Calculations:

As, the angle of incidence for which the corresponding angle of refraction become 90° is called as critical angle. So, by using Snell's law, when light enters in air from water, we have

$$\frac{\sin r}{\sin i} = n$$

Or $n\sin i = \sin$

$n\sin i = \sin 90°$

$n\sin i = 1$

But $n = 1.33$

Therefore,

$\sin i = 1/1.33$

Or $i = \sin^{-1}[1/1.33]$

Critical angle C=48.8°

Result:

Hence the critical angle of water is 48.8°.

12.6 APPLICATIONS OF TOTAL INTERNAL REFLECTION

LONG QUESTIONS

Q.1 What are totally reflecting prisms? Also write its uses.

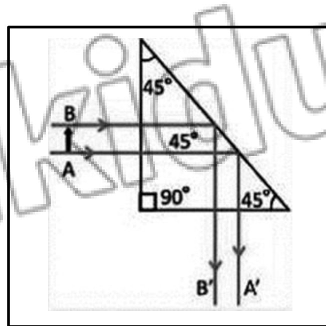
Ans: **TOTALLY INTERNAL REFLECTING PRISM**

Definition:

"Such prisms which reflect a beam of light through 90° or 180° by total internal reflection are called totally internal reflecting prisms**"**.

Working:

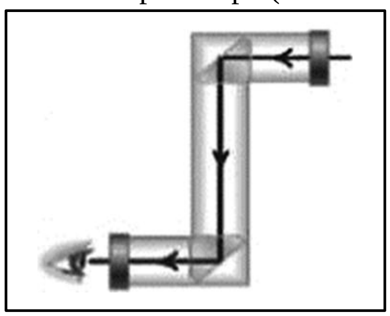
One of the angles of a right-angled prism is 90°. When a ray of light strikes a face of prism perpendicularly, it enters the prism without deviation and strikes the hypotenuse at an angle of 45° (As shown in Fig.).



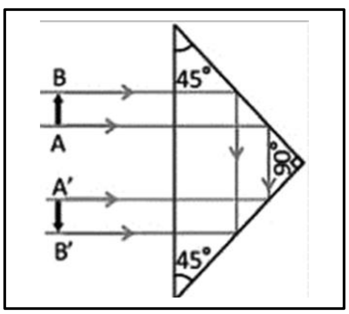
Since the angle of incidence 45° is greater than critical angle of the glass which is 42°, the light is totally reflected by the prism through an angle of 90°.

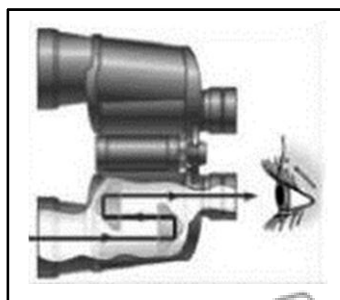
Uses:

- Two such prisms are used in periscope (As shown in Fig.).



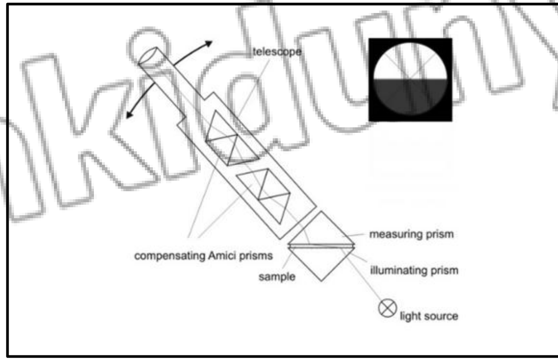
- When the light is totally reflected by the prism by an angle of 180°.Two such prisms are used in binoculars.





- Penta prism is used in camera as shown in figure.

- Compensatic amici, measuring and illuminating



Q.2 What do you know about optical fibre? Also describe how light totally reflected through an optical fibre. **(FSD-G2)-2015 / (SGD-G2)(LHR-G1)-2016**

Ans:

OPTICAL FIBRE

Introduction:

Total internal reflection is used in fiber optics which has number of advantages in telecommunication field.

Definition:

"Optical fibre or fibre optic is a hair size thread made up of glass or plastic through which light can travel by total internal reflection".

PARTS OF OPTICAL FIBRE

Following are the parts of optical fibre:

- Core
- Cladding

Core:

The inner part of the fiber optics is called core that carries the light.

Cladding:

An outer concentric shell is called cladding.

Core:

The core is made of glass or plastic of relatively **high index of refraction**.

Cladding:

The core is made of glass or plastic, but of relatively low refractive index of refraction.

Phenomenon:

Light entering from one end of the core strikes the core-cladding boundary at an angle of Incidence greater than critical angle and is reflected back into the core. In this way, light travels many kilometers with small loss of energy. In this way light travels many kilometers with small loss of energy (as shown in figure).

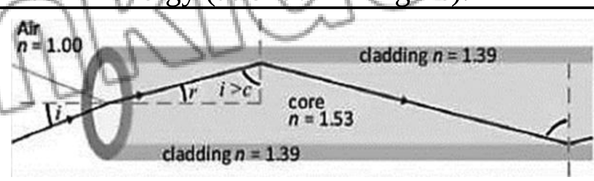


Figure: Passage of Light through Optical Fibre

Uses:

- In Pakistan, optical fiber is being used in telephone and advanced telecommunication systems.
- We can listen thousands of phone calls without any disturbance.

Q.3 What do you know about endoscope and endoscopy? Describe the types of an endoscope.

Ans: **ENDOSCOPE**

Definition:

"An endoscope is a medical instrument used for exploratory diagnostics, and surgical purposes".

Use:

An endoscope is used to explore the interior organs of the body. Due to its small size, it can be inserted through the mouth and thus eliminates the invasive surgery.

Endoscopy:

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

Figure: The Doctors are Examining are Examining a Patient with Endoscope

Construction:

An endoscope uses two fiber-optic tubes through a pipe.

Types:

Its types are as follows:

- Gastroscope
- Cystoscope
- Bronchoscope

Gastroscope:

The gastroscope is used to examine the stomach, bladder and throat.

Cystoscope:

The cystoscope is used to examine bladder.

Bronchoscope:

The bronchoscope is used to view the throat.

Phenomenon:

The light shines on the organ of patient to be examined by entering through one of the fiber tubes of the endoscope. Then light is transmitted back to the physician's viewing lens through the other fiber tube by total internal reflection.

Flexible endoscopes:

Flexible endoscopes have a tiny camera attached to the end. Doctor can see the view recorded by the camera on a computer screen.

SHORT QUESTIONS

Q.1 What is a light pipe? Write down its (medical) use?

Ans: **LIGHT PIPE**

Definition:

"Light pipe is a bundle of thousands of optical fibers bounded together".

Uses:

- They are used to illuminate the inaccessible places by the doctors or engineers.

- Doctors view inside the human body. They can also be used to transmit images from one place to another.

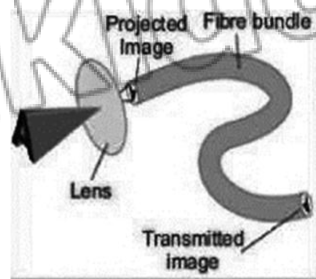


Figure: Light Pipe

Q.2 Define optical fibre. **(FSD-G1)-2015 / (GRW-G2)(BWP-G1)-2016 / (GRW-G2)(SWL-G2)-2017**

Ans: **OPTICAL FIBRE**

It is a hair size thread made up of glass or plastic through which light can be travelled.

- The inner part of fibre optic is called core that carries light.
- The outer part is concentric shell caused cladding.

Q.3 Differentiate between core and cladding of a optical fibre. **(MTN-G1)-2017**

Ans: **DIFFERENTIATE**

The differences between core and cladding of a optical fibre are as follows:

The differences between the frequency and pitch are as follows:

Core	Cladding
Definition	
• The inner part of the fibre optics is called core that carries the light. • The core is made from glass or plastic of relatively high index of refraction.	• An outer concentric shell is called cladding. • The cladding is made of glass or plastic, but of relatively low refractive index.

Q.4 How light travels with the use of total internal reflection in optical fibre. **(RWP-G1)-2014 / (SWL-G2)-2017**

Ans: **REFLECTION THROUGH OPTICAL FIBRE**

In optical fibre light entering from one end of the core strikes the core-cladding boundary at an angle of incidence greater than critical angle and is reflected back into the core. In this way light travels many kilometres with small loss of energy.

Q.5 What is meant by endoscopy? **(BWP-G1)-2016 / (SWL-G2)-2017**

Ans: **ENDOSCOPY**

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

Q.6 Define cystoscope and gastroscope. **(RWP-G1)-2014 / (SWL-G2)-2017**

Ans: **CYSTOSCOPE**

Definition:

The cystoscope is used to examine the bladder.

GASTROSCOPE

Definition:

The gastroscope is used to examine the stomach internally.

MULTIPLE CHOICE QUESTIONS

1. To see from submarine and the ship at the surface of water, we use:
(A) Telescope (B) Microscope
(C) Periscope (D) Prism

2. In totally reflecting prism one angle is of:
(A) 45° (B) 90°
(C) 180° (D) 120°

3. In totally reflecting prism one angle is of 90°, and other two angles are of:
(A) 30°,30° (B) 45°,90°
(C) 45°,45° (D) 40°,40°

4. Totally reflecting prism is used in:
(A) Periscope (B) Binoculars
(C) Periscope and binocular (D) Telescope

5. Totally reflecting prism turns the incident ray at an angle of:
(A) 90° (B) 60°
(C) 75° (D) 45°

6. The refractive index of internal coating of optical fibre is:
(A) 1.56 (B) 1.51
(C) 1.53 (D) 1.58

7. Optical fibres are:
(A) Cheap (B) Flexible
(C) Lighter (D) All of these

8. Optical fibre works on the principal of:
(A) Reflection (B) Refraction
(C) Total internal reflection (D) Diffraction

9. Which pipe is a bundle of thousand of optical fibres bounded together?
(A) Light pipe (B) Telescope
(C) Microscope (D) Projector

10. It is used to explore the interior organs of the body? **(GRW 2013)**
(A) Telescope (B) Endoscope
(C) Microscope (D) Projector

11. Endoscope used to diagnose the stomach is;
(A) Cystoscope (B) Gastroscope
(C) Bronchoscope (D) Pancreoscope

12. Endoscope which is used to diagnose throat is;
(A) Gastroscope (B) Cystoscope
(C) Bronschoscope (D) None of these

12.7 REFRACTION THROUGH PRISM

Q.1 What are totally reflecting prisms? Also write its uses.

Ans: **TOTALLY INTERNAL REFLECTING PRISM**

Definition:

Definition:

"Prism is a transparent object (made of optical glass) with at least two smooth plane faces Inclined towards each other from which light is refracted**"**.

Explanation:

In case of triangular prism (as shown in figure), the emergent ray is not parallel to the incident ray. It is deviated by the prism from its original path. The incident ray PE makes an angle of incidence '*i*' at point E and is refracted towards the normal N as EF. The refracted ray EF makes an angle '*r*' with the normal inside the prism and travels to the other face of the prism. This ray emerges out from prism at point *F* making an angle '*e*'. Hence the emerging ray FS is not parallel to the incident ray PE but is deviated by an angle *D* which is called angle of deviation.

Angle of Deviation:

"Light rays after refraction through a glass prism deviate through an angle. This angle is called angle of deviation**"**.

SHORT QUESTIONS

Q.7 What is prism? **(LHR-G2)-2015 / (GRW-G2)-2017**

Ans: **PRISM**

Prism is a transparent object made up of optical glass with at least two polished plane faces inclined towards each other from which light is refracted.

MULTIPLE CHOICE QUESTIONS

1. **Angle opposite to the base of triangle of prism is called:**
   (A) Angle of incidence (B) Angle of refraction
   (C) Angle of refraction (D) Emerging angle
2. **The refracted light striking to the side of prims is called:**
   (A) Refracted ray (B) Incident ray
   (C) Reflected ray (D) Emergent ray
3. **The minimum value of angle of deviation is called:**
   (A) Minimum angle (B) Incident angle
   (C) Angle of minimum deviation (D) None of these
4. **The angle at which prism deviates the incident ray is called:**
   (A) Angle of incident (B) Angle of reflection
   (C) Angle of deviation (D) Angle of minimum deviation
5. **It is a transparent body (made of optical glass) with at least two polished plane faces inclined towards each other from which light is refracted:**
   (a) Prism (b) Camera
   (c) Lens (d) Mirror

12.8 LENSES

LONG QUESTIONS

Q.1 Define lens. Also describe its uses and types. **(FSD-G1)-2015**

Ans: **LENS**

Definition:

"A lens is any transparent material having two surfaces, of which at least one is curved. Lenses refract light in such a way that an image of the object is formed".

Uses:

- Lenses of many different types are used in optical devices such as cameras, eyeglasses, microscopes, telescopes, and projectors.
- They also enable millions of people to see clearly and read comfortably.

Types of Lenses:

There are different types of lenses, which are given below:

- Convex mirror
- Concave mirror

Convex Lens / Converging Lens:

Definition:

"The lens which causes incident parallel rays to converge at a point is known as convex or converging lens".

Formation:

This lens is thick at the center but thin at the edges.

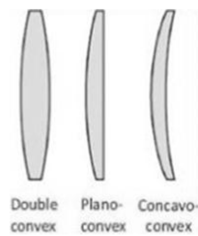


Figure: Convex Lens

Concave Lens / Diverging Lens:

Definition:

"The type of lens which causes the parallel rays of light to diverge from a point is called concave or diverging lens".

Formation:

This lens is thin at the center and thick at the edges.

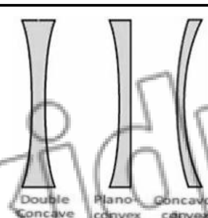


Figure: Concave Lens

Q.4 Describe the following lens terminologies.

- **Principal axis**
- **Optical Centre**
- **Focal length**
- **Principal focus of convex & concave lens**

Ans:

LENS TERMINOLOGIES

Principal Axis:

Definition:

"Each of the two surfaces of a spherical lens is a section of a sphere. The line passing through the two centre of curvatures of the lens is called principal axis".

Optical Center:

Definition:

"A point on the principal axis at the centre of lens is called optical centre".

Symbol:

It is denoted by C.

Principal Focus of Convex Lens:

The light rays travelling parallel to the principal axis of a convex lens after refraction meet at a point on the principal axis, called principal focus or focal point F. Convex lens is also called converging lens.

Symbol:

It is denoted by F (as shown in figure).

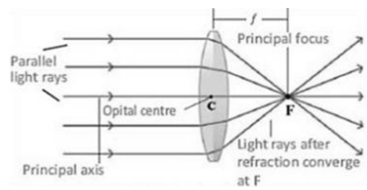


Figure: **Convex Lens**

Principal Focus of Concave Lens:

For a concave lens, the parallel rays appear to come from a point behind the lens called principal focus F. Hence concave lens is also called diverging lens.

Symbol:

It is denoted by f (as shown in figure).

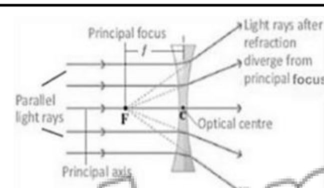


Figure: **Concave Lens**

Focal Length:

Definition:

"The distance between the optical centre and the principal focus is called focal length of lens".

Symbol:

It is denoted by f.

Q.5 Define power of the lens. Also define the unit of power of lens.

Ans: **POWER OF LENS**

Definition:

"Power of a lens is defined as the reciprocal of its focal length in metres".

Formula:

The formula of power of lens is:

Power of a lens = P =1 / focal length in metre

Unit:
The SI unit of power of a lens is "Dioptre", denoted by a symbol D.

SHORT QUESTIONS

Q.1 Define lens.

Ans: **LENS**

Definition:
"A lens is any transparent material having two surfaces, of which at least one is curved. Lenses refract light in such a way that an image of the object is formed".

Types of Lenses:
There are different types of lenses, which are given below:
- Convex mirror
- Concave mirror

Q.2 Write down the uses of lens.

Ans: **USES OF LENSES**

The uses of lenses are as follows:
- Lenses of many different types are used in optical devices such as cameras, eyeglasses, microscopes, telescopes, and projectors.
- They also enable millions of people to see clearly and read comfortably.

Q.3 Define convex lens and concave lens.

Ans: **CONVEX LENS**

Definition:
"The lens which causes incident parallel rays to converge at a point is known as convex or converging lens".

Formation:
This lens is thick at the centre but thin at the edges.

CONCAVE LENS

Definition:
"The lens which causes the parallel rays of light to diverge from a point is called concave or diverging lens".

Formation:
This lens is thin at the centre and thick at the edges.

Q.4 What do you know about principal axis and principal focus of lens?

Ans: **PRINCIPAL AXIS**

Each of the two surfaces of a spherical lens is a section of a sphere. The line passing through the two centres of curvatures of the lens is called principal axis.

PRINCIPAL FOCUS

For Convex lens:
"The light rays travelling parallel to the principal axis of a convex lens after refraction meet at a point on the principal axis called principal focus or focal point F of convex lens". Hence convex lens is also called converging lens.

For Concave lens:

"For the concave lens, the parallel rays appear to come from a point behind the lens called principal focus F of concave lens". Hence concave lens is also called diverging lens.

Q.5 Define optical centre and focal length of lens?

Ans: **OPTICAL CENTRE**

Definition:

"A point on the principal axis at the centre of lens is called optical centre".

FOCAL LENGTH

Definition:

"This is the distance between optical centre and the principal focus of lens is called focal length of lens.".

Q.6 What do you know about power of lens?

Ans: **POWER OF LENS**

Definition:

"Power of lens is defined as the reciprocal of its focal length in metres".

Formula:

$$\text{Power of lens} = \frac{1}{\text{focal length in metre}} \Rightarrow P = \frac{1}{\text{f in metre}}$$

SI unit:

SI unit of power of lens is "dioptre" and is denoted by symbol D.

Q.7 Define unit of power of lens.

Ans: **DIOPTRE**

Definition:

"1 Dioptre is the power of lens whose focal length is 1 metre".

Formula:

If f is expressed in metres so that,

$1D=1m^{-1}$

Power of Convex Lens:

Because the focal length of a convex lens is positive. Therefore, its power is also positive.

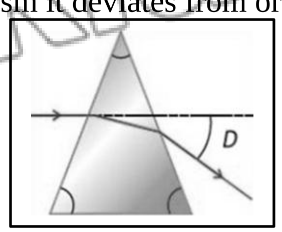
Power of Concave Lens:

The power of a concave lens is negative, for it has negative focal length.

Q.8 What happens when light passes through prism? **(Refraction through prism Pg. # 48)**

Ans: **REFRACTION THROUGH PRISM**

When light passes through prism it deviates from original path due to refraction.



Q.9 How does the combination of two triangular prisms resemble a concave or convex lens?

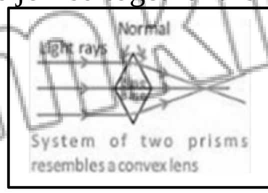
Ans: **COMBINATION OF TWO PRISMS**

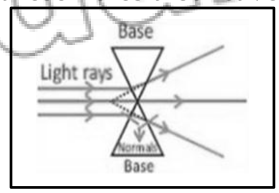
When Bases Combined:

If the base of two triangular prisms are joined together then it resembles a convex lens.

When Cones Combined:

If two triangular prisms are joined in such a way that their bases held opposite to each other and cones are joined together then it resembles a concave lens.





Q.10 Why diopters are handy to use? Explain with the help of an example.

(For your information Pg. # 49)

Ans: **HANDY TO USE**

Diopters are handy to use because if two thin lenses are placed side by side, the total power is simply the sum of the individual powers.

Example:

An ophthalmologist places a 2.00 dioptre lets next to 0.25 dioptre lens and immediately knows that the power of combination is 2.25 dioptre.

Q.11 What is the critical point which must be kept in mind while dealing with diverging lenses?

(Remember it Pg. # 49)

Ans: **DIVERGING LENSES**

When dealing with diverging lenses, be careful not to omit the negative sign associated with the focal length and the image position.

MULTIPLE CHOICE QUESTIONS

1. The line passing through the two centres of curvatures of the lens is called:
(a) Principal focus (b) Optical centre
(c) Principal axis (d) Focal length

2. Optical centre is represented by:
(a) A (b) f
(c) F (d) C

3. For a concave lens, the parallel rays appear to come from a point behind the lens is called:
(a) Principal focus (b) Principal axis
(c) Focal length (d) Optical length

4. The distance between the optical centre and the principal focus is:
(a) Principal focus (b) Principal axis
(c) Focal length (d) Optical length

5. In a lens, number of curved surfaces will be at least:
(a) Two (b) Three
(c) One (d) Four

6. Lenses are used in optical devices:
(a) Camera (b) Eyeglasses
(c) Microscope (d) All given

7. The lens which causes incident parallel rays to converge at a point is:
(a) Convex lens (b) Converging lens
(c) Both a & b (d) Concave lens

8. Lens thick at the centre but thin at the edges is:
(a) Concave (b) Convex

(c) Diverging (d) Plane

9. SI unit of power of lens is:

(a) Meter (b) Diopter

(c) Centimeter (d) Millimeter

10. 1D = ?

(a) $1m^{-1}$ (b) m^{-2}

(c) m^{-3} (d) cm^{-1}

11. It has positive focal length:

(a) Simple lens (b) Concave lens

(c) Convex lens (d) None of above

12.9 IMAGE FORMATION BY LENSES

LONG QUESTIONS

Q.1 Explain the image formation by lenses with the help of ray diagrams of three principal rays. **(AJK-G1)(BWP-G2)-2015**

Ans: **IMAGE FORMATION BY LENSES**

In mirrors images are formed through reflection, but lenses form images through refraction.

Image Formation in Convex Lens:

Image formation in convex lens can be explained with the help of ray diagram of three principal rays (as shown in figure).

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

Ray Diagram:

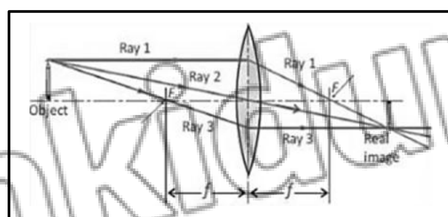
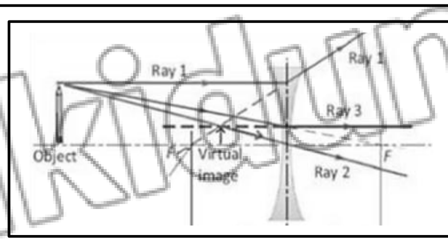


Image Formation in Concave Lens:

Image formation in concave lens can be explained with the help of ray diagram of three principal rays (as shown in figure).

- The ray parallel to the principal axis diverged outside after refraction by the lens.
- The ray passing through the optical centre passes straight through the lens and remains undeviated.
- The ray parallel to the principal axis diverged after refraction by the lens.



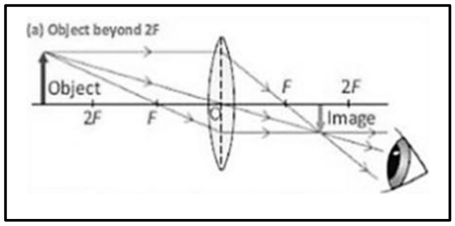
Q.2 Explain the image formation in convex lens with the help of ray diagram. Also describe the nature of image by convex lens depending upon the location of object.

Ans: **IMAGE FORMATION IN CONVEX LENS**

Images formed by the convex lens, depending upon the location of object are given as follows:

Object beyond 2F:

When the object is placed beyond 2F in front of convex lens, image is formed between F and 2F.

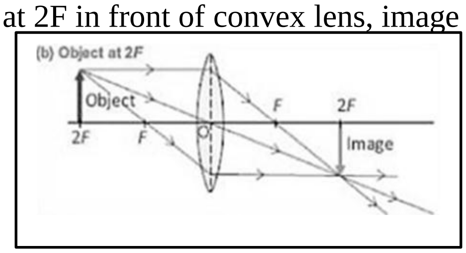


Nature:

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

Object at 2F:

When the object is placed at 2F in front of convex lens, image is also formed at 2F.

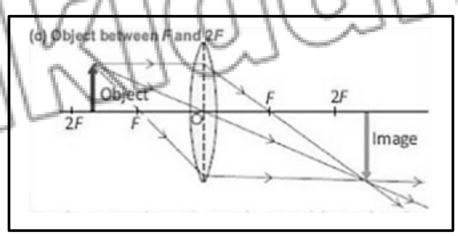


Nature:

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

Object between F and 2F:

When the object is placed between F and 2F in front of convex mirror, image is formed beyond 2F.

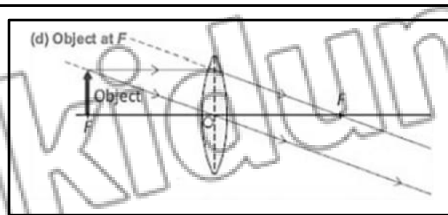


Nature:

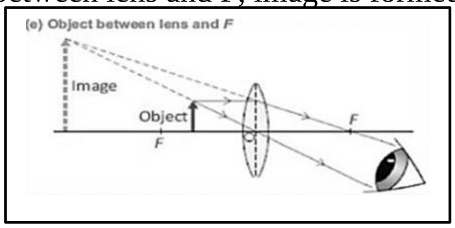
The image is beyond 2F, real, inverted, larger than the object.

Object at F:

When the object is placed at E in front of convex lens, image will not be formed. Because rays become parallel after refraction by the lens.



Nature:
No image is formed because the refracted rays are parallel and never meet.
Object between Lens and F:
When the object is placed between lens and F, image is formed behind the object.



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

SHORT QUESTIONS

Q.1 Write down the characteristics of three principal rays, passing through the convex lens.

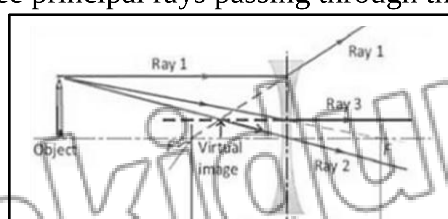
Ans: **CHARACTERISTICS**

The characteristics of three principal rays, passing through the convex lens are as follows:
- The ray parallel to the principal axis passes through the focal point after refraction by the lens.
- The ray passing through the optical centre passes straight through the lens and remains underivated.
- The ray passing through the focal point becomes parallel to the principal axis after refraction by the lens.

Q.2 Draw the ray diagram of three principal rays passing through the concave lens.

Ans: **RAY DIAGRAM FOR CONCAVE LENS**

The ray diagram of three principal rays passing through the concave lens is given below:



Q.3 What is the nature of image formed in convex lens at following different locations of object in front of convex lens?

Ans: (See Topic 12.9, Long Question-2)

Q.4 Write down the ways to compare lenses simply by looking at them.
(For your information Pg. # 50)

Ans: **WAYS TO COMPARE LENSES**

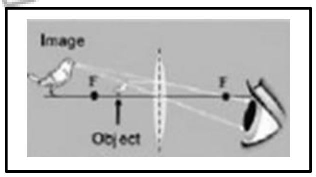
The ways of comparing lenses are:
- Lenses can be compared simply by looking at them.

- A lens with a long focal length is thin; its surfaces are not very strongly curved.
- A lens with a short focal length is fatter; its surfaces are more strongly curved.

Q.5 How can we make a converging lens into magnifying glass? **(Physics Insight Pg. # 50)**

Ans: **MAKING MAGNIFYING GLASS**

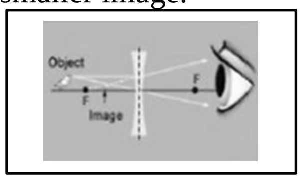
A converging lens becomes a magnifying gals when an object is located inside the lens's focal length.



Q.6 When do we have the same ray diagram of diverging lens as that of converging lens? **(Physics Insight Pg. # 50)**

Ans: **RAY DIAGRAM OF DIVERGING LENS**

A diverging lens always forms a smaller image.



Q.7 What can we assume about thin lens formula compared with the thick lens when objects and images are far away? **(Approximations Pg. # 51)**

Ans: **THICK AND THIN LENS**

The thin lens formula assumes the lenses have no thickness. This is a good assumption when objects and images are far away compared with the thickness of a lens.

MULTIPLE CHOICE QUESTIONS

1. In mirrors images are formed through reflection, but lenses form images through;

(a) Refraction (b) Incidence
(c) Diffraction (d) Reflection

2. In case of convex lens when object is placed beyond 2F,the image is formed;

(a) Between F and 2F (b) Real, inverted
(c) Smaller than object (d) All of these

3. The image with convex lens is formed at 2F, real , inverted, the same size as the object when the object is placed at:

(a) 2F (b) Between F and 2F
(c) F (d) C

4. When object is at F the image is;

(a) Inverted (b) Real
(c) Small (d) Not formed

12.10 IMAGE LOCATION BY LENS EQUATION

LONG QUESTIONS

Q.1 What is lens equation? How can we locate the image by lens equation?

(Example 12.6)(AJK-G1)-2016 / (GRW-G1)(FSD-G2)(BWP-G2)-2017

Ans: **LENS EQUATION**

Definition:

"The relation between the object and Image distance from the lens In terms of the focal length of the lens is called lens formula**"**.

Formula:

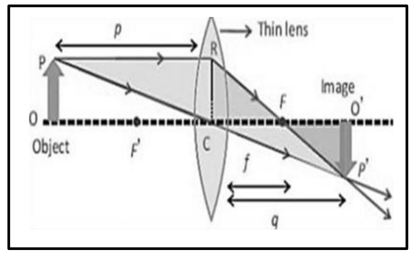
$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

Validity:

The lens equation is valid for both concave and convex lenses.

Explanation:

In figure, let an object OP be placed in front of a convex lens at a distance p. A ray PR parallel to the principal axis after refraction passes through focus F. Another ray PC meets the first ray at point P' after passing through the optical center C. If this process is repeated for the other points of the object, a real and inverted image O'P' is formed at a distance q from the lens.



Sign Conventions for Lenses:

The sing conventions for lenses are:

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.

SHORT QUESTIONS

Q.1 What is Lens formula?

Ans: **LENS FORMULA**

Definition:

"The relation between the object and image distance from the lens in terms of focal length of the lens is called lens formula**"**.

Mathematical Equation:

The lens formula is:

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

Validity:
It is true / valid for both concave and convex lens.

Q.2 What are the sign conventions for focal length in lenses?

Ans: **SIGN CONVENTIONS FOR FOCAL LENGTH**

The sign conventions for lenses for focal length in lenses are:

- f is positive for a converging lens.
- f is negative for a diverging lens.

Q.3 What are the sign conventions for object distance in lenses?

Ans: **SIGN CONVENTIONS FOR OBJECT DISTANCE**

The sign conventions for object for object distance in lenses are:

- 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.

Q.4 What are the sign conventions for image distance in lenses?

Ans: **SIGN CONVENTIONS FOR MAGE DISTANCE**

The sign conventions of image distance for image distance in lenses are:

- 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.

Q.5 Define optics and geometrical optics. How much is it useful in other branches of sciences?

(For your information Pg. # 51)

Ans: **OPTICS AND GEOMETRICAL OPTICS**

Optics:

Definition:

"The study of behavior of light behavior is called optics".

Geometrical Optics:

Definition:

"The branch of optics that focuses on the creation of images is called geometrical optics" because it is based on relationships between angles and lines that describe light rays.

Uses in other Branches of Science:

Optics also includes the study of the eye itself because the human eye forms an image with a lens.

Q.6 Write down the names of objects / devices of daily life in which lenses are used.

Ans: **NAMES OF OBJECTS**

The objects in which lenses are used that are:

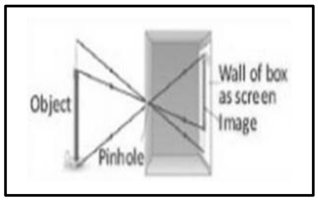
- Spectacles
- Magnifying glass
- Microscope
- Slide projector
- Binoculars
- Camera

Q.7 What is a pinhole camera? How can we make pinhole camera without lens?

(A camera without lens Pg. # 53)

Ans: **PINHOLE CAMERA**

Even simpler than a camera with one lens is a pinhole camera. To make a pinhole camera, a tiny pinhole is made in one side of a box. An inverted, real image is formed on the opposite side of the box.



MULTIPLE CHOICE QUESTIONS

1. Lens formula is

(a) $\frac{1}{p}=\frac{1}{f}+\frac{1}{q}$ (b) $\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$

(c) $\frac{1}{f}=\frac{q}{p}+\frac{1}{q}$ (d) $\frac{1}{f}=\frac{1}{p}-\frac{1}{q}$

2. For a converging lens f is;

(a) Negative (b) Positive

(c) Sometime negative and sometime positive (d) Smaller

3. The study of behaviour of light is called;

(a) Optics (b) Geometry

(c) Plasma (d) Geometrical optics

4. If the object is on the right side of the lens then p is;

(a) Positive (b) Negative

(c) Smaller (d) Larger

EXAMPLE 12.5

A person 1.7 m tall is standing 2.5 m in front of a camera. The camera uses a convex lens whose focal length is 0.05 m. Find the image distance (the distance between the lens and the film) and determine whether the image is real or virtual.

Solution:

Given Data:

Focal length of convex lens = f = 0.05 m

Distance of person from lens = p = 2.5 m

Required:

Distance of image = q = ?

Nature of image = ?

Formula:

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

Calculations:

By using formula, we have

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

Or $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

$$\frac{1}{q}=\frac{1}{0.05m}-\frac{1}{2.5m}$$

$$\frac{1}{q}=19.6m^{-1}$$

Or $q = 0.05m$

Image Nature:

Since the image distance is positive, so a real image is formed on the film at the focal point of the lens.

Result:

Hence, the image distance is 0.05 m from the lens. Since the image distance is positive, so a real image is formed on the film at the focal point of the lens.

EXAMPLE 12.6

A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also find the magnification of the lens.

Solution:

Given Data:

Distance of image from concave lens = q = –10 cm

Focal length of concave lens = f = –15 cm

Required:

(a) Distance of object from lens = p = ?

(b) Magnification of the lens = m = ?

Formula:

(a) $$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

(b) $$m=\frac{q}{p}$$

Calculations:

By using formula, we have

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

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

$$=-\frac{1}{(-10cm)}+\frac{1}{(-15cm)}$$

$$=\frac{1}{10cm}-\frac{1}{15cm}$$

$$\frac{1}{p}=\frac{3cm-2cm}{30cm^2}$$

$$\frac{1}{p}=-\frac{1}{30cm}$$

$$p=30cm$$

(b) Magnification of the lens is = $m=\frac{q}{p}=\frac{10cm}{30cm}=\frac{1}{3}$ (Ignore negative sign)

Result:

Hence, the object is 30cm, on the left side from the concave lens and the image is reduced to one-third in size than the object.

12.11 APPLICATIONS OF LENSES

LONG QUESTIONS

Q.1 Describe the application of lenses in camera with ray diagram.

Ans: **CAMERA**

Definition:

"A device for recording visual images in the form of photographs, movie films or video signals".

Construction:

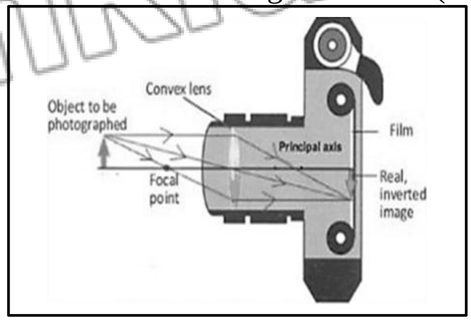
A simple camera consists of a light-proof box with a converging lens in front and a light sensitive plate or film at the back. The lens focuses images to be photographed onto the film. In simple lens camera, the distance between lens and film is fixed which is equal to the focal length of the lens.

Position of Object:

In camera, object is placed beyond 2F.

Nature of Image:

A real, inverted and diminished image is formed (as shown in figure).



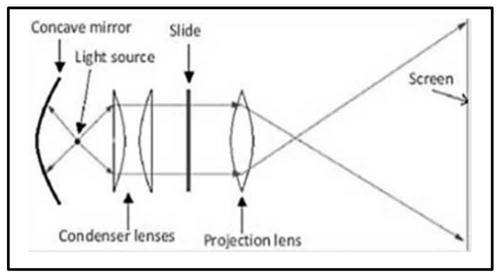
Q.2 Explain the working of slide projector with the ray diagram to describe the application of lens.

Ans: **SLIDE PROJECTOR**

Definition:

"An optical instrument that projects on enlarged image of individual slides into a screen or wall".

Construction and Working:



The light source is placed at the centre of curvature of a converging or concave mirror. The concave mirror is used to reflect light back in fairly parallel rays. The condenser is made up of 2 converging lenses that refract the light so that part of slide are illuminated with parallel rays.

The projection or converging lens provides a real, large and inverted image. It must be real to be projected on a screen.

Object Position:

The slide (object) must be placed between F and 2F of projection lens.

Nature:

Lens produces a real, large, and inverted image.

Placement of Slide:

Because the image is inverted, the slide must be placed upside down and laterally inverted so the erect Image can be seen properly.

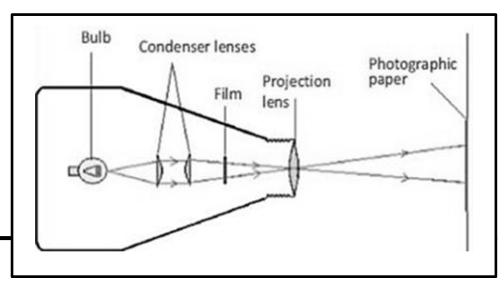
Q.3 Describe the working of photograph enlarger with the ray diagram.

Ans: **PHOTOGRAPH ENLARGER**

Definition:

An optical instrument for making enlarged photographic prints in which a negative is brightly illuminated and its enlarged image is focuses onto a sheet of sensitized paper.

Construction:



It uses a convex lens to produce a real, magnified and inverted image of the film on photographic paper.

Working Principle:

The working principle of photograph enlarger is basically the same as that of a slide projector.

Position of Object:

In the case of photograph enlarger object is placed at distance of more than F but less than 2F.

Nature of Image:

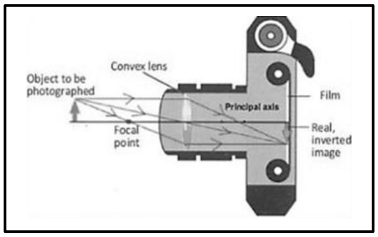
We get a real, inverted and enlarged image.

SHORT QUESTIONS

Q.1 What is the construction of camera?

Ans: **CONSTRUCTION OF CAMERA**

A simple camera consists of a light proof box with a converging lens in front and a light sensitive plate or film at the back. The lens focuses images to be photographed on to film. In simple lens camera, the distance between lens and film is fixed which is equal to the focal length of the lens.



Q.2 What is the nature of image formed by camera?

Ans: **NATURE OF IMAGE BY CAMERA**

A real, inverted and diminished image is formed by camera.

Q.3 What is the image f, position of object for a camera?

Ans: **OBJECT POSITION FOR CAMERA**

In the camera, object is placed beyond 2F to form real, inverted and diminished image.

Q.4 What is the object position for slide projector?

Ans: **OBJECT POSTION FOR SLIDE PROJECTOR**

The slide (object) must be placed between F and 2F projection lens.

Q.5 What is the image nature for slide projection?

Ans: **IMAGE NATURE OF SLIDE PROJECTOR**

A real, Inverted and large image is formed through slide projector.

Q.6 What is the working principle of photograph enlarger?

Ans: **WORKING PRINCIPLE OF PHOTGRAPH ENLARGER**

The working principle of photograph enlarger is basically the same as that of a slide projector. It uses a convex lens to produce a real, magnified, inverted image of the film on photographic paper.

MULTIPLE CHOICE QUESTIONS

1. Optical device is;

(a) Camera (b) Slide projector
(c) Photograph enlarger (d) All of given

2. Which statement is correct about image formed by camera?

(a) Real image is formed (b) Inverted image is formed
(c) Diminished image is formed (d) All options are true

3. In case of photograph enlarger the object is placed at distance;
(a) More than F (b) Less than 2F
(c) Both (a) and (b) (d) More than 3F

4. The working principle of photograph enlarger is the same as;
(a) Slide projector (b) Camera
(c) Telescope (d) Endoscope

12.12 SIMPLE MICROSCOPE

LONG QUESTIONS

Q.1 How does image formation take place in simple microscope? Also derive the formula of magnifying power.

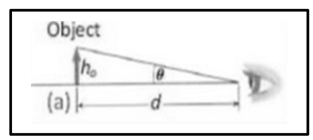
Ans: <u>SIMPLE MICROSCOPE</u>

<u>Definition</u>:
"A magnifying glass is a convex lens which is used to produce magnified images of small objects. Hence, it is also called simple microscope".

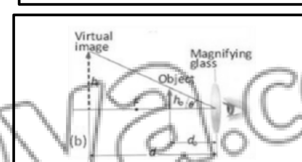
<u>Object Position to Lens</u>:
The object is placed nearer to the lens than the principal focus such that an upright, virtual and magnified image is seen clearly at 25cm from the normal eye.

<u>Magnifying Power</u>:
It is ratio of angular size of final image produced by magnifying glass to the angular size of object seen without magnifying glass.

<u>Explanation</u>:
Let θ be the angle subtended at the eye by a small object when it is placed at near point of the eye (as shown in figure)



If the object is now moved nearer to the eye (as shown in figure), the angle on the eye will increase and becomes θ', but the eye will not be able to see it clearly. In order to see the object clearly, we put a convex lens between the object and the eye, so that the lens makes a large virtual image of the object at near point of the eye. In this way, the object appears magnified.



<u>Mathematical Equation</u>:
The magnifying power in this case will be:

$$M = \frac{\theta'}{\theta} = \frac{\text{Angular size of final image produced by magnifying glass}}{\text{Angular size of object seen without magnifying glass}}$$

It can be shown that the magnifying power is given by the relation:

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

Where *f* is the focal length of lens and *d* is near point of eye. It is clear from this relation that a lens of shorter focal length will have greater magnifying power.

SHORT QUESTIONS

Q.1 What do you mean by resolving power of an instrument?

Ans: **RESOLVING POWER**

Definition:

"The resolving power of an instrument is its ability to distinguish between two closely placed objects or point sources".

High Resolving Power:

- In order to see objects that are close together, we use an instrument of high resolving power.

Example:

We use high resolving power microscope to see tiny organisms and telescope to view distant stars.

Q.2 What is a simple microscope? **(FSD-G1)-2016**

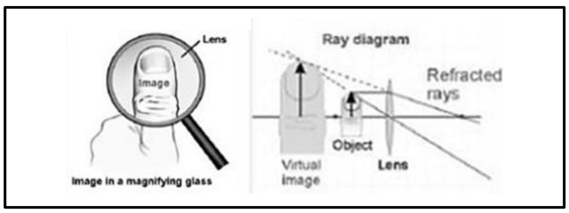
Ans: **SIMPLE MICROSCOPE**

A magnifying glass is a convex lens which is used to produce magnified image of small objects. Hence it is also called a simple microscope.

Q.3 What is a magnifying glass?

Ans: **IMAGE OF MAGNIFYING GLASS**

Magnifying glass is a lens that forms a virtual image that is larger than object and appears behind the lens.



Q.4 What do you mean by linear magnification?

Ans: **LINEAR MAGNIFICATION**

Definition:

"The ratio of the size of image to that of the size of object is called linear magnification".

Mathematical Formula:

$$m = \frac{\text{image height}}{\text{object height}} = \frac{h_i}{h_o} = \frac{q}{p}$$

Unit:

It has no unit because it is a ratio of two same quantities.

MULTIPLE CHOICE QUESTIONS

1. A magnifying glass is a convex lens which is used to produce magnified images of small objects. It is also called;

(a) Compound microscope (b) Simple microscope
(c) Electron microscope (d) Light microscope

2. For seeing tiny objects we use microscope of:

(a) Low resolving power (b) High resolving power
(c) Electron microscope (d) Light microscope

12.13 COMPOUND MICROSCOPE

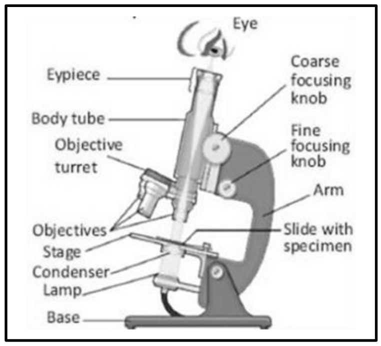
LONG QUESTIONS

Q.1 Describe compound microscope. Also describe its magnification.
(MTN-G2) (DGK-G2)-2015 / (GRW-G2)(BWP-G1)-2016

Ans: **COMPOUND MICROSCOPE**

Definition:

"Compound microscope has two converging lenses, the objective and the eyepiece and is used to investigate structure of small objects".



Features:

Following are some features of compound microscope:

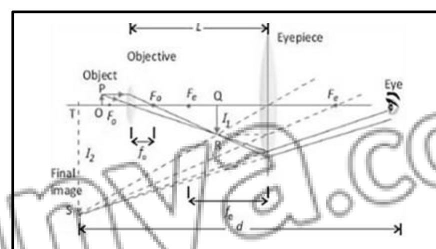
- It gives greater magnification than a single lens.
- The objective lens has a short focal length , $f_o < 1\text{cm}$.
- The eyepiece has larger focal length, f_e of a few cm.

Magnification of the Compound Microscope:

Objective forms a small image I_1, inside the focal point of eyepiece. This image acts as an object for the eyepiece and the final larger image I_2 is formed outside the focal point of the objective.

Mathematical Equation:

The magnification of compound microscope is given by



$$M = \frac{L}{f_\circ}\left(1 + \frac{d}{f_\circ}\right)$$

Where L is the length of compound microscope which is equal to the distance between objective and eye piece, d is distance of final image from eye, f_0, and f_e, are the focal lengths of objective and eye piece respectively.

Uses of Compound Microscope:

- A compound microscope is used to study bacteria and other micro objects.
- It is also used for research in several fields of sciences like Microbiology, Botany, Geology and Genetics.

SHORT QUESTIONS

Q.1 Define compound microscope. **(GRW-G1)-2017**

Ans: **COMPOUND MICROSCOPE**

"Compound microscope has two converging lenses, the objective and the eyepiece and is used to investigate structure of small object."

Q.2 What are the features of compound microscope? **(AJK-G1)-2014**

Ans: **<u>FEATURES OF COMPOUND MICROSCOPE</u>**

The features of compound microscope are:

- It gives greater magnification than a single lens.
- The eyepiece has larger focal length f_e of a few cm.

Q.3 What are the uses of compound microscope? **(Compound microscope Pg. # 57)**

Ans: **<u>USES OF COMPOUND MICROSCOPE</u>**

The uses of compound microscope are:

- To study bacteria and other micro objects.

It is also used for research in several fields of sciences like microbiology, botany, geology and genetics.

Q.4 Compare the focal length of objective lens and eyepiece of compound microscope.

Ans: **<u>COMPOUND MICROSCOPE</u>**

Objective lens has smaller focal length, than the eyepiece. Distance between the objective lens and the eyepiece is greater than $f_o + f_e$. It is used to see very small objects.

Q.5 What do you know about astronomical telescope? **(Astronomical Telescope Pg. # 57)**

Ans: **<u>ASTRONOMICAL TELESCOPE</u>**

Objective lens has larger focal length than the eyepiece. Distance between the objective lens and the eyepiece is equal to $f_o + f_e$. It is used to see distant astronomical objects.

MULTIPLE CHOICE QUESTIONS

1. Which statement is correct about compound microscope? **(RWP-G2)-2015**

(a) Focal length of objective lens is smaller than eyepiece.
(b) Distance between objective lens and eyepiece is greater than $f_0 + f_e$.
(c) It is used to see very small object
(d) All given statements are true

2. The magnification of compound microscope is;

(a) $M = \frac{L}{f_0}\left(1+\frac{d}{f_e}\right)$ (b) $M = \frac{L}{f_0}$

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

12.14 TELESCOPE

LONG QUESTIONS

Q.1 Describe the working and magnification of telescope. **(BWP-G2)-2016**

Ans: **<u>TELSECOPE</u>**

<u>Definition</u>:

"Telescope is an optical instrument which is used to observe distant objects using lenses or mirrors".

<u>Refracting Telescope</u>:

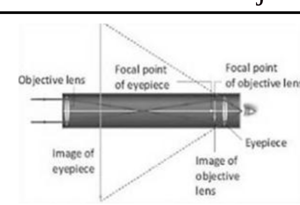


Figure: **<u>An Astronomical Telescope Creates a Virtual Image that is Inverted Compared to that</u>**

A telescope that uses two converging lenses is called refracting telescope (as shown in figure). In refracting telescope, an objective lens forms *a* real image of the distant object, while an eyepiece forms a virtual image that is viewed by the eye.

Working of Refracting Telescope:

When parallel rays from a point on a distant object pass through objective lens, a real image I_1, is formed at the focus $F_\circ$, of the objective lens. This image acts as an object for the eyepiece. A large virtual image I_2, of I_1, is formed by the eyepiece at a large distance from the objective lens. This virtual image makes an angle 0 at the eyepiece.

Magnification of Telescope:

Magnification of a refracting telescope can be determined by $M = \dfrac{f_0}{f_e}$

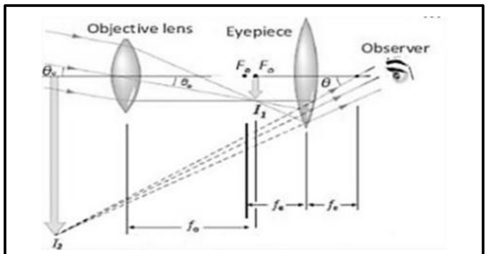


Figure: Ray Diagram of Refracting

SHORT QUESTIONS

Q.1 What is telescope? **(SGD-G1)-2014**

Ans: **TELESCOPE**

Definition:

Telescope is an optical instrument which is used to observe distant object using lenses or mirrors.

Q.2 What is refracting telescope? **(MTN-G2)-2016**

Ans: **REFRACTING TELESCOPE**

Definition:

"A telescope that uses two converging lenses is called refracting telescope".

Q.3 What do you know about terrestrial telescope? **(For your information Pg. # 58)**

Ans: **TERRESTRIAL TELESCOPE**

Terrestrial telescope is similar to refracting telescope except with an extra lens between objective and eyepiece.

Q.4 What will be the magnification of combination of lenses? **(For your information Pg. # 58)**

Ans: **MAGNIFICATION OF COMBINATION OF LENSES**

The magnification of a combination of lenses is equal to the product of the magnification of each lens.

Q.5 What is the importance of telescope in astronomy? **(For your information Pg. # 58)**

Ans: **PURPOSE OF TELESCOPE**

A telescope cannot make stars look bigger, because they are too far away. But there is something important the telescope can do– it makes stars look brighter. Dim stars look bright, and stars that are too faint to see come into view. Without a telescope, we can see up to 3000 individual stars in the night sky; a small telescope can increase this by a factor of at least 10. So a telescope is better than the naked eye for seeing dim stars. The reason is that the telescope gathers more light than the eye.

Q.6 Write two differences between telescope and microscope. **(SWL-G2)-2017**

Ans:

<u>DIFFERENTIATION</u>

The differences between telescope and microscope are as follows:

Telescope	Microscope
• It is optical instrument which is used to observe distant object using lenses or mirrors. • Telescope is used to see distant astronomical objects.	• Microscope is used to investigate structure of small objects. • A microscope is used to study bacteria and other micro objects.

MULTIPLE CHOICE QUESTIONS

1. It is an optical instrument which is used to observe distant objects using lens or mirror;

(a) Microscope (b) Kaledoscope
(c) Telescope (d) Light microscope

2. Magnification of telescope can be determined by using formula;

(a) $M = \frac{f_0}{f_e}$ (b) $M = \frac{f_0}{f_0}$
(c) $M = \frac{F}{L}$ (d) $M = \frac{L_0}{f_0}$

12.15 THE HUMAN EYE

LONG QUESTIONS

Q.1 Describe the structure and image formation in human eye? **(LHR-G1)-2015**

Ans:

<u>THE HUMAN EYE</u>

<u>Definition</u>:

"Eye is an organ of a human body used for vision".

<u>Image Formation</u>:

The image formation in human eye is shown in figure. Human eye acts like a camera.

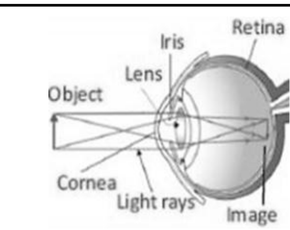


Figure: <u>Image Formation in Human Eye</u>

Parts of Human Eye:

The parts of human eye which plays an important role in the image formation are described as below:

Retina:

Human eye acts like a camera. In place of the film, the retina records the picture. The eye has a refracting system containing a converging lens. The lens forms an image on the retina which is a light sensitive layer at the back of the eye.

Lens:

In the camera, the distance of lens from film is adjusted for proper focus but in the eye, the lens changes focal length.

Cornea:

Light enters the eye through a transparent membrane called the cornea.

Iris:

The iris is the colored portion of the eye and controls the amount of light reaching the retina.

Pupil:

Iris has an opening at its center called the pupil. The iris controls the size of the pupil.

Controlling Pupil Size:

In bright light, Iris contracts the size of the pupil while in dim light pupil is enlarged. The lens of the eye is flexible and accommodates objects over a wide range of distances.

Q.2 What do you know about accommodation? Also describe the mechanism for focusing in eye.

Ans:

ACCOMODATION

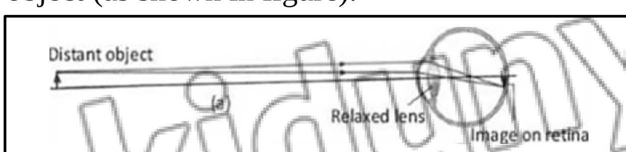
Definition:

"The variation of focal length of eye lens to form a sharp image on retina is called accommodation**"**.

- It is large in young people while it goes on decreasing with age.

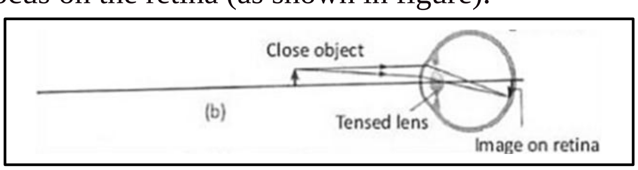
For Distant Objects:

If an object is far away from the eye, the deviation of light through the lens must be less. To do this, the ciliary muscles relax and decrease the curvature of the lens, thereby, increasing the focal length. The rays are thus focused onto the retina producing a sharp image of the distant object (as shown in figure).



For Close Objects:

If an object is close to the eye, the ciliary muscles increase curvature of the lens, thereby, shortening the focal length. The divergent rays from the nearer object are thus bent more so as to come to a focus on the retina (as shown in figure).



Correction:

Defects in accommodation may be corrected by using different type of lenses in eyeglasses.

Focusing Mechanism of Eye:

- The camera focuses the image of an object at a given distance from it by moving the lens towards or away from the film.
- The eye has different adjusting mechanism for focusing the image of an object onto the retina. Its ciliary muscles control the curvature and thus the focal length of the lens, and allow objects at various distances to be seen.

Q.3 Describe the near point and far point of an eye.

Ans: **NEAR POINT**

Definition:

"The near point of the eye is the minimum distance of an object from the eye at which it produces a sharp image on the retina".

- This distance is also called the least distance of distinct vision.

Explanation:

When we hold a book too close, the print is blurred because the lens cannot adjust enough to bring the book into focus. An object closer to the eye than the near point appears blurred. For people in their early twenties with normal vision, the near point is located about 25 cm from the eye. It increases to about 50 cm at the age 40 years and to roughly 500 cm at the age of 60 years.

FAR POINT

Definition:

"The far point of the eye is the maximum distance of a distant object from the eye on which the fully relaxed eye can focus".

Explanation:

A person with normal eyesight can see objects very far away, such as the planets and stars, and thus has a far point located at infinity. Majority of people do not have "normal eyes" in this sense!

SHORT QUESTIONS

Q.1 Define accommodation.

Ans: **ACCOMODATION**

Deficiency:

"The variation of focal length of eye lens to form a sharp image on retina is called accommodation".

Q.2 How do we see? **(For your information Pg. # 59)**

Ans: **SEEING OBJECT**

We see because the eye forms images on the retina at the back of the eyeball.

Q.3 How the size of the pupil of our eye will change? **(Quick quiz Pg. # 59)**

- In dim light
- In bright light

Ans: **SIZE OF PUPIL**

In Dim Light:

In dim light pupil is enlarged.

In Bright Light:

In bright light, iris contracts the size of the pupil.

Q.4 Define near point and far point.

Ans: **NEAR POINT**

Definition:

"The near point of the eye is the minimum distance of an object from the eye at which it produces a sharp image on the retina".

- This distance is also called the least distance of distinct vision.

FAR POINT

Definition:

"The far point of the eye is the maximum distance of a distant object from the eye on which the fully relaxed eye can focus".

MULTIPLE CHOICE QUESTIONS

1. Human eye acts like:

(a) Camera (b) Telescope
(c) Kaledoscope (d) Microscope

2. Light enters the eye through transparent membrane called:

(a) Retina (b) Cornea
(c) Iris (d) Pupil

3. The coloured portion of eye controls the amount of light reaching the retina.

(a) Iris (b) Pupil
(c) Cornea (d) Eye lens

4. The variation of focal length of eye lens is called:

(MTN-G2)-2014 / (BWP-G2)-2016 / (LHR-G1)-2017

(a) Variation (b) Accommodation
(c) Magnification (d) Resolution

12.16 DEFECTS OF VISION

LONG QUESTIONS

Q.1 What do you mean by defects of vision? Describe he main defects of vision and how as minimized? **(LHR-G1)-2015**

Ans: **DEFECTS OF VISION**

Definition:

"The Inability of the eye to see the image of objects clearly is called defect of vision".

Causes of Defects of vision:

The defects of vision arise when the eye lens is unable to accommodate effectively.

Effect:

The images formed are therefore blurred.

Nearsightedness (myopia):

Definition:

"Some people cannot see distant objects clearly without the aid of spectacles. This defect of vision is known as short sight or nearsightedness".

Reason:

It may be due to the eyeball being too long. Light rays from a distant object are focused in front of the retina and *a* blurred image is produced.

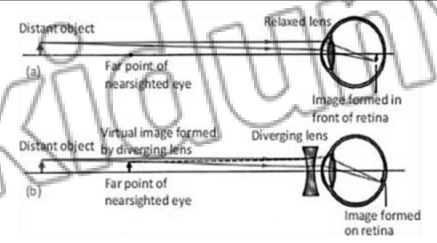


Figure: **Correction of Nearsightedness**

Correction:

The nearsighted eye can be corrected with glass or contact lenses that use diverging lenses. Light rays from the distant objects are now diverged by this lens before entering the eye. To the observer, these light rays appear to come from far point and are therefore focused on the retina, thus forming a sharp image.

Farsightedness (hypermetropia):

Definition:

“The disability of the eye to form distinct images of nearby objects on its retina is known as farsightedness**”**.

Reason:

IT may be due to eye ball being too short.

Correction:

When a farsighted eye tries to focus on a book held closer than the near point, it shortens its focal length as much as it can. However, even at its shortest, the focal length is longer than it should be. Therefore, the light rays from the book would form a blurred image behind the retina (as shown in figure)

This defect can be corrected with the aid of a suitable converging lens. The lens refracts the light rays and they converge to form an Image on the retina. To an observer, these rays appear to come from near point to form a sharp virtual image on the retina (as shown in figure)

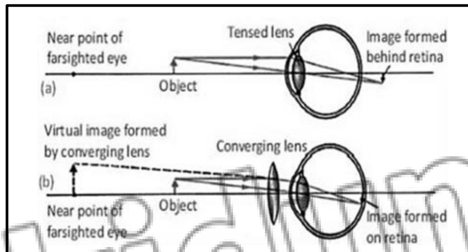


Figure: **Correction of Farsightedness**

SHORT QUESTIONS

Q.1 Compare the contact lenses with the eyeglasses?

Ans: **CONTACT LENSES**

Contact lenses produces the same results as eyeglasses do. These small, thin lenses are placed directly on the corneas. A thin layers of tears between the cornea and lens keeps the lens in the place. Most of the refraction occurs at the air-lens surface, where the difference in indices of refraction is greatest.

Q.2 Which animals can move their eye lenses forward or backward?

(Interesting information Pg. # 61)

Ans: **MOVING EYE LENSES**

Some animals like fish has the ability to move their eye lenses forward or backward and hence, are able to see clearly objects around them.

Q.3 How can we prevent the glare of reflected light from an eye?

(Interesting information Pg. # 61)

Ans: **PREVENTION**

A thin film can be placed on the lenses of eyeglasses to keep them from reflecting wavelengths of light that are highly visible to the human eye. This prevents the glare of reflected light.

Q.4 Define nearsightedness and farsightedness.

(GRW-G1)(MTN-G2)-2016 / (FSD-G1)(LHR-G1)-2017

Ans: **NEARSIGHTEDNESS (MYOPIA)**

Definition:

"Some people cannot see distant objects clearly without the aid of spectacles. This defect of vision is known as short sight or nearsightedness**"**.

FARSIGHTEDNESS (HYPERMETROPIA)

Definition:

"The disability of the eye to form distinct images of nearby objects on its retina is known as farsightedness**"**.

MULTIPLE CHOICE QUESTIONS

1. When people cannot see distant objects clearly without the aid of spectacles the defect of vision is called as:

(a) Short-sighted (b) Near-sightedness
(c) Both (a) & (b) (d) Farsightedness

2. Short sighted may be due to eyeball being:

(a) Too long (b) Too short
(c) Too thick (d) Too thin

3. Which animal has the ability to move eye lens forward or backward?

(a) Fish (b) Human
(c) Birds (d) Dog

4. The nearsighted eye can be corrected by using;

(a) Diverging lens (b) Converging lens
(c) Both (a) & (b) (d) Concave mirror

5. The disability of the eye to form distinct images of nearby object on retina is called forsightedness or:

(a) Short sightedness (b) Isometropia
(c) Hypermetropia (d) Myopia

6. Farsightedness can be corrected by using:

(a) Converging lens (b) Diverging lens
(c) Concave mirror (d) Convex mirror

7. Power of concave lens is:

(a) Greater (b) Less
(c) Positive (d) Negative

8. Long sightedness is caused due eye ball being.

(a) Too thick (b) Too thin

(c) Too short (d) Too long

9. Near point of a normal human being is: **(GRW 2013)**

(a) 25 cm (b) 50 cm

(c) 100 cm (d) Infinity

10. Long sightedness can be corrected by:

(a) Convex mirror (b) Concave mirror

(c) Convex lens (d) Concave lens

MCQ'S ANSWER KEY (TOPIC WISE)

12.1 REFLECTION OF LIGHT

1	2	3	4	5	6	7	8	9
A	C	B	A	A	B	D	A	B

12.2 SPHERICAL MIRRORS

1	2	3	4	5	6	7	8	9
D	A	C	D	B	B	C	A	C

12.3 IMAGE LOCATION BY SPHERICAL MIRROR FORMULA

1	2	3	4
C	A	B	A

12.4 REFRACTION OF LIGHT

1	2	3	4	5	6	7	8
B	C	C	A	C	B	C	B

12.5 TOTAL INTERNAL REFLECTION

1	2	3	4	5	6	7	8
B	B	B	A	A	B	B	D

12.6 APPLICATION OF TOTAL INTERNAL REFLECTION

1	2	3	4	5	6	7	8	9	10	11	12
C	B	C	C	A	C	D	C	A	B	B	C

12.7 REFRACTION THROUGH PRISM

1	2	3	4	5
D	A	C	C	A

12.8 LENSES

1	2	3	4	5	6	7	8	9	10	11
C	D	A	C	C	D	C	B	B	A	C

12.9 IMAGE FORMATION BY LENSES

1	2	3	4
A	A	A	D

12.10 IMAGE LOCATION BY LENSES

1	2	3	4
B	B	D	B

12.11 APPLICATION OF LENSES

1	2	3	4
D	D	C	A

12.12 SIMPLE MICROSCOPE

1	2
B	B

12.13 COMPOUND MICROSCOPE

1	2
D	A

12.14 TELESCOPE

1	2
C	A

12.15 THE HUMAN EYE

1	2	3	4
A	B	A	B

12.16 DEFECTS OF VISION

1	2	3	4	5	6	7	8	9	10
C	A	A	A	C	A	D	C	A	D

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. Which of the following quantity is not changed during refraction of light?
(a) Its direction (b) Its speed
(c) Its frequency (d) Its wavelength

ii. A converging mirror with a radius of 20cm creates a real image 30cm from the mirror. What is the object distance?
(a) –5.0cm (b) –7.5cm
(c) –15cm (d) –20cm

iii. An object is placed at the centre of curvature of a concave mirror. The image produced by the mirror is located:
(a) Out beyond the centre of curvature
(b) At the centre of curvature
(c) Between the centre of curvature and the focal point

(d) At the focal point

iv. An object is 14cm in front of a convex mirror. The image is 5.8cm behind the mirror. What is the focal length of the mirror?

(a) –4.1cm (b) –8.2cm
(c) –9.9cm (d) –20cm

v. The index of refraction depends on:

(a) The focal length (b) The speed of light
(c) The image distance (d) The object distance

vi. Which type of image is formed by a convex lens on a screen?

(a) Inverted and real (b) Inverted and virtual
(c) Upright and real (d) Upright and virtual

vii. Which type of image is produce by the converging lens of human eye if it views a distant object?

(a) Real, erect same size (b) Real, inverted, diminished
(c) Virtual, erect, diminished (d) Virtual, inverted, magnified

viii. Image formed by a camera is:

(a) Real, inverted and diminished (b) Virtual, upright and diminished
(c) Virtual, upright and magnified (d) Real, inverted and magnified

ix. If a ray of light in glass is incident on an air surface at an angle greater than the critical angle, the ray will:

(a) Refract only (b) Reflect only
(c) Partially refract and partially reflect (d) Diffract only

x. The critical angle for a beam of light passing from water into air is 48.8 degrees. This means that all light rays with an angle of incidence greater than this angle will be:

(a) Absorbed (b) Totally reflected
(c) Partially reflected and partially transmitted (d) Totally transmitted

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix	x
C	C	B	C	B	A	B	A	B	B

REVIEW QUESTIONS

12.1 What do you understand by reflection of light? Draw a diagram to illustrate reflection at a plane surface.

Ans: (See Topic 12.1, Short Question-1)

12.2 Describe the following terms used in reflection:

(i) Normal (ii) Angle of incidence (iii) Angle of reflection

Ans:

ANGLE OF INCIDENCE

Definition:

“The angle between the incident ray and normal is called as angle of incidence (i)**”**

ANGLE OF REFLECTION

Definition:

"The angle between normal and reflected ray at the point of incidence is called as angle of reflection (r)"

NORMAL

Definition:

"A line (imaginary) at right angle to the plan (surface) is called normal to the surface"

12.3 State laws of reflection. Describe how they can be verified graphically.

Ans: (See Topic 12.1, Long Question-1)

12.4 Define refraction of light. Describe the passage of light through parallel-sided transparent material.

Ans: (See Topic 12.4, Long Question-1)

12.5 Define the following terms used in refraction:

(i) Angle of incidence (ii) Angle of refraction

Ans:

ANGLE OF INCIDENCE

Definition:

"Incidence ray makes an angle with normal line is called angle of incidence"

ANGLE OF REFRACTION

Definition:

"The angle made by refracted ray with normal line is called angle of refraction"

12.6 What is meant by refractive index of a material? How would you determine the refractive index of a rectangular glass slab?

Ans: (See Topic 12.4, Long Question-2)

12.7 State the laws of refraction of light and show how they may be verified using rectangular glass slab and pins.

Ans: (See Topic 12.4, Long Question-2)

12.8 What is meant by the term total internal reflection?

Ans: (See Topic 12.5, Short Question-2)

12.9 State the conditions for total internal reflection.

Ans: (See Topic 12.5, Short Question-3)

12.10 What is critical angle? Derive a relationship between the critical angle and the refractive index of a substance.

Ans: (See Topic 12.5, Long Question-1)

12.11 What are optical fibres? Describe how total internal reflection is used in light propagating through optical fibres.

Ans: (See Topic 12.6, Long Question-2)

12.12 Define the following terms applied to a lens:

(i) Principal axis (ii) Optical centre (iii) Focal length

Ans: (See Topic 12.8, Long Question-4)

12.13 What is meant by the principal focus of a (a) convex lens (b) concave lens? Illustrate your answer with ray diagrams.

Ans: (See Topic 12.8, Long Question-4)

12.14 Describe how light is refracted through convex lens.

Ans: (See Topic 12.9, Long Question-1)

12.15 With the help of a ray diagram, how can you show the use of thin converging lens as a magnifying glass?

Ans: (See Topic 12.12, Short Question-3)

12.16 A coin is placed at a focal point of a converging lens. Is an image formed? What is its nature?

Ans: (See Topic 12.9, Long Question-2) (object at F)

12.17 What are the differences between real and virtual images?

Ans:

REAL IMAGE

- The image that can be obtained on screen is called real image
- In real image, rays of light actually converge to form image
- Image is inverted

VIRTUAL IMAGE

- The image that can not be obtained on screen is called virtual image.
- In virtual image, rays of light appear to diverge
- Virtual image is erect

12.18 How does a converging lens form a virtual image of a real object? How does a diverging lens form a real image of a real object?

Ans:

CONVERGING LENS

- Converging lens form a virtual image of real object when the object is placed between optical centre and principal focus. The image is formed behind the object, virtual and larger in size than object.

DIVERGING LENS

- Diverging lens form a virtual image of real objects therefore, it is not possible for a diverging or concave lens to form a real image of real object.

12.19 Define power of a lens and its units.

Ans: (See Topic 12.8, Short Question-6)

12.20 Describe the passage of light through a glass prism and measure the angle of deviation.

Ans: (See Topic 12.7, Long Question-1)

12.21 Define the terms resolving power and magnifying power.

Ans: (See Topic 12.12, Long & Short Question-1)

12.22 Draw the ray diagrams of

(i) Simple microscope (ii) Compound microscope (iii) Refracting telescope

Ans: **Image**

12.23 Mention the magnifying powers of the following optical instruments:
(i) Simple microscope (ii) Compound microscope (iii) Refracting telescope

Ans:

SIMPLE MICROSCOPE

Magnifying Power:

Magnifying power of simple microscope can be determined by using formula:

$$M = \frac{Q'}{\theta} = \frac{\text{Angular size of final image produced by magnifying glass}}{\text{Angular size of object seen without glass}}$$

OR

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

COMPOUND MICROSCOPE

Magnifying Power:

Magnifying power of compound microscope can be determined by using formula:

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

TELESCOPE

Magnifying Power:

Magnifying power of telescope can be determined by using formula.

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

12.24 Draw ray diagrams to show the formation of images in the normal human eye.

Ans: (From Text Book, Pg#59 Fig 12.35)

12.25 What is meant by the terms nearsightedness and farsightedness? How can these defects be corrected?

Ans: (See Topic 12.6, Long Question-1)

CONCEPTUAL QUESTIONS

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

Ans: **IMAGE BY PLANE MIRROR**

Images produced by the plane mirror are virtual, upright, left-right reversed, the same distance from the mirror and of same size as object.

A plane mirror produces virtual image. If we view an image of our self in a plane mirror, we will quickly notice that there is an apparent left right reversal of the image. That's why if we raise our left hand, the image facing him raising his right hand due to the left-right reversal of the orientation.

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

Ans: **REFRACTION OF LIGHT WAVES**

When light rays enter from one transparent medium into another medium the speed of light changes due to change in wavelength. The speed of light is different in different materials due to difference in densities so light rays are refracted at the boundary between two materials.

12.3 Explain why a fish under water appears to be at a different depth below the surface than it actually is. Does it appear deeper or shallower?

Ans: **FISH IN WATER**

A fish under water appears to be at different depth below the surface, it appears to be shallower because apparent depth is always less than the real depth and image is formed after the refraction of light in water at the apparent depth.

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

Ans: **CONCAVE MIRRORS FOR MAKEUP**

Concave mirrors are suitable for make up because when a person stands between principal focus and pole of mirror, he sees an enlarge erect and virtual image of his face and it is not suitable, when a person is not with in the focal length of mirror because the image formed will be real and inverted.

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

Ans: **DRIVER'S SIDE MIRROR AS CONVEX**

The image formed by the convex mirror is always virtual, erect and diminished so convex mirrors are used in automobiles which enable the driver to see the automobiles coming behind him.

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.

Ans: **OPTICIAN'S TESTING FORSIGHT**

If the optician's room is small, then for testing the patients eye sight original words are placed at the back side of patient and mirror is placed in front of the patient. So, that the image of words is formed at the distance doubled than the size of room.

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

Ans: **EFFECT OF HICKNESS OF A LENS**

As we know that f=R/2, focal length is half of the radius of curvature. Thickness of lens (or) curvature of lens affect the focal length of lens. A thick lens has short focal length and a thin lens has large local length.

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

Ans: **VIRTUAL IMAGE BY CONVERGING LENS**

If the object is placed between principal focus and optical centre of converging lens, the image formed will be virtual, erect and large in size than the object.

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

Ans: **REAL & SAME SIZE IMAGE**

If object is placed at a distance of 2F from the optical centre of converging lens, the image formed will be real, inverted and same size as that of object.

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

Ans: **REFRACTIVE TELESCOPE WITH LARGE OBJECTIVE LENS**

In telescope, objective lens of large focal length is used in order to collect information of distant object from infinity. Objective lens forms a real, inverted and diminished image at the principal foucs of objective lens. This image acts as an object for the eye piece lens and this lens forms the large, errects virtual image at a large distance from the objective lens.

NUMERICAL PROBLEMS

12.1 An 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 Data:

Distance of object = p = 10 cm

Distance of image = q = –5 cm (For convex mirror)

Required:

Focal length f = ?

Formula:

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

Calculations:

By putting the values

$$\frac{1}{f} = \frac{1}{10cm} - \frac{1}{5cm}$$

$$= \frac{1-2}{10cm}$$

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

f = –10 cm

Result:

Hence the focal length of convex mirror is 10 cm. Here, negative sign indicates that image is virtual.

12.2 An object 30.0 cm tall is located 10.5 cm from a concave mirror with focal length 16.0cm. (a) Where is the image located) (b) How high is it?

Solution:

Given Data:

Object height = h_o = 30 cm

Distance of object = p = 10.5 cm

Focal length = f = 16 cm

Required:

(a) Distance of image = q = ?

(b) Image height = h_i = ?

Formula:

(a) Using the formula

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

(b) we know that

$$\frac{image\,height}{object\,height} = \frac{q}{p}$$

Calculations:

(a) By using formula, we have

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

Or $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

$$\frac{1}{q}=\frac{1}{16\,cm}-\frac{1}{10.5\,cm}$$

Or $$\frac{1}{q}=\frac{1}{16\,cm}-\frac{10}{105\,cm}$$

$$=\frac{105-160}{(16)(105)\,cm}$$

$$=-\frac{55}{(16)(105)\,cm}$$

q = –30.54 cm

(b) By using formula, we have

or $$\frac{h_i}{h_o}=\frac{q}{p}$$

by putting the values

$$\frac{h_i}{30\,cm}=\frac{30.54\,cm}{10.5\,cm}$$

$$h_i=\frac{30.54\,cm}{10.5\,cm}\times 30\,cm$$

h_i = 87.26 cm

Result:

Hence the distance of image will be 30.54 cm from concave mirror. Here, negative sign indicates the image is virtual. The height of image formed will be

12.3 An object and its image in a concave mirror are of the same height, yet inverted, when the object is 20.0 cm form the mirror. What is the focal length of the mirror?

Solution:

Given Data:

Distance of object = p = 20 cm

Distance of image = q =20 cm

Required:

Focal length = f =?

Formula:

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

Calculations:

By using the formula, we have

$$\frac{1}{f} = \frac{1}{20cm} + \frac{1}{20cm}$$
$$= \frac{1+1}{20\,\text{cm}}$$
$$= \frac{2}{20\,\text{cm}}$$
$$f = \frac{20\,\text{cm}}{2}$$
$$f = 10\text{ cm}$$

Result:

Hence, the focal length of mirror will be 10 cm.

12.4 Find the focal length of a mirror that form an image 5.66 cm behind a mirror of an object placed at 34.4 cm in front of the mirror

Solution:

Given Data:

Distance of the image form the mirror = q = 5.66

Distance of object form the mirror = p = 34.4 cm

Required:

Find out the focal length of the mirror = f = ?

Formula:

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

Calculations:

By using the above formula

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

As the image is formed behind the mirror, so it would be convex mirror, so q will be taken negative.

q = - 5. 66 cm

p = + 34 .4 cm

By substituting values in above equation, we get;

$$\frac{1}{f} = -\frac{1}{5.66} + \frac{1}{34.4}$$
$$\frac{1}{f} = -0.177 + 0.029$$
$$\frac{1}{f} = -0.148$$
$$f = -6.77cm$$

Result:

Hence, the focal length of mirror will be 6.77 cm and here, negative sign indicates that the image is virtual.

12.5 An image of a statue appears to be 11.5 cm behind a convex mirror with focal length 13.5 cm. find the distance form the statue to the mirror. (GRW 2014)

Solution:

Given Data:

Distance of image = q = –11.5 cm (For convex mirror)

Focal length = f = 13.5 cm

Required:

Distance of object = p = ?

Formula:

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

Calculations:

By using the formula, we have

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

Or $$\frac{1}{p} = \frac{1}{f} - \frac{1}{q}$$

By putting the values

$$\frac{1}{p} = \frac{1}{13.5\,\text{cm}} + \frac{1}{11.5\,\text{cm}}$$

$$= \frac{11.5 + 13.5}{(13.5)\,(11.5)\,\text{cm}}$$

$$= \frac{25}{155.25\,\text{cm}}$$

$$p = \frac{155.25\,\text{cm}}{25}$$

$$p = 6.21 \text{ cm}$$

Result:

Hence the distance of statue from the mirror will be 6.21 cm.

12.6 An image is produced by a concave mirror of focal length 8.70cm. 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:

Given Data:

Focal length f = 8.70 cm

Object height h_o = 13.2 cm

Distance of object p = 19.3 cm

Required:

(a) Location of image = q = ?

(b) Height of image = h_o = ?

Formula:

(a) $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

(b) $\frac{h_i}{h_o} = \frac{q}{p}$

Calculations:

(a) By using the formula, we have

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

Or $\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

By putting the values

$$\frac{1}{q} = \frac{1}{8.7\,\text{cm}} - \frac{1}{19.3\,\text{cm}}$$

$$\frac{1}{q} = \frac{19.3 - 8.7}{(8.7)\,(19.3)\,\text{cm}}$$

$$\frac{1}{q} = \frac{10.6}{167.9\,\text{cm}}$$

$$q = \frac{167.9\,\text{cm}}{10.6}$$

$$q = 15.83 \text{ cm}$$

(b) By using the formula, we have

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or $h_i = \frac{q}{p} \times h_o$

By putting the values

$$h_i = \frac{15.84\,\text{cm}}{19.3\,\text{cm}} \times 13.2 \text{ cm}$$

$$h_i = \frac{209.09\,\text{cm}}{19.3}$$

$$h_i = 10.83 \text{ cm}$$

(b) When the object is twice as far from the mirror, then

p = 19.3 cm × 2 = 38.6 cm

Now, again using the formula

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or $h_i = \frac{q}{p} \times ho$

By putting the values

$$h_i = \frac{15.84\,cm}{38.6\,cm} \times 13.2\ cm$$

$$h_i = \frac{2.09.09\,cm}{38.6}$$

$$h_i = 5.42\ cm$$

Result:

Hence the image formed will be at the distance of 15.83cm and the image height will be 10.83 cm. But if object is at double distance then height will be 5.42

12.7 Nabeela uses a concave mirror when applying makeup. The mirror has a radius of curvature of 38.0 cm. (a) what is the focal length of the mirror? (b) Nabeela is located 50cm from the mirror. Where will her image appear? (c) Will the image be upright or invited?

Solution:

Given Data:

Radius of curvature = R = 38 cm
Distance of object = p = 50 cm

Required:

(a) Focal length = f = ?
(b) Distance of image = q = ?
(c) Nature of image = ?

Formula:

(a) $f = \frac{R}{2}$

(b) $\frac{1}{f} = \frac{1}{q} + \frac{1}{p}$

Calculations:

(a) By using the formula, we have

$$f = \frac{R}{2}$$

or $$f = \frac{38\,cm}{2}$$

$$f = 19\ cm$$

(b) Using the formula

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

Or $$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

$$\frac{1}{q} = \frac{1}{19\,cm} - \frac{1}{50\,cm}$$

$$= \frac{50 - 19}{(19)\,(50)\,cm}$$

$$= \frac{31}{950\,cm}$$

Therefore, $q = \frac{950\,cm}{31}$

$q = 30.64$ cm

(c) **Nature of image:**

The image formed will be real, inverted and smaller in size than object.

Result:

Hence, the focal length of mirror will be 19 cm and distance of image will be 30.64 cm. The image formed will be real, inverted and smaller in size than

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

Solution:

Given Data:

Height of object = ho = 4cm

Distance of object = p = 12 cm

Focal length = f = 8 cm

Required:

(a) Position of image = q = ?

(b) Size of image = h_i = ?

(c) Nature f the image = ?

Formula:

(a) $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

(b) $\frac{h_i}{h_o} = \frac{q}{p}$

Calculations:

(a) By using the formula, we have

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

or $\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

By putting the values

$$\frac{1}{q} = \frac{1}{8\,cm} - \frac{1}{12\,cm}$$

$$= \frac{12 - 8}{(8)\ (12)\,cm}$$

$$= \frac{4}{96\,cm}$$

$$q = \frac{96\,cm}{4}$$

$q = 24$ cm

(b) by using formula, we have

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or $$h_i = \frac{q}{p} \times h_o$$

By putting the values

$$h_i = \frac{24\,cm}{12\,cm} \times 4cm$$

$$h_i = \frac{96\,cm}{12\,cm}$$

$$h_i = 8 \text{ cm}$$

(c) **Image nature:**

Since the lens in convex and size of image is larger than the size of the object, therefore, image formed is real, inverted and magnified.

Result:

Hence, the position of the image will be 24 cm and the size of image will be 8 cm. Since the lens in convex and size of image is larger than the size of the object, therefore, image formed is real, inverted and magnified.

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

(LHR 2014)

Solution:

Given Data:

Size of object = ho = 10 cm

Distance of object = p = 20 cm

Focal length = f = –15 cm (for concave lens)

Required:

(a) Politico of image = q = ?

(b) Size of image = h_i = ?

(c) Nature of image = ?

Formula:

Calculations:

(a) By using the formula, we have

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

or $$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

By putting the values

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

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

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

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

$$= -8.57\ cm$$

(b) By using formula, we have

$$\frac{h_i}{h_o} = \frac{q}{p}$$

Or $h_i = \frac{q}{p} \times h_o$

By putting the values

$$h_i = \frac{8.57\,cm}{20\,cm} \times 10cm$$

$h_i = 4.28$ cm

(c) **<u>Image nature:</u>**

Since the lens is concave and object is larger in size than the size of the image, t Therefore, the image in virtual, erect and diminished.

<u>Result</u>:

Hence, the position of image will be 8.57 cm. Here negative sign indicates that image is virtual. The size of image will be 4.28 cm. Image will be virtual erect and diminished.

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

Solution:

Given Data:

Focal length = f = 6 cm (For virtual image)

Distance of image = q = –3p

Required:

Distance of object p = ?

Formula:

By using the formula, we have

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

Calculations:

By putting the values,

$$\frac{1}{6\,cm} = \frac{1}{p} - \frac{1}{3p}$$

$$\frac{1}{6\,cm} = \frac{3-1}{3p}$$

$$\frac{1}{6\,cm} = \frac{2}{3p}$$

Or 3p = 12 cm

$$p = \frac{12\,cm}{3}$$

p = 4cm

Result:

Hence, the distance of object will be 4 cm form convex lens.

12.11 A ray of light from air is incident on a liquid surface at an angle of incidence 35°. Calculate the angle refraction if the refractive index of the liquid is 12.5. Also calculate the critical angle between the liquid air inter-face.

Solution:

Given Data:

Angle of incidence i ss= 35°

Refractive index n = 1.25

Required:

(a) Angle of refraction r = ?

(b) Critical angle = C = ?

Formula:

(a) $n = \frac{\sin \hat{i}}{\sin \hat{r}}$

(b) $\sin C = \left(\frac{1}{n}\right)$

Calculations:

(a) Using Snell's law

$$n = \frac{\sin \hat{i}}{\sin \hat{r}}$$

Or $\sin r = \frac{\sin i}{n}$

By putting the values

$$\sin r = \frac{\sin(35^o)}{1.25}$$

$$\sin r = \frac{0.57}{1.25}$$

$$= 0.456$$

$$r = \sin^{-1}(0.456)$$

$$r = 27.13^o$$

(b) For critical angle. We know that

$$\sin C = \left(\frac{1}{n}\right)$$

or $C = \sin^{-1}\left(\frac{1}{n}\right)$

By putting the values

$$C = \sin^{-1}\left(\frac{1}{1.25}\right)$$

$$= \sin^{-1}(0.8)$$

$$C = 52.13^o$$

Result:

Hence, the angle of reflection of light from air to liquid will be 27.12° and critical angle between liquid air inter-face will be 52.13°.

12.12 The power of a convex lens is 5D. At what distance the object should be placed from the lens so that its real and 2 times larger image is formed. (LHR 2013, LHR 2016)

Solution:

Given Data:

Power of the lens p = 5D

Size of image = q = 2p

Required:

Distance of object = p = ?

Formula:

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

Calculations:

To find the distance object from convex lens, first we have to find the focal length of lens. So that by using formula, we have

Power of lens $p = \frac{1}{f}$

or $5 = \frac{1}{f}$

or $f = \frac{1}{5}$

or $f = 0.2m$

$= \frac{2}{10} \times 100 \text{ cm} = 20 \text{ cm}$

Now using the formula

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

By putting the values

$$\frac{1}{20\,\text{cm}} = \frac{1}{p} + \frac{1}{2p}$$

$$\frac{1}{20\,\text{cm}} = \frac{2+1}{2p}$$

$$\frac{1}{20\,\text{cm}} = \frac{3}{2p}$$

$2p = 60$ cm

$p = \frac{60\,\text{cm}}{2}$

$p = 30$ cm

Result:

Hence, the distance of object from the convex length will be 30 cm.

Activity 12.1:

Take a convex mirror or a well-polished spoon (using the outside of the spoon, with the convex surface bulging outward), and hold it in one hand. Hold a pencil with its tip in the upright position in the other hand. Try to look at its image in the mirror. Is the image erect or inverted? Is the image smaller or larger in size than the object? Move the pencil away from the mirror. Does the image become smaller or larger? Guess, whether the image will move closer to or farther from the focus?

Activity 12.2:

Take a concave mirror or a well-polished spoon (using inside of the spoon with concave surface bulging inward). Hold it in hand towards a distant object, such as a building, a tree or a pole. Try to get a sharp, well-focused image of the distant object on the wall or a screen. Measure the distance of the screen from the mirror using a meter scale. Can you find out the rough focal length of the concave mirror? Draw the ray diagram to show the image formation in this situation.

Experiment 12.3:
Place a convex lens in front of a white screen and adjust its position until a sharp image of a distant object is obtained on the screen. For example, we can do this experiment before an open window to get the image of window on a wall or screen (Fig.12.22). Measure the distance between the lens and the screen. This is the approximate focal length of the lens. Explain.
(**Hint:** Make a ray diagram). What is the nature of image?

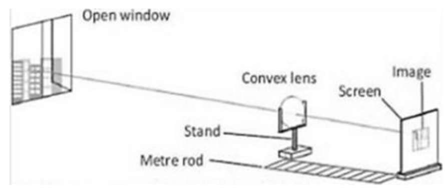


Figure: **Approximate Method of Finding Focal Length of a Convex Lens**

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. In a convex mirror the size of the image:
(A) Is smaller than the size of the object (B) Is greater than the size of the object
(C) Depends upon the position of the object (D) Is equal to the size of the object

2. The index of refraction depends on:
(A) The focal length (B) The speed of light
(C) The image distance (D) The object distance

3. An object is 14 cm in front of a convex mirror. The image is 5.8 cm behind the mirror. What is the focal length of the mirror?
(A) 4.1 cm (B) 8.2 cm
(C) 9.9 cm (D) 20 cm

4. After refraction from a convex lens, rays of light parallel to the principal axis converge at a point, this point of convex lens is called:
(A) Principal focus (B) Pole
(C) Focal length (D) Optical centre

5. The focal length is related to radius of curvature by the formula:
(A) $f = \frac{R}{2}$ (B) $f = 2R$
(C) $f = R2$ (D) $f = 3R$

6. Optical fibers work on the principle of:
(A) Refraction (B) Continuous refraction
(C) Total internal reflection (D) Both B & C

Q.2 Give short answers to following questions. **(5×2=10)**
i. State laws of reflection.
ii. What are the characteristics of focus of a concave and convex mirror?
iii. What is meant by total internal reflection?
iv. Define power of a lens. Give its mathematical form and SI unit.
v. Illustrate the image formation in a convex lens with the help of a ray diagram when the object is place beyond 2F.

Q.3 Answer the following questions in detail. **(4+5=9)**
a) What is meant by total internal reflection? Explain in detail.
b) An object 10 cm high is placed at a distance of 20 cm from a concave lens of focal length 15 cm. Calculate position and size of the image. Also, state the nature of the image.

Note:
Parents or guardians can conduct this test in their supervision in order to check the skill of students.

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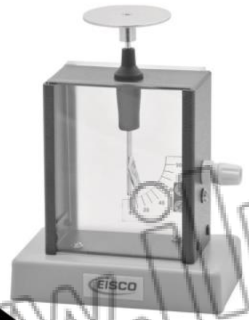


UNIT 13

ELECTROSTATICS

13.1 PRODUCTION OF ELECTRIC CHARGES

LONG QUESTIONS

Q.1 What is electrostatic? How electric charges be produced? Explain it with experiments.
OR How can you show by simple experiments that there are two types of electric charges? *(K.B+U.B+A.B)* **(Review Question 13.1)**

Ans:

ELECTROSTATICS

Definition:

"Study of charges at rest is called electrostatics or static electricity".

Production of Electric Charges:

We can produce electric charge by rubbing a neutral body with another neutral body. The following activates show that we can produce two types of electric charges through the process of rubbing.

Experiment 1:

Take a plastic rod. Rub it with fur and suspend it horizontally by a silk thread. Now take another plastic rod and rub it with fur and bring near to the suspended rod.

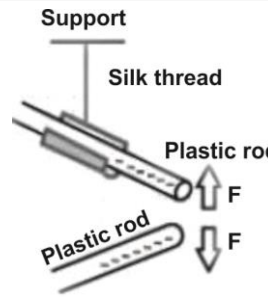


Figure: Like Charges Repel Each Other

Observation:

We will observe that both the rods will repel each other. It means during the rubbing both the rods were charged both rods have same charge.

Experiment 2:

Now take a glass rod and rub it with silk and suspend it horizontally. When we bring the plastic rod rubbed with fur near to the suspended glass rod.

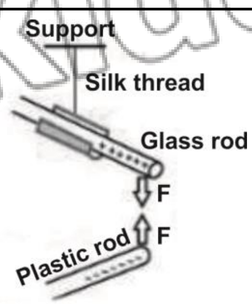


Figure: Unlike charges attract each other

Observation:

We observe that both the rods attract each other. In the first activity, both rods are plastic and both of them have been rubbed with fur. Therefore, we assume that charge on both rods will be off same kind. In the second activity, rods are unlike and their attraction implies that charge on the two rods are not of the same kind but of opposite nature. These opposite charges are conventionally called positive charge and negative charge. During the process of rubbing negative charge is transferred from one object to another object from these activities we conclude that:

Conclusions:

1. **Charge is a basic property of a material body due to which it attracts or repels another object.**
2. **Friction produces two different types of charge on different material such as glass and plastic).**
3. **Like charges always repel each other.**
4. **Unlike charges always attract each other.**
5. **Repulsion is the sure test of charge on a body.**

13.1 SHORT QUESTIONS

Q.1 How can we produce a charge in neutral body? *(K.B)*

Q.2 What is electrostatics? *(K.B)* **(LHR 2013)**

Q.3 Rod cannot be charged by rubbing, if held by hand? **(Conceptual 13.8)**

Ans: **CHARGING OF A GLASS ROD**

Because glass rod is an insulator, so charge developed on it during rubbing does not flow to the ground through the hand holding it. However, iron rod is a conductor and charge developed on it during rubbing can easily flow to the ground through the hand holding it. For this reason all metal objects used in electrostatic have insulating handles or stands.

Q.4 What are the characteristics of charges? *(K.B)*

Q.5 If cat skin is rubbed with lead then which one will get positive charge? *(K.B)*
(For your information Pg. # 70)

Ans: **RUBBING OF CAT SKIN WITH LEAD**

According to the priority list of material rubbed with one another.

1. Asbestos	**2.** Glass Mica	**3.** Woollen cloth	**4.** Cat's skin
5. Lead	**6.** Silky cloth	**7.** Aluminium	**8.** Cotton cloth
9. Wood	**10.** Cooper	**11.** Rubber	**12.** Plastic

The material occurring first in the list would have positive charge and that occurring next would have negative charge. Since cat's skin is occurring first therefore it would get positive charge and lead would get negative charge.

Q.6 Do you think amount of positive charge on the glass rod after rubbing it with silk cloth will be equal to the amount of negative charge on the silk? Explain. *(K.B+U.B+A.B)* **(Self-Assessment Pg. # 70)**

Ans: **AMOUNT OF CHARGE**

When a glass rod is rubbed with silk cloth then due to friction heat is generated. The electrons of glass rod are loosely bounded, they absorb heat and jump on the silk cloth and hence, glass rod gets positive charge. For example, if it loses two electrons then the same is received by silk cloth. Therefore,

Charge on glass rod $= +\ 2 \times 1.6 \times 10^{-19}$ C

$= +3.2 \times 10^{-19}$ C

Charge on silk cloth $= -\ 2 \times 1.6 \times 10^{-19}$ C

$= -3.2 \times 10^{-19}$ C

Conclusion:

Hence, amount of positive charge on the glass rod after rubbing it with silk cloth will be equal to the amount of negative charge on the silk.

Q.7 What would happen if a neutral glass rod is brought near a positively charged glass rod?*(K.B)*

Ans: **NEUTRAL GLASS ROD**

When a neutral glass rod is brought near a positively charged glass rod, then the electrons of the neutral glass rod will be attracted by the positively charged glass rod. Due to this attraction, near end of the neutral glass rod will become negative and other end will become positive.

13.1 MULTIPLE CHOICE QUESTIONS

1. **Study of charges at rest is called: *(K.B)***
(A) Electrostatics (B) Magnetism
(C) Electrochemistry (D) Electric Current
2. **An insulating rod is charged positively by rubbing. This is due to: *(K.B+U.B)***
(A) Deficiency of protons (B) Excess of protons
(C) Deficiency of electrons (D) Excess of electrons
3. **When an insulating rod is charged negatively, this is due to? *(K.B+U.B)***
(A) Deficiency of protons (B) Excess of protons
(C) Deficiency of electrons (D) Excess of electrons
4. **If we run a plastic comb through hair and then bring it near shell pieces of paper. The comb will: *(K.B+A.B)***
(A) Attract them (B) Repel them
(C) Both a and b (D) None of these
5. **Electric charges can be produced by rubbing a neutral body with: *(K.B)***
(A) Charged body (B) Another neutral body
(C) Both a and b (D) None of these
6. **SI unit of electric charge is*(K.B)***
(A) Coulomb (B) Ampere
(C) Volt (D) Watt
7 **A positive charge: *(K.B)***
(A) Attract other positive (B) Repel other positive charge
(C) Attract the natural charge (D) Repels a neutral charge
8. **An object gain excess negative charge after being rubbed against another object: *(K.B)***
(A) Neutral (B) Negative charged
(C) Positively charge (D) Either a, b or c
9. **A body can be charged by: *(K.B)***
(A) Rubbing with another body (B) Conduction
(C) Electrostatic induction (D) All of these

10. How many type charges exist only? *(K.B)* **(GRW 2013)**

(A) One (B) Two
(C) Three (D) Four

11. When a glass rod is rubbed with a silk cloth, then? *(K.B)*

(A) Glass rod acquires negative charge while silk acquires positive charge
(B) Glass rod acquires positive charge while silk acquires negative charge
(C) Both glass rod and silk acquire negative charge
(D) Both glass rod and silk acquire positive charge

12. If a glass rod is rubbed with a silk cloth, it receives charge by the process of: *(K.B)*

(A) Heating (B) Separation of charge
(C) Rubbing (D) Electric force

13. Which one of the following statements is correct? (*K.B)*

(A) Similar charges attract each other
(B) Similar charges repel each other
(C) Similar charges attract and repel each other
(D) Similar charges neither attract nor repel each other

14 Which one of the following statements is correct? *(K.B)*

(A) Opposite charges attract each other
(B) Opposite charges repel each other
(C) Opposite charges attract and repel each other
(D) Opposite charges neither attract nor repel each other

15. Metals are good conductors of electricity, because they have: *(K.B)*

(A) Large number of bounded electrons (B) Small number of bounded electrons
(C) Large number of free electrons (D) Small number of free electrons

16. Free electrons are: *(K.B)*

(A) Tightly bound (B) Fixed
(C) Loosely bound (D) Strongly fixed

17. The number of electrons in one coulomb charge is equal to: *(K.B+U.B)*

(A) 6.25×10^{18} (B) 1.6×10^{-19}
(C) Zero (D) 6.2×10^{21}

18. Like charges always. *(K.B)*

(A) Attract each other (B) Repel each other
(C) Attract and repel each other (D) None of these

13.2 ELECTROSTATIC INDUCTION

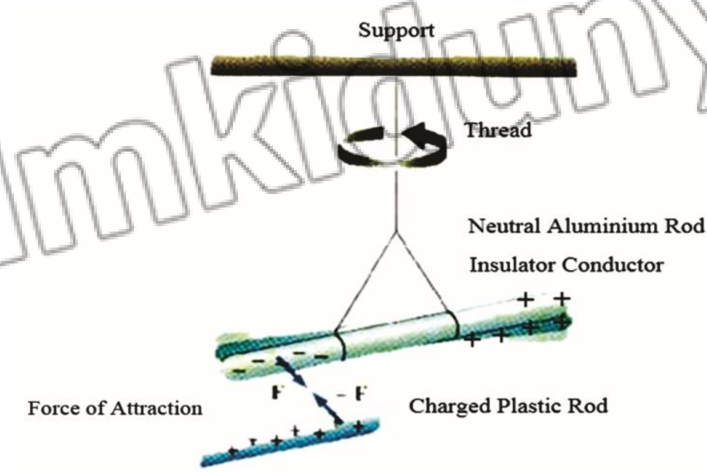
LONG QUESTION

Q.1 Describe the method of charging bodies by electrostatic induction. *(K.B+U.B+A.B)*
(Review Question 13.2)

Ans: **ELECTROSTATIC INDUCTION**

Definition:

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



Whenever a charged body is brought close to an insulator conductor, the near end of the conductor develops an unlike charge while the far end of the conductor develops a like charge. This separation of charges is called electrostatic induction.

Experiment 1:

If we bring charged plastic rod near suspended neutral aluminium rod, both rods attract each other.

This attraction between the charged and uncharged rods shows as if both rods have unlike charges. But this is not true. Charged plastic rod produces displacement of positive and negative charges on the neutral aluminium rod which is the cause of attraction between them. But total charge on aluminium rod is still zero. It implies that attraction is not the sure test of charge on a body.

It also shows that electrostatic induction is another method of charging a body.

Method of Charging a Bodies by Electrostatic Induction:

Experiment 2:

Bring two metal spheres A and B and fix them on insulated stands, such that they touch each other. Now bring a positively charged rod near sphere A. Rod will attract negative charge towards it and repel positive charge away from it. Negative charge will appear on the left surface of the sphere A which is close to the rod.

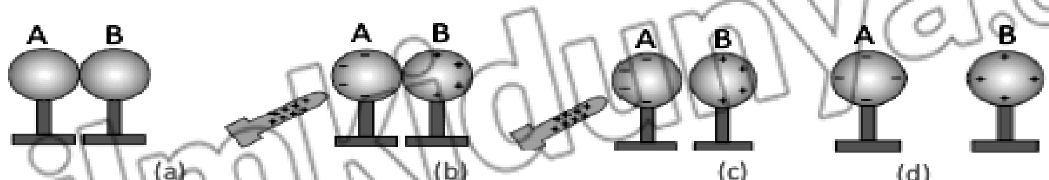


Figure: Electrostatic Induction

While positive charge will appear on the right surface of the sphere B. Now separate the spheres while the rod is still near the sphere A. Now if you test the two spheres, you will find that the two spheres, will be oppositely charged. After removing the rod, the charges are uniformly distributed over the surfaces of the spheres.

Conclusion:

In this process, an equal and opposite charges appear on each metal sphere. This is called charging by induction.

SHORT QUESTIONS

Q.1 What is meant by electrostatic induction, for which purpose it is used? *(K.B+A.B)*

(GRW 2013, LHR 2016)

Q.2 How electric charge is produced in bodies by friction? *(K.B)*

Ans: **CHARGING BY FRICTION**

When we rub two bodies, we provide external force by rubbing. Then the loosely bound electrons in one body are transferred to the other body. As electrons carry negative charge, therefore, a negative charge is developed on the body which gets electrons and positive charge is developed on that body which loses electrons.

Q.3 Where electrostatic induction is used? *(A.B)*

OR What are the applications of electrostatic induction?

Ans: **APPLICATION OF ELECTROSTATIC INDUCTION**

Electrostatic is used in everyday lives which includes:

- Photocopying
- Car painting
- Extracting dust from chimneys of industrial machinery.

Q.4 What is electrostatic precipitators? *(Conceptual Base+ A.B)*

Ans: Electrostatic precipitators are fitted to the chimneys of some power stations and factories. They reduce pollution by removing tiny bits of ash from the waste gases. Inside the chamber of a precipitator, the ash is charged by wires, and then attracted to the metal plates by an opposite charge. When shaken from the plates, the ash collects in the tray at the bottom.

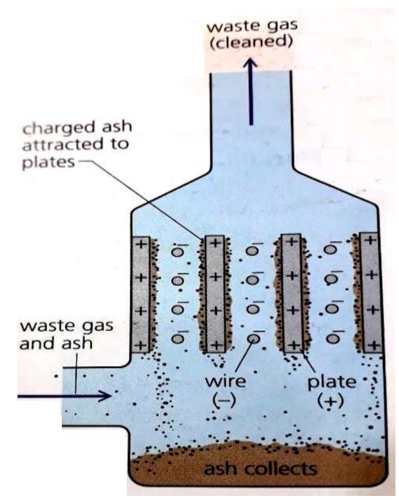


Fig. Electrostatic Precipitators

Q.5 What is induced charges? *(Conceptual+A.B)*

Ans: Charges that 'appear' on an uncharged object because of a charged object nearby are called induced charges. In the diagram below, a metal sphere is being charged by induction. The sphere ends up with an opposite charge to that on the rod, which never actually touches the sphere.

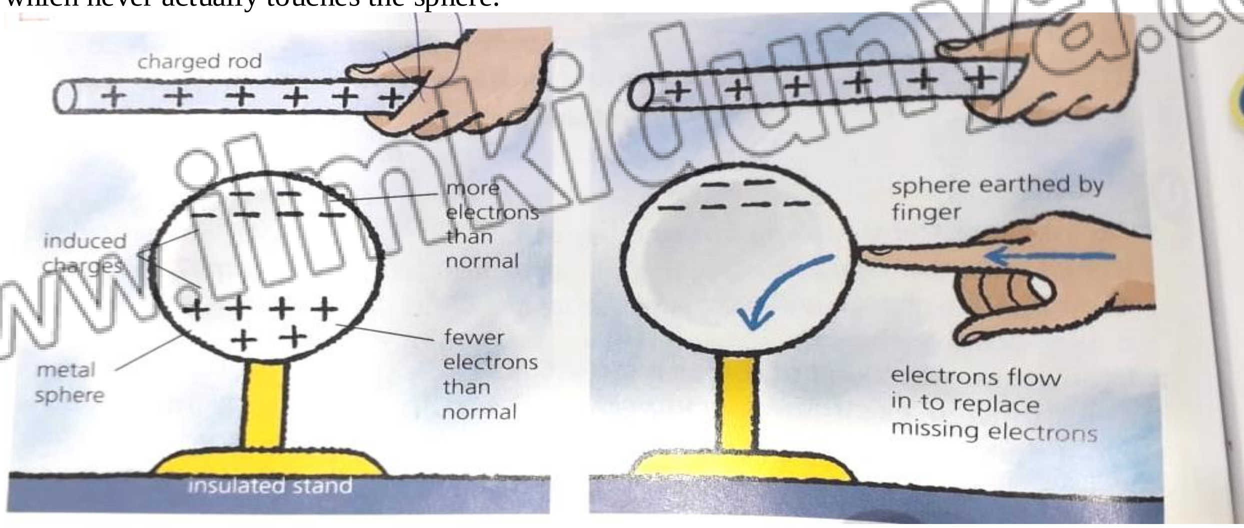


Figure of Induced Charges

Q.6 How photocopier works? *(Conceptual+A.B)*

Ans: Photocopier work using the principle shown in the diagrams below.

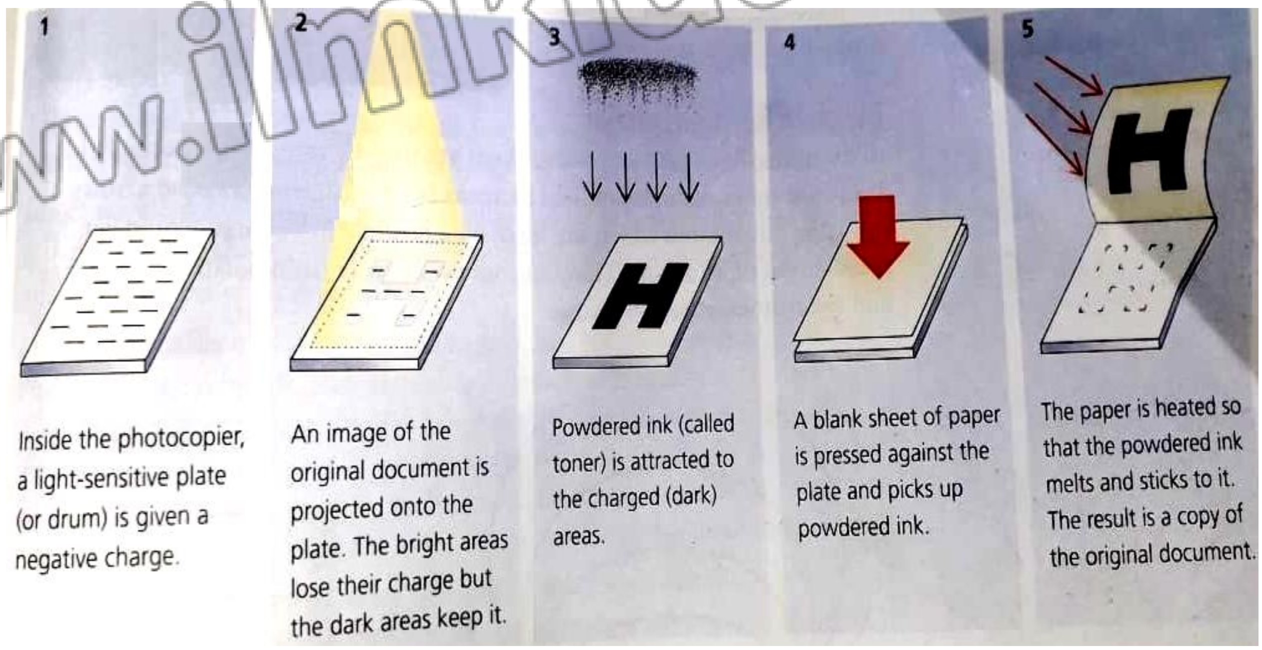


Figure of Photocopier

Q.7 How does electrostatic induction differ from charging by friction? *(K.B+U.B)*

(Review Question 13.3)

Ans: **DIFFERENT METHODS OF CHARGGING**

During the process of charging by friction, we rub a neutral body with another neutral body. But in the process of electrostatic induction. We charge a conductor without making any contact with the charging body.

Q.8 An charge rod attracts pieces of paper. After a while these pieces fly away! Why? *(K.B+U.B)* **(Conceptual 13.1)**

Ans: **ELECTRIFIED ROD AND PIECES OF PAPERS**

When a glass rod is rubbed with a silk cloth, it is positively charged. This electrified rod attracts pieces of paper. When the pieces of paper touch the rod, they give up some electrons to the glass rod and become positively charged. They are then flown away by the rod due to force of repulsion form the positive charge remaining on the rod.

Q.9 Why attraction is not the sure test for detecting the presence of charge on a body? *(K.B+U.B)*

Ans: ***Given on Page # 156(Experiment No.1)***

13.2 MULTIPLE CHOICE QUESTIONS

1. **In the presence of a charged body an insulated conductor develops positive charge at one end and negative charges at other end, this process is called the. *(K.B)***

(A) Electrostatic induction (B) Conduction
(C) Friction (D) All of these

13.3 ELECTROSCOPE

LONG QUESTION

Q.1 What is gold leaf electroscope? Discuss its working principle with a label diagram. ***(K.B+U.B+A.B)***

OR Describe a gold leaf electroscope. By using an electroscope, how can we find the

(i) Presence of charge on a body **(Review 13.6)**

(ii) The nature of the charge on a body **(Review 13.7)**

(iii) Whether a body is an insulator or a conductor **(LHR 2015)**

OR Suppose you have a glass rod which becomes positively charged when you rub it with wool. Describe how you would charge the electroscope. **(Review 13.5)**

Ans: **GOLD LEAF ELECTROSCOPE**

Definition:

The gold leaf electroscope is a sensitive instrument for detecting charges, nature of charges and identifying conductor and insulator.

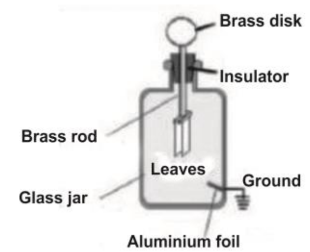


Figure: Gold Leaf Electroscope

Construction & Working:

It consists of a brass rod with a brass disk at the top and two thin leaves of gold foil hanging at the bottom. The rod passes through an insulator that keeps the rod in place. The whole assembly is filled in a glass jar. Charges can move freely from the disk to the leaves through the rod.

A thin aluminum foil is attached on the lower portion of the inside of the jar. Usually, the aluminum foil is grounded by connecting a copper wire. This protects the leaves from the external electrical disturbances.

(i) Detecting the Presence of Charge:

In order to detect the presence of charge on anybody, bring the body near the disk of an uncharged electroscope. If the body is neutral there will be no deflection of the leaves.

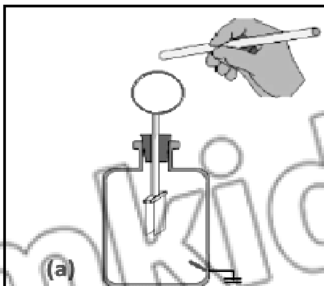


Figure: Uncharged Body

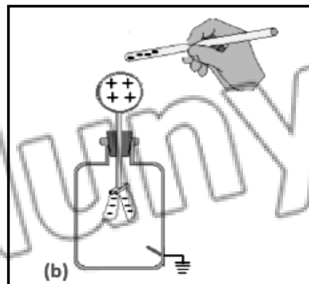


Figure: Charged Body

But if the body is positively or negatively charged, the leaves of the electroscope diverge. For example, if the body is negatively charged then due to electrostatic induction, positive charge will appear on the disk while negative charge will appear on the leaves.

The leaves of electroscope repel each other and diverge because each leave gets similar charge. The divergence of leaves will depend on the amount of charge.

Conclusion:

The divergence of leaves show that the body is charged.

Charging the Electroscope by Electrostatic Induction:

Electroscope can be charged by the process of electrostatic induction. In order to produce positive charge on the electroscope, bring a negatively charged body near the disk of the electroscope. Positive charge will appear on the disk of the electroscope while negative charges will shift to the leaves. Now connect the disk of electroscope to the earthed aluminum foil by a conducting wire.

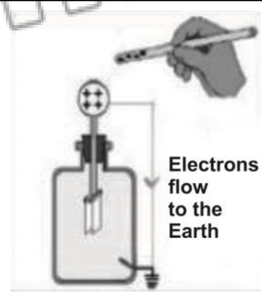


Figure: Charging the Electroscope Positively

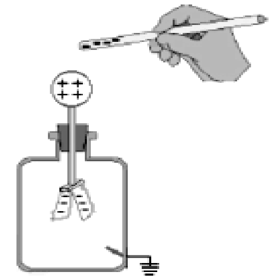


Figure: Charging the Electroscope Positively

Charge of the leaves will flow to the Earth through the wire. Now if we first break the Earth connection and then remove the rod, the electroscope will be left with positive charge.

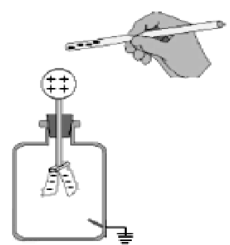


Figure: Charging the Electroscope Positively

Charging the Electroscope by Conduction:

Electroscope can also be charged by the process of conduction. Touch a negatively charged rod with the disk of a neutral electroscope. Negative charge from the rod will transfer to the electroscope and will cause its leaves to diverge.

(ii) Detecting the Type of Charge:

For the detection of type of charge on a body, electroscope is first charged either positively or negatively. Suppose the electroscope is positively charged.

Figure: Charged Electroscope

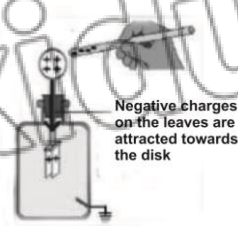


Figure: Detecting –ve Charge

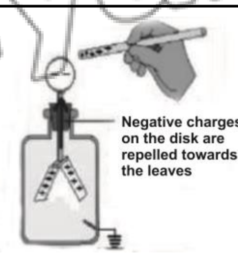


Figure: Detecting +ve Charge

Now in order to detect the type of charge on a body, bring the charged body near the disk of the positively charged electroscope.

Conclusion:

If the divergence of the leaves increases, the body carries positive charge. On the other hand if the divergence decreases, the body has negative charge.

(iii) Identifying Conductors and Insulators:

Electroscope can also be used to distinguish between insulators and conductors. Touch the disk of a charged electroscope with material under test. If the leaves collapse from their diverged position the body would be a good conductor. If there is no change in the divergence of the leaves, it will show that the body under test is an insulator.

13.3 SHORT QUESTION

Q.1 How electroscope can be charged? *(K. B+U.B)*

Ans: **CHARGING OF ELECTROSCOPE**

Electroscope can be charge by the process of electrostatic induction. It can also be charged by process of conduction.

Q.2 What is electroscope? Give its construction. *(K.B)*

Ans: ***Given on Page # 160***

Q.3 How can we detect with electroscope that body is conductor or insulator? *(K.B+U.B+A.B)* **(GRW 2014, LHR 2016).**

Ans: ***Given on Page # 161***

Q.4 How much negative charge has been removed from a positively charged electroscope if it has a charge of 7.5 x 10^{-11}C? *(U.B)* **(Conceptual 13.2)**

Ans: **REMOVAL OF NEGATIVE CHARGE**

A charge of -75 $\times$ 10^{-11} C has been removed from a positively charged electroscope which has a charge of 7.5 $\times$ 10^{-11}C.

Q.5 Why leaves of charged electroscope diverge if we touch its disk with a metal rod but they do not diverge if we touch the disk with a rubber rod? *(A.B+C.B+U.B)*

(Point to ponder Pg. # 74)

Ans: **DIVERGENCE OF LEAVES**

If we touch the disk of a charged electroscope with a conductor, electrons will flow from electroscope of the ground or from ground to the electroscope. It depends upon the type charge on the disk of the electroscope. Due to this transfer of charges, divergence of leaves will decrease or increase accordingly. As in case of an insulator, there is no any flow of charges (as insulators are bad conductors), so there is not any change in the position of leaves of the electroscope.

Q.6 In a dry day, if we walk in a carpeted room and then touch some conductor, we will get a small electric shock! Can you tell why does it happen? *(C.B)*

(Point to ponder Pg. # 74)

Ans: **ELECTRIC SHOCK**

It is caused by static electric charges accumulated on our body due to friction while walking on a carpet.

Q.7 Show diagrammatically how like charges repel and unlike charges attract? (U.B)

(For your information Pg. # 71)

Ans: **CHARGES**

Figure: Like Charges Repel

Figure: Unlike Charges Attract

Q.8 Why we get more electric shock in winter as compared to in summer? *(C.B+A.B)*

Ans: Because in winter the air is dry and do not have humidity that is why our body accumulate electrostatic charges and when we touch a conductor we get electric shock because our body discharge. But in summer air has a lot of humidity so our body continuous discharge.

13.3 MULTIPLE CHOICE QUESTIONS

1. **Electroscope is an instrument used for. *(A.B)*** **(LHR 2015)**
(A) Detecting presence of charge (B) To detect the type of charges
(C) To identify conductor and insulator (D) All of these

2. **Electroscope can be charge by the process. *(K.B)***
(A) Magnetism (B) Internal reflection
(C) Electrostatic induction (D) Electromagnetic tension

13.4 COULOMB'S LAW

LONG QUESTION

Q.1 Explain Coulomb's law of electrostatic and write its mathematical form. *(K.B+U.B+A.B)* **(Review 13.8)**

Ans: **COULOMB'S LAW**

Introduction:

In 1785, a French scientist Charles Coulomb established the fundamental law of electric force between two stationary charged particles.

Statement:

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

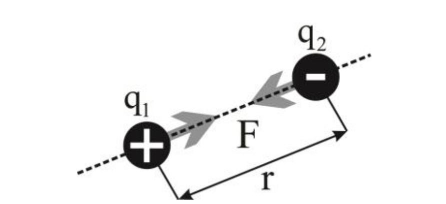


Figure: Attraction between Opposite Charges

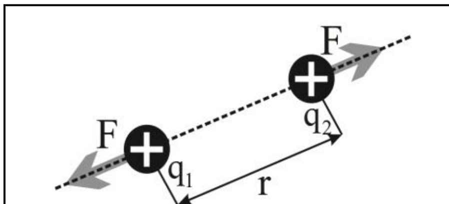


Figure: Repulsion between Similar Charges

Mathematically:

$$\mathbf{F} \propto q_1 q_2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$\mathbf{F} \propto \frac{1}{r^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Combining equations (i) and (ii) we get

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

$$F = k\frac{q_1 q_2}{r^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

Equation (iii) is known as coulomb's law.

Where **F** is the force between the two charges and is called the coulomb force, $\mathbf{q_1}$ and $\mathbf{q_2}$ are the quantities of two charges and **r** is the distance between the centre of two charges. **K** is the constant of proportionality.

Dependence of Value of K:

The value of **K** depends upon the medium between the two charges. Now if the medium between the two charges is air then the value of **K** in **SI** units will be $\mathbf{9 \times 10^9\ Nm^2C^{-2}}$.

Point Charges

Definition:

"Point charges are the charges whose sizes are very smallest compared to the distance between them".

Validity of Coulomb's Law:

Coulomb's law is true only for point and stationary charges.

13.4 SHORT QUESTIONS

Q.1 State the Coulomb's law. *(K.B+U.B+A.B)* **(GRW 2013(R), LHR 2015)**

Ans: ***Given on Page # 162***

Q.2 What is the SI unit of charge?(K.B) **(For your Information Pg. # 74)**

Ans: **SI UNIT OF CHARGE**

The SI unit of charge is Coulomb (C). It is equal to the charge of 6.25×10^{18} electrons. This is very big unit. Usually, charge is measured in micro coulomb is equal to 10^{-6} C.

Q.3 What is meant by point charges? *(K.B)* **(LHR 2015)**

Ans: ***Given on Page # 163***

Q.4 What will happen to Coulomb's force, if the distance between two point charges becomes double? *(U.B+A.B)* **(Quick quiz Pg. # 76)**

Ans: **COULOMB'S FORCE WHEN DISTANCE IS DOUBLED**

According to coulomb's law

$$F = k\frac{q_1q_2}{r^2}$$

When r = 2r

$$F' = k\frac{q_1q_2}{(2r)^2}$$

$$F' = k\frac{q_1q_2}{4r^2}$$

Then

$$F' = \frac{1}{4}k\frac{q_1q_2}{r^2}$$

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

Result:

Thus if the distance between two point charges is doubled, the coulomb's force between them will be one fourth of the original force.

Q.5 In which direction Coulomb's force act between the two charges? *(K.B)*

Ans: **DIRECTION OF COULOM'S FORCE**

The Coulomb's forces have equal magnitude but always act in opposite directions between two similar charges.

Q.6 Suppose two spheres are positively charged. If charge on one of the sphere is doubled then what will be the electrostatic force of attraction between them and what will be the nature of the force? *(U.B+A.B)*

Ans: **ELECTROSTATIC FORCE**

According to coulomb's law

$$F = \frac{kq_1 \times q_2}{r^2}$$

Put $q_2 = 2q_2$

$$F' = 2F$$

Result:

$$F' = \frac{kq_1 \times 2q_2}{r^2}$$

$$F' = 2 \times \frac{kq_1 \times q_2}{r^2}$$

Hence, electrostatic force between the charges is two time the original electrostatic force. Since both the charges are positive therefore electrostatic force between them is force of repulsion.

13.4 MULTIPLE CHOICE QUESTIONS

1. **Who established fundamental law of electric force between two stationary charged particles? *(K.B)***
   (A) Planks (B) Faraday
   (C) Quantum (D) Coulomb

2. **According to Coulomb's law: *(U.B)***
   (A) $F=K\frac{q_1r^2}{q_2}$ (B) $F=\frac{kr_1r_2}{(q)^2}$
   (C) $F=\frac{kq_1q_2}{r^2}$ (D) $F=k\frac{q_1q_2}{r}$

3. **K is constant of proportionality given by *(K.B+U.B)***
   (A) $K=\frac{1}{4\pi\in_o}$ (B) $K=\frac{\in}{4\pi}$
   (C) $K=\frac{4\pi}{\in_o}$ (D) None of these

4. **SI unit of K is: *(K.B)***
   (A) Nm^2C (B) Nm^2C^{-2}
   (C) $N^2m^2C^{-1}$ (D) None of these

5. **The value of K is *(K.B)*** **(LHR 2013)**
   (A) $8.85 \times 10^9\ Nm^2C^{-2}$ (B) $9 \times 10^9\ Nm^2C^{-2}$
   (C) $6.67 \times 10^9\ Nm^2C^{-2}$ (D) None of these

6. **Force of attraction or repulsion acts between: *(K.B)***
   (A) Two charged bodies (B) Neutral bodies
   (C) Non charged bodies (D) All of these

7. **The value of Coulomb's constant K depends upon *(K.B)***
   (A) The system of units used
   (B) Medium between the charges
   (C) Quantity of the charges
   (D) The system of units and the medium between the charges

8. **If the distance between the two charged bodies is halved, the force between them becomes *(U.B)***
   (A) Doubled (B) Half
   (C) Four times (D) One half

9. If the distance between two charges is doubled, the electric force between them will become *(U.B)*

(A) Four times (B) Twice

(C) Half (D) One fourth

10. Electric charge of 100μC is 13 m apart from another charge 16.9μC. The force between them in Newton is *(U.B+A.B)*

(A) 9×10^{7} (B) 0.09

(C) 90 (D) 9×10^{5}

11. The electric force of repulsion between two electrons at a distance of 1 m is *(U.B+A.B)*

(A) 1.8 N (B) 1.5×10^{-9}N

(C) 2.30×10^{-27}N (D) 2.30×10^{-27}N

12. What will be the electrostatic force between two charges each of one coulomb separated by 1m? *(U.B+A.B)*

(A) 8.85 x 10^{9} N (B) 9 x 10^{9} N

(C) 6.67 x 10^{9} N (D) None of these

13. How much is the gravitational force which the Earth exerts on a billion kilogram object on the sea level? *(K.B+U.B)*

(A) 8.85 x 10^{9} N (B) 9 x 10^{9} N

(C) 6.67 x 10^{9} N (D) None of these

EXAMPLE 13.1

Two bodies are oppositely charged with 500 μC and 100 μC charge. Find the force between the two charges if the distance between them in air is 0.5m. (U.B, A.B)

Solution:

Given Data:

$q_1 = 500\ \mu C$

$q_2 = 100\ \mu C$

r = 0.5m

To Find:

F =?

Formula:

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

Calculations:

$$F = \frac{9\times10^{9}\times500\times10^{-6}\times100\times10^{-6}}{(0.5)^2}$$

Putting the values from given data in the formula.

F = 1800 N

Result:

Hence, coulomb's force between the charges is 0.2N. Since both charges are positive therefore nature of force is repulsive.

13.5 ELECTRIC FIELD AND ELECTRIC FIELD INTENSITY

LONG QUESTION

Q.1 What is meant by electric field and electric intensity? Find the electric intensity due to point charge. ***(K.B+U.B+A.B)*** **(Review Question 13.9)(GRW 2014, LHR 2014)**

Ans:

ELECTRIC FIELD

Definition:

"The region of space surrounding the charge q in which it exerts a force on the charge q_0 is known as electric field of the charge q."

OR

"The electric field is a region around a charge in which it exerts electrostatic force on another charges."

Explanation:

According to Coulomb's law if a unit positive charge q_o (call it the test charge) is brought near a charge q (call it the field charge) placed in space, the charge q_o will experience a force. The value of this force would depend upon the distance between the two charges. If the charge q_o is moved away form q, this force would decrease till at a large distance the force would practically reduce to zero. Now the charge q_o is out of the influence of charge q.

ELECTRIC FIELD INTENSITY

Definition:

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

OR

"The electric field intensity at any point is defined as the force acting on a unit positive charge placed at that point".

Formula:

In order to find the value of electric intensity at a point in the field, of charge **+ q**, we place a test charge $\mathbf{q_0}$ at that point. If **F** is the force acting on the test charge $\mathbf{q_0}$, the electric field intensity is given by

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

Electrical Force:

If the electric field due to a given arrangement of charges is known at some point, the force on any particle with charge q placed at that point can be calculated by using the formula:

$$\mathbf{F = q\,E}$$

Type of Quantity:

Electric field intensity is a vector quantity. It has the same direction as that of force acting on the positive test charge. If the test charge is free to move, it will always move in the direction of electric intensity.

Unit:

SI unit of electric intensity is $\mathbf{N\,C^{-1}}$.

Q.2 What is meant by electric lines of force? Write their characteristics. ***(K.B)***
(LHR 2014, LHR 2015)

Ans: **<u>ELECTRIC FIELD LINES</u>**

<u>Introduction</u>:

The direction of electric field intensity in an electric field can also be represented by drawing lines. These lines are known as electric lines of forces. These lines were introduced by Michael Faraday;

<u>Definition</u>:

The field lines are imaginary lines around a field charge with an arrow head indicating the direction of force.

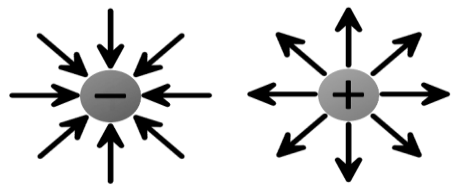
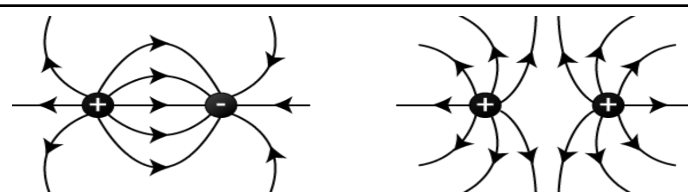


Figure: **<u>Electric Field Lines of Isolated Positive & Negative Charge</u>**



(a) (b)

Figure: **<u>(a) Electric Field Lines of Two Opposite & Equal Charges</u>**
<u>(b) Electric Field Lines of Two Same & Equal Charges</u>

<u>Characteristics</u>:

- These are imaginary lines.
- They never intersect each other.
- Their direction is always from positive charge to negative charge.
- They are closer near the charge and wider away from the charge.

13.5SHORT QUESTIONS

Q.1 Define electric field intensity? ***(K.B)*** **(GRW 2014)**

Ans: ***Given on Page # 166***

Q.2 Who introduce the electric lines of force? ***(K.B)***

Ans: ***Given on Page # 167*** **(LHR 2013)**

Q.3 Are the electric field lines physical entities? ***(K.B)***

Ans: **<u>NATURE OF ELECTRIC FIELD LINES</u>**

Electric field lines themselves are not physical entities. They are just used for the pictorial representation of another physical quantity i.e. electric field at various positions.

Q.4 What is work of Charles Coulomb? ***(K.B)***

Ans: ***Given on Page # 164***

Q.5 What is direction of electric intensity? *(K.B)*

Ans: **DIRECTION OF ELECTRIC INTENSITY**

Electric intensity being a force is a vector quantity. Its direction is the same as that of the force acting on the positive test charge.

Q.6 On which factors the value of K depends? *(U.B+K.B)*

Ans: *Given on Page # 164*

Q.7 In what direction will a positively charged particle move in an electric field? *(K.B)*
(Conceptual 13.3)

Ans: **DIRECTION OF POSITIVE CHARGE**

A positive charge released in an electric field will move along the direction electric field i.e. from higher potential to the lower potential.

Q.8 A strong electric field exists in the vicinity of the "Faraday cage". Yet the person inside the cage is not affected. Can you tell why? *(K.B+U.B)* **(Point to ponder Pg. # 77)**

Ans: **FARADAY'S CAGE**

A Faraday's cage is an enclosure made of a conducting material to block internal electric fields. In the presence of internal electric field, the electric charges on the surface of cage are redistributed in such a way so that electric field becomes zero inside the interior of Faraday's cage.

Q.9 Show variation of magnitude of Coulomb force between two opposite charges of different magnitude? *(U.B+A.B)* **(Physics Insight Pg. # 77)**

Ans: **VARIATION OF COULOMB FORCE**

Variation of magnitude of Coulomb's force between two opposite charges of different magnitudes.

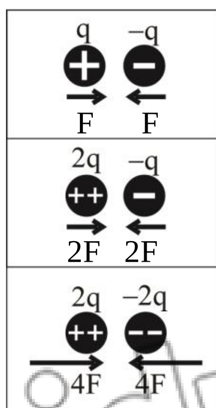


Figure: Variation of Magnitude of Coulomb Force Between Two Opposite Charges

Q.10 If two same charges are separated by 1 m distance having 9×10^9 N. Then relate this force with gravitational force? *(U.B+A.B)*

Between electromagnetic force and gravitational force which one is more responsible for the stability of universe. *(Conceptual Base)* **(Physics Insight Pg. # 77)**

Ans: **RELATION OF FORCE**

The electrostatic force acting on two charges each of 1 C separated by 1 m is about 9×10^9 N. This force is equal to the gravitational force that the earth exerts on a billion kilogram object at sea level. This means that electromagnetic force is billion time stronger than gravitational force. So electromagnetic force is more responsible for the stability of this universe.

13.5 MULTIPLE CHOICE QUESTIONS

1. A region around the charge in which it exerts electrostatic force on another charge is called: *(K.B)*
(A) Gravitational field (B) Magnetic field
(C) Electric field (D) All of these

2. SI unit of electric intensity is *(U.B)* **(LHR 2014)**
(A) Nm^{-1} (B) NC^{-1}
(C) Nm^{-2} (D) Nm

3. The spacing between the field lines shows the *(K.B)*
(A) Strength of electric field (B) Direction of electric field
(C) Both a and b (D) None of these

4. The space around the charge within which other charges are influenced by it is called *(K.B)*
(A) Electric intensity (B) Electric field
(C) Electric flux (D) Electric potential

5. Force experienced by a unit positive charge placed at a point in the electric field is known as: *(K.B)* **(LHR 2017)**
(A) Electric field intensity (B) Magnetic field intensity
(C) Electric potential (D) Capacity

6. The force per unit charge is known as *(K.B+U.B)*
(A) Electric flux (B) Electric intensity
(C) Electric potential (D) Electric volt

7. SI unit of electric field intensity is *(A.B+K.B)* **(GRW 2013)**
(A) Coulomb (B) Volt
(C) Newton/coulomb (D) Ampere

8. Electric field intensity is a vector quantity and its direction is *(K.B)*
(A) Perpendicular to the direction of field (B) Opposite to the direction of force
(C) Along the direction of force (D) At a certain angle

9. The electric intensity at infinite distance from the point charge is: *(U.B)*
(A) Zero (B) Infinite
(C) 1 Volt – m^{-1} (D) Positive

10. Electric field is strong when line are: *(K.B)*
(A) Separated (B) Closer
(C) Smaller (D) Larger

11. What is the electric field intensity 30 cm away from a light bulb? *(U.B+A.B)*
(A) 4 NC^{-1} (B) 5 NC^{-1}
(C) 0 NC^{-1} (D) None of these

12. An electron in a hydrogen atom experiences an electric intensity in the order of: *(U.B+A.B)*
(A) $10^9\ NC^{-11}$ (B) $10^{11}\ NC^{-1}$
(C) $10^{10}\ NC^{-1}$ (D) None of these

13. To detect the nearby objects, some animals produces *(A.B)*
(A) Electric Field (B) Magnetic Field
(C) Gravitational Field (D) None of these

14. Electric field 30 cm away from a light bulb is: *(A.B)* **(For your information Pg. # 77)**
(A) 5 NC^{-1} (B) 50 NC^{-1}
(C) 500 NC (D) None of these

15. Electric field experienced by an electron of hydrogen atom from the nucleus is of the order of: *(U.B)* **(For your information Pg. # 77)**
(A) 10^{11} NC^{-1} (B) 10^{10} NC^{-1}
(C) 10^{9} NC^{-1} (D) None of these

13.6 ELECTROSTATIC POTENTIAL

LONG QUESTION

Q.1 What is meant by electric potential? Explain. *(K.B+U.B+A.B)* **(GRW 2013)**

Ans:

ELECTRIC POTENTIAL

Definition:
"Electric potential at a point in an electric field is equal to the amount of work done in bringing a unit positive charge form infinity to that point."

Mathematically:
If W is the **work done** in moving a **unit positive charge** *q* from **infinity** to a certain point in the field, the **electric potential** V at this point would be given by

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

It implies that electric potential is measured relative to some reference point and like potential energy we can measure only the change in potential between two points.

Quantity:
Electric potential is a scalar quantity.

Unit:
It SI unit is volt which is equal to $\mathbf{JC^{-1}}$

Volt:
If one joule of work is done against the electric field in bringing one coulomb positive charge from infinity to a point in the electric field then the potential at that point will be one volt. Or if the potential energy of one coulomb of charge at a point in the electric field is one joule, the potential of the point will be one volt.

POTENTIAL DIFFERENCE

Definition: **(Review 13.12)**
"The **energy supplied** by a **unit charge** as it moves from one point to the other in the direction of the field is called potential difference between two points".

Explanation: **(Review 13.13)**
A body in gravitational field always tends to move from a point of higher potential energy to a point of lower potential energy. Similarly, when a charge is released in a electric field, it moves from a point of higher potential say A to a point at lower potential say B.

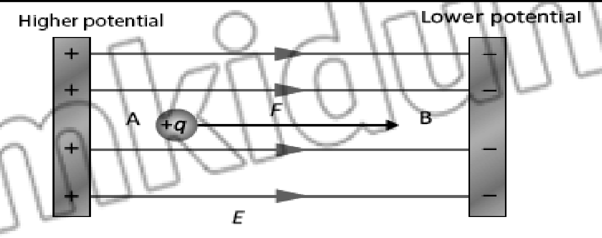


Figure: Potential Difference between Two Points

If the potential of point **A** is $\mathbf{V_a}$ and that of point **B** is $\mathbf{V_b}$ the potential energy of the charge at these points will be $\mathbf{qV_a}$ and $\mathbf{qV_b}$ respectively. The change in potential energy of the charge when it moves from point **A** to **B** will be equal to $\mathbf{qV_a - qV_b}$. This energy is utilized in doing some useful work.

Thus Energy supplied by the charge $= \mathbf{q(V_a - V_b)}$

If q is equal to one coulomb, then the potential difference between two points becomes equal to the energy supplied by the charge. Thus, we define potential difference between two points as:

- If a positive charge is transferred form a point of lower potential to a point of higher potential i.e. against the field direction, energy would have to be supplied to it.
- When we release a negative charge in an electric field, its behaviour will be opposite to that of positive charge. A more useful unit for the electrical energy is electron volt **(eV)**.

13.6 SHORT QUESTIONS

Q.1 What is meant by electric potential? ***(K.B)***

Ans: ***Given on Page # 170***

Given on Page # 170

Q.2 Define potential difference between two points. ***(K.B+U.B)***

Ans: ***Given on Page # 170***

Q.3 What is electron volt? Also find its energy in joules. ***(U.B+A.B+K.B)***

Ans:

ELECTRON VOLT

Definition:

"It is equal to the amount of energy supplied by an electron as it moves between two points having a potential difference of one volt**"**.

Mathematically:

Charge on an electron = q = 1.6×10^{-19} C.

Potential difference $\Delta v = V_A - V_B = 1$ V

$1\text{ eV} = 1.6 \times 10^{-19}\text{ C} \times 1\text{ V}$

$1\text{ eV} = 1.6 \times 10^{-19}\text{ J}$

Result:

$\boxed{\textbf{Hence, } 1\text{ eV} = 1.6 \times 10^{-19}\text{ J}}$

Q.4 Is the presence of charge necessary for the existence of electrostatic potential? ***(K.B)***

Ans:

EXISTENCE OF ELECTRIC POTENTIAL

Yes, the presence of charge is necessary for the existence of electrostatic potential. Electric potential is the work done in bringing a unit +ve charge from infinity to a point inside the electric field. Hence to produce electric field charge is necessary.

Q.5 What is the difference between electric potential and electric potential energy? *(K.B)*

Ans: **DIFFERENTIATION**

The difference between electric potential and electric potential energy is as follows:

Electric Potential	Electric Potential Energy
• Electric potential is a characteristic of the field of source charge and is independent of a test charge that may be placed in the field.	• Potential energy is a characteristic of both the field and test charge. It is produced due to the interaction of the field and the test charge placed in the field.

Q.11 What is positive test charge? And why it is used to measure electric field and electric potential? *(C.B+A.B)*

Ans: A positive test charge is a positive charge having unit magnitude and it is used to measure electric field and electric potential because its electric field is negligible.

13.6 MULTIPLE CHOICE QUESTIONS

1. The magnitude of the charge on the electron is: *(K.B)*

(A) 1.2×10^{-19}C (B) 1.6×10^{-19}C
(C) 2.6×10^{-19}C (D) 1.81×10^{-19}C

2. Work done in bringing a unit positive charge from infinity to that point in an electric field is called: *(K.B)*

(A) Potential difference (B) Resistance
(C) Capacitance (D) Electric potential

3. Which point in an electric field is equal to amount of work done in bringing unit positive charge from infinity to that point? *(K.B)*

(A) Electric intensity (B) Potential difference
(C) Electric potential (D) Volt

4. Which statement is true about electrical potential?*(K.B)*

(A) Its SI unit is volt (B) It is scalar quantity
(C) At any point $v = \frac{w}{q}$ (D) All of these

5. The potential difference between two points is one volt. The amount of work done in moving a charge of one coulomb from one point to another is: *(U.B)*

(A) One erg (B) One Joule
(C) One electron volt (D) One coulomb

6. Electron volt is the unit of: *(K.B)*

(A) Potential difference (B) Electric energy
(C) Electric current (D) Capacitance

7. The electron energy is one electron – volt when it is accelerated through a potential difference of: *(K.B)*

(A) One volt (B) One joule
(C) One Coulomb (D) One erg

8. Electric potential is a: *(K.B)*

(A) Vector quantity (B) Scalar quantity
(C) Neither scalar nor vector (D) Sometimes scalar and sometimes vector

9. One electron volt is equal to: ***(U.B)***

(A) 1.6×10^{-19}J (B) 1.6×10^{19}J
(C) 6.25×10^{-18}J (D) 6.25×10^{18}J

10. The work done in moving a unit positive charge from one point to another against the electric field is a measure of: ***(K.B)***

(A) Intensity of electric field (B) Resistance between two points
(C) Capacitance (D) Potential difference between two points

11. Voltage across a device has the same meaning of: ***(K.B)***

(A) e.m.f (B) Potential difference
(C) Potential energy (D) None of these

13.7 CAPACITORS AND CAPACITANCE, COMBINATION OF CAPACITOR

LONG QUESTIONS

Q.1 Define and explain capacitor. ***(K.B+U.B+A.B)*** **(GRW 2014, LHR 2014)**

Ans: **CAPACITOR**

Definition:

"Capacitor is a device which is used to store the electric charge".

Construction:

It consists of two thin metal plates, parallel to each other separated by a very small distance. The medium between the two plates is air or a sheet of some insulator. This medium is known as dielectric.

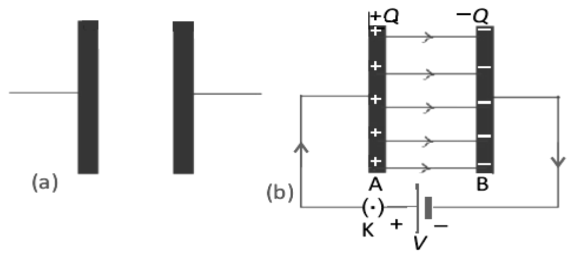


Figure: (a) Parallel Plate Capacitor, (b) Plates of Capacitor Connected with Battery

Charging of a Capacitor: **(Review 13.14)**

If a capacitor is connected to a battery of V volts, then the battery transfers a charge +Q from plate B to plate A, so that -Q charge appears on plate B and +Q charge appears on plate A.

The charges on each plate attract each other and thus remain bound within the plates. In this way, charge is stored in a capacitor for a long time.

Mathematical Expression:

The **charge** Q stored on plates is **directly proportional** to the **potential difference** V across the plates i.e.

$$Q \propto V$$

$$Q = CV$$

Where C is the constant of proportionality, called the capacitance of the capacitor.

Capacitance:

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

Formula:

$$C = \frac{Q}{V}$$

Unit:

S.I unit of capacitance is Farad (F)

Farad:

"If **one coulomb** of charge given to the plates of a capacitor produces a potential difference of **one volt** between the plates of the capacitor then its capacitance would be **one farad**".

Smaller Unit:

Farad is a large unit, usually, we use a smaller unit such as micro farad **(μF)**, Nano farad **(nF)** and Pico farad **(pF)** etc.

Dependence:

It depends upon

- Type of insulator between the plates of a capacitor.
- Distance between the plates of a capacitor.
- Area of the plates of a capacitor.

Q.2 How the capacitors are connected in parallel? Describe the characteristics features of this combination. ***(U.B+A.B+K.B)*** **(LHR 2014, 2017)**

OR Derive the formula for the equivalent capacitance for a parallel combination of a number of capacitors.

Ans: **PARALLEL COMBINATION OF CAPACITORS**

Definition:

In this combination, the left plate of each capacitor is connected to the positive terminal of the battery by a conducting wire. In the same way, the right plate of each capacitor is connected to the negative terminal of the battery.

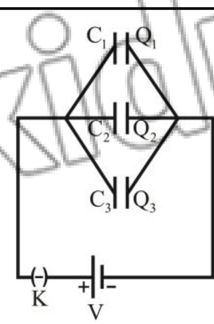


Figure: Parallel Combination of Capacitor

Characteristics of Parallel Combination:

This type of combination has the following characteristics:

1. Each capacitor connected to a battery of voltage V has the same potential difference V across it. i.e.
$V_1 = V_2 = V_3 = V$
2. The charge developed across the plates of each capacitor will be different due to different value of capacitances.
3. The total charge Q supplied by the battery is divided among the various capacitors. Hence,
$$Q = Q_1 + Q_2 + Q_3$$
$$Q = C_1V + C_2V + C_3V$$
$$Q = V(C_1 + C_2 + C_3)$$
$$\frac{Q}{V} = C_1 + C_2 + C_3$$
4. Thus, we can replace the parallel combination of capacitors with one equivalent capacitor having capacitance C_{eq}, such that
$$C_{eq} = C_1 + C_2 + C_3$$
In the case of 'n' capacitors connected in parallel, the equivalent capacitance is given by
$C_{eq} = C_1 + C_2 + C_3 + ... + C_n$

Conclusion:

The equivalent capacitance of a parallel combination of capacitors is greater than any of the individual capacitances.

Q.3 How the capacitors are connected in series? Describe the characteristics features of this combination. *(U.B+A.B+K.B)* (Review 13.16) (LHR 2013, LHR 2015, 2017)

OR Derive the formula for the equivalent capacitance for a series combination of a number of capacitors.

Ans: **SERIES COMBINATION OF CAPACITORS**

Definition:

In this combination, the capacitors are connected side by side i.e., the right plate of one capacitor is connected to the left plate of the next capacitor.

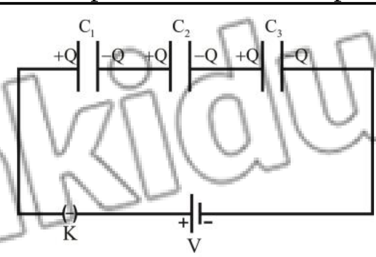


Figure: Series Combination

Characteristics:

This type of combination has the following characteristics:

1. Each capacitor has the same charge across it. If the battery supplies +Q charge to the left plate of the capacitor C1 due to induction –Q charge is induced on its right plate and +Q charge on the left plate of the capacitor C_2 i.e.,
$Q_1 = Q_2 = Q_3 = Q$

2. The potential difference across each capacitor is different due to different values of capacitances.
3. The voltage of the battery has been divided among the various capacitors. Hence

$$V = V_1 + V_2 + V_3$$

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

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

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

4. Thus, we can replace series combination of capacitors with one equivalent capacitor having capacitance C_{eq}.i.e.

$$\frac{1}{C_{eq}} = (\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3})$$

In the case of 'n' capacitors connected in series, we have

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} .... + \frac{1}{C_n}$$

Conclusion:

The equivalent capacitance of a series combination of capacitors is less than any of the individual capacitances.

13.7 SHORT QUESTIONS

Q.1 What is difference between battery and capacitor? ***(Conceptual Base)***

Ans: The main difference between Battery and Capacitor is Battery store electrical energy in the form of chemical energy whereas the Capacitor store electrical energy in the form of electrical charge. The capacitor supply all its energy at once but battery supply its energy for a long time. Battery can store charges for a long time but capacitor cannot store charges for a long time.

Q.2 What is meant by capacitance? ***(K.B)***

Ans: ***Given on Page # 174***

Q.3 Capacitor store charges or electrical energy? ***(Conceptual Base)***

Ans: By definition, a capacitor is a device that stores energy in the form of an electric field. When a capacitor is connected across a voltage source electrons will flow from the negative terminal of the battery to the plate of the capacitor that is connected to the said terminal hence the plate will be negatively charged.

Also, the electrons will be attracted from the other plate of the capacitor to the positive terminal of the battery or the negatively charged plate will attract the positive charge on the other plate and the plate will become positively charged. This process will continue until the charge on the negative plate begins to repel the further accumulation of electrons on the plate. Now the capacitor is fully charged. In simple word we can say that capacitor just only recombine the charges but do not store them its store energy. **(LHR 2013)**

Q.4 How does capacitor store charge? *(K.B+U.B)* **(For your Information Pg. # 80)**

Ans: **CHARGING OF CAPACITOR**

If +Q amount of charge is transferred to its one plate, due to electrostatic induction it would induce -Q charge on the inner surface of other plate. There exists a force of attraction between the charges +Q stored on the first plate and the charge -Q induced on the inner surface of other plate.

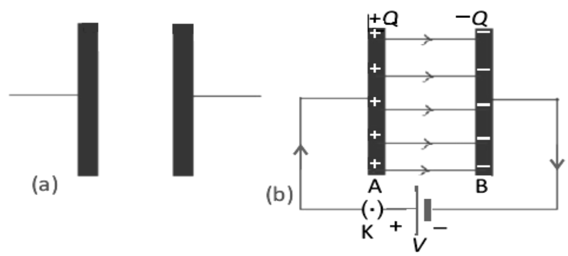


Figure: **(a) Parallel Plate Capacitor, (b) Plates of Capacitor Connected with Battery**

Due to this force of attraction, the charges are bound with the plate and remain stored for long periods.

Q.5 Why charge cannot be stored on capacitor for a long time? *(C.B)*

Ans: **CHARGE ON A CAPACITOR**

Charge cannot be stored on a conductor for a long period of time because the stored charges mutually repel each other due to which they spread on the whole surface of the conductor and also tend to leak out from there.

Q.6 What is parallel combination of capacitor? *(K.B)*

Ans: ***Given on Page # 174***

Q.7 What is series combination of capacitor? *(K.B)*

Ans: ***Given on Page # 175***

Q.8 What is the relation between equivalent capacitance of parallel combination and individual capacitance of each capacitor in this combination? *(U.B+A.B+K.B)*

OR Is the equivalent capacitance of parallel capacitors larger or smaller than the capacitance of any individual capacitor in the combination? *(U.B+A.B+K.B)*
(Quick quiz Pg. # 80)

Ans: **RELATION**

The equivalent capacitance of a parallel combination of capacitors is greater than any of the individual capacitances as related under;

$C_{eq} = C_1 + C_2 + C_3 + \dots\dots\dots\dots + C_n$

Q.9 What is the relation between equivalent capacitance of series combination and individual capacitance of each capacitor in this combination? *(U.B+A.B+K.B)*

OR Is the equivalent capacitance of series capacitors larger or smaller than the capacitance of any individual capacitor in the combination? *(U.B+K.B+A.B)*
(Quick quiz Pg. # 81)

Ans: **RELATION**

The equivalent capacitance of a series combination of capacitors is less than any of the individual capacitances as related under;

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots\dots + \frac{1}{C_n}$$

Q.10 Defined farad. ***(K.B+UB.)***

Ans: *Given on Page # 175*

Q.11 What is the working principle of capacitor? ***(K.B)***

Ans: Capacitor is a device that is used to store charges. It works on the principle of electrostatic induction which is defined as

Electrostatic Induction:

In the presence of a charged body, an insulated conductor develops positive charge at one end and negative charge at the other end.

Q.12 Does each capacitor carry equal charge in series combination? Explain. **(Conceptual 13.4)**

Ans: **CHARGE ON CAPACITORS IN SERIES**

As in series combination each capacitor is connected side by side, so each capacitor carries equal magnitude of charge due to electrostatic induction.

Q.13 Each capacitor in parallel combination has equal potential difference between its two plates. Justify the statement. ***(K.B+U.B)*** **(Conceptual 13.5)**

Ans: **POTENTIAL DIFFERENCE IN PARALLEL COMBINATION**

In a parallel combination of capacitors, two plates of each capacitor are connected to the positive and negative terminals of a battery between the same two points. Hence potential difference between two plates of each capacitor is equal i.e equal to the potential difference of the battery.

Q.14 Capacitor blocks D.C. current but allows A.C. current to pass through a circuit. How does this happen? ***(U.B+C.B)*** **(Point to ponder Pg. # 84)**

Ans: **CAPACITOR BLOCKS D.C**

D.C current flows only in one direction. When capacitor connected' to any D.C source (e.g battery) is fully charged there is no further flow of current in the circuit. In case of A.C the polarity of A.C. source changes again and again due to which charge polarity on the plates of capacitor also changes. Due to this reason. A.C. is not stopped or blocked through the circuit.

Q.15 How capacitor store energy? ***(K.B)*** **(Point to ponder Pg. # 84)**

Ans: **CAPACITOR STORE ENERGY**

Capacitor stores energy in an electric field between two plates in the form of electrostatic potential energy.

Q.16 What are the factors on which the capacitance of a capacitor depends? ***(K.B+U.B)***

Ans: **FACTORS AFFECTING CAPACITANCE**

Three factors affects the ability of a capacitor to store the charge.

- Area of the plates
- Distance between the plates
- Type of insulator used between the plates

13.7 MULTIPLE CHOICE QUESTIONS

1. In order to store the charge a device is used which is called: ***(K.B)***

(A) Potential (B) Capacitor
(C) Momentum (D) Voltage

2. SI unit of capacitance: ***(K.B)*** **(LHR 2013, 2017)**

(A) Farad (F) (B) Coulomb
(C) Newton (D) Voltage

3. **Parallel plate capacitor consists of two metal plates separated by: *(K.B)***
(A) Metal (B) Insulator
(C) Conductor (D) All of these

4. **Which is incorrect for parallel capacitor? *(U.B)***
(A) $v_1 = v_2 = v_3 = v$ (B) $Q = Q_1 + Q_2 + Q_3$
(C) $C_e = C_1 + C_2 + C_3$ (D) $Q_1 = Q_2 = Q_3 = Q$

5. **The capacitance C of a capacitor is given by the relation *(U.B)*** **(LHR 2017)**
(A) C = QV/2 (B) C = QV
(C) C = Q/V (D) C = V/Q

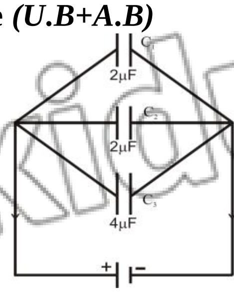
6. **A capacitor is a perfect insulator for *(K.B)***
(A) Direct current (B) Alternating current
(C) Both for the direct and alternating current (D) Electric charge

7. **Which one of the following is correct? *(K.B)***
(A) 1 μF = 10^{-6}F (B) 1ρF = 10^{-13}F
(C) 1ρF = 10^{-6}μ F (D) All of the above

8. **When capacitors are connected in parallel, their equivalent capacitance is equal to(K.B)**
(A) The product of their individual capacitances
(B) The sum of their individual capacitances
(C) The product of their individual reciprocal capacitances
(D) The sum of the reciprocals of the individual capacitances

9. **When capacitors are connected in series, their equivalent capacitance is equal to *(K.B)***
(A) The product of their individual capacitances
(B) The sum of their individual capacitance
(C) The sum of the reciprocals of the individual capacitances
(D) The product of their individual reciprocal capacitances

10. **Three capacitors C_1, C_2 and C_3 are connected in parallel as in the Fig. Their equivalent capacitance will be *(U.B+A.B)***



(A) 8μF (B) 0.8μF
(C) 1μF (D) 16μF

11. **Tick the correct statement: *(K.B)***
(A) Capacitance decreases in parallel combination
(B) Capacitance decreases in series combination
(C) Capacitance is the same in both combinations
(D) All of the above

12. **If 4μF and 2μF capacitors are connected in series, the equivalent capacitance is given by:** ***(U.B+A.B)***

(A) 6μF (B) 2μF
(C) 1.3μF (D) 8μF

13. **Two 50μF capacitors are connected in parallel. The equivalent capacitance of the combination is:** ***(U.B+A.B)***

(A) 1μF (B) 100μF
(C) 50μF (D) 25μF

14. **The equivalent capacitance is greater than individual capacitance in** ***(K.B)***

(A)Series combination (B) Parallel combination
(C) Series and parallel combination (D) All of them

15. **Farad is defined as** ***(K.B)***

(A) Coulomb/Volt (B) Ampere/Volt
(C) Coulomb/Joule (D) Joule/coulomb

EXAMPLE 13.2

The capacitance of parallel plate capacitor is 100 μC. If the potential difference between its plate is 50 volts, find the quantity of charge on each plate. ***(A.B+U.B)***

Solution:

Given Data:

Capacitance of a capacitor = C = 100 μC

Voltage =V = 50 V

To Find:

Capacitance = C =?

Formula:

Q = CV

Calculations:

Putting the values from given data in the formula.

$$Q = 100 \times 10^{-6} \times 50$$

$Q = 5 \times 10^{-3}$ C = 5 mC

Result:

Hence, charge of each plate will be 5 mC because each plate has equal amount of charge.

EXAMPLE 13.3

Three capacitors with capacitances of 3.0 μF, 4.0 μF and 5.0 μF are arranged in parallel combination with a battery of 6 V, where 1 μF = 10^{-6} F. Find ***(A.B+U.B)***

(a) The total capacitance

(b) The voltage across each capacitor

(c) The quantity of charge on each plate of the capacitor

Solution:

Given Data:

Capacitance of first capacitor = C_1 = 3 μF

Capacitance of second capacitor = C_2 = 4 μF

Capacitance of third capacitor = C_3 = 5 μF

Voltage = V = 6 Volts

To Find:

(i) Equivalent capacitance = C_{eq} =?
(ii) Charge on one capacitor = Q_1 =?
(iii) Charge on second capacitor = Q_2 =?
(iv) Charge on third capacitor = Q_3 =?
(v) Potential difference across each capacitor = V =?

Formula:

$C_{eq} = C_1 + C_2 + C_3$ ———————— (1)
$Q_1 = C_1V$ ———————— (2)
$Q_2 = C_2V$ ———————— (3)
$Q_3 = C_3V$ ———————— (4)

Calculations:

(i) Putting the values from given data in the formula (1)
$C_{eq} = 3\mu F + 4\mu F + 5\mu F$
$C_{eq} = 12\mu F$

(ii) Putting the values from given data in the formula (2)
$Q_1 = 3\mu F \times 6\ V$
$Q_1 = 18\ \mu C$

(iii) Putting the values from given data in the formula (3)
$Q_2 = 4\ \mu\ F \times 6\ V$
$Q_2 = 24\ \mu C$

(iv) Putting the values from given data in the formula (4)
$Q_3 = 5\ \mu\ F \times 6\ V$
$Q_3 = 30\ \mu C$

(v) Since the capacitors are connected in parallel, therefore, potential difference across each capacitor will be 6V.

Conclusion:

Hence,
Equivalent capacitance of parallel combination is 12μF.
Charge on each first capacitor is 18 μC.
Charge on each second capacitor is 24 μC.
Charge on each third capacitor is 30 μC.
Potential difference across each capacitor is 6V.

EXAMPLE 13.4

Three capacitors with capacitances of 3.0 μF, 4 μF and 5 μF are arranged in series combination to a battery of 6 V, where 1 μF = 10^{-6} F. Find ***(A.B+U.B)***

(a) The total capacitance of the series combination

(b) The quantity of charge across each capacitor

(c) The voltage across each capacitor

Solution:

Given Data:

Capacitance of first capacitor = C_1 = 3 μF

Capacitance of second capacitor = C_2 = 4 μF

Capacitance of third capacitor = C_3 = 5 μF

Voltage = V = 6 Volts

To Find:

(i) Equivalent capacitance = C_{eq} =?

(ii) Charge on each capacitor = Q =?

(iii) Potential difference across one capacitor = V_1 =?

Potential difference across second capacitor = V_2 =?

Potential difference across Third capacitor = V_3 =?

Formula:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \qquad (1)$$

$$Q = CV \qquad (2)$$

$$V_1 = \frac{Q}{C_1} \qquad (3)$$

$$V_2 = \frac{Q}{C_2} \qquad (4)$$

$$V_3 = \frac{Q}{C_3} \qquad (5)$$

Calculations:

(i) Putting the values from given data in the formula (1).

$$\frac{1}{C_{eq}} = \frac{1}{3\mu F} + \frac{1}{4\mu F} + \frac{1}{5\mu F}$$

$$\frac{1}{C_{eq}} = \frac{20+15+12}{60\mu F}$$

$$\frac{1}{C_{eq}} = \frac{47}{60\mu F}$$

$$C_{eq} = \frac{60\mu F}{47}$$

$$C_{eq} = 1.3\ \mu F$$

(ii) Putting the values from given data in the formula (2).

$$Q = 1.3 \times 10^{-6}\ F \times 6V$$

$$Q = 7.8 \times 10^{-6}\ FV$$

$$Q = 7.8\ \mu C$$

(iii) Putting the values from given data in the formula (3).

$$V_1 = \frac{7.8\mu C}{6\mu F} = 2.6V$$

(iv) Putting the values from given data in the formula (4).

$$V_2 = \frac{7.8\mu C}{4\mu F} = 1.9V$$

(v) Putting the values from given data in the formula (5).

$$V_2 = \frac{7.8\mu C}{5\mu F} = 1.56V$$

Conclusion:

Hence,

- **Equivalent capacitance of parallel combination is 12μF.**
- **Charge on each capacitor is 7.8 μC.**
- **Potential difference across one capacitor is 2.6 V.**
- **Potential difference across second capacitor is 1.9 V.**
- **Potential difference across third capacitor is 1.56 V.**

13.8 DIFFERENT TYPES OF CAPACITORS

LONG QUESTIONS

Q.1 Discuss different types of capacitors. ***(K.B+A.B)***

(Review Question 13.15)(LHR 2015)

Ans:

TYPES OF CAPACITORS

Capacitors have different types depending upon their construction and the nature of dielectric used in them. Capacitors are either variable or fixed. In variable capacitors,

- Fixed capacitor
- Variable capacitor

FIXED CAPACITOR

Definition:

"If the capacitor is such that its plates are immovable, it is known as a fixed capacitor. Its value does not change**"**.

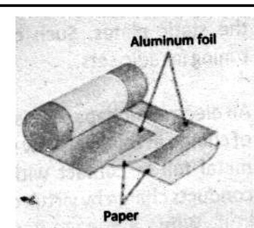


Figure: Paper Capacitor

Types of Fixed Capacitor:

- Paper capacitor
- Mica capacitor

Paper Capacitors:

Paper capacitor is an example of fixed capacitors. The paper capacitor has a cylindrical shape. Usually an oiled or greased paper or a thin plastic sheet is used as a dielectric between two aluminium foils. The paper or plastic sheet firmly rolled in the form of a cylinder and is then enclosed into a plastic case.

Mica Capacitor: **16)**

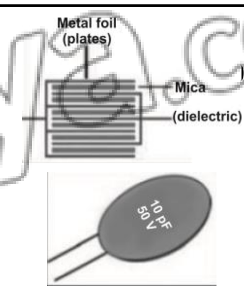


Figure: Mica Capacitor

Capacitor another example of fixed capacitors. In these capacitors, mica is used as dielectric between the two metal plates. Since mica is very fragile. For convenience and safety purposes it is enclosed in a plastic case or in a case of some insulator. Wires attached to plates project out of the case for making connections.

If the capacitance is to be increased, large number of plates is piled up, one over the other with layers of dielectric in between and alternative plates are connected with each other.

VARIABLE CAPACITOR

Definition: **(GRW 2013, LHR 2013, 2017)**

"The capacitor whose capacitance can be increased or decreased is called variable capacitor**"**.

Construction:

In variable type of capacitors, some arrangement is made to change the area of the plates facing each other. It is generally a combination of many capacitors with air as dielectric. It consists of two sets of plates. One set remains fixed while the other set can rotate so the distance between the plates does not change and they do not touch each other. The common area of the plates of the two sets which faces each other, determines the value of capacitance. Thus, the capacitance of the capacitor can be increased or decreased by turning the rotatable plates in or out of the space between the static plates. Such capacitors are usually utilized for tuning in radio sets.

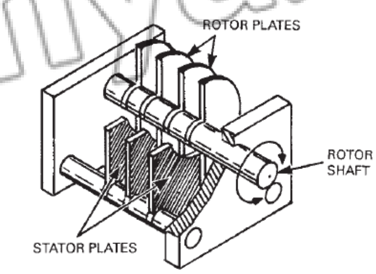


Figure: Variable Capacitor

An Electrolytic Capacitor:

An electrolytic capacitor is often used to store large amounts of charge at relatively low voltages. It consists of a metal foil in contact with an electrolyte –a solution that conducts charge by virtue of the motion of the ions contained in it.

When a voltage is applied between the foil and the electrolyte, a thin layer of metal oxide (an insulator) is formed on the foil, and this layer serves as the dielectric. Enormous capacitances can be attained because the dielectric layer is very thin.

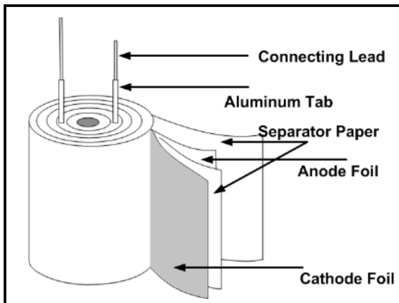


Figure: Electrolytic Capacitor

Q.2 Write down few uses of capacitors. ***(A.B)*** **(Review Question 13.17)(GRW 2013, LHR 2015)**

Ans:

USES OF CAPACITORS

Capacitors have wide range of applications in different electrical and electronic circuits.

For Tuning Some Appliance:

They are used for turning transmitters, receivers and transistor radios.

For Home Appliance:

They are used for table fans, celling fans, exhaust fans, fan motors in air conditioners; coolers, motors washing machines, air conditioners and many other appliances for their smooth working.

In Electronic Circuits:

Capacitors are used in electronic circuits of computers etc.

Low and High Frequency:

Capacitors can be used to differentiate between high frequency and low frequency signal which make them useful in electronic circuits.

Filter Circuit:

Capacitors are used in the resonant circuits that tune radios to particular frequencies. Such circuits are called filter circuit.

13.8 SHORT QUESTIONS

Q.1 What do you know about paper capacitor? *(K.B)*

Ans:

PAPER CAPACITOR

Paper capacitor is an example of fixed capacitors. The paper capacitor has a cylindrical shape. Usually an oiled or greased paper or a thin plastic sheet is used as a dielectric between two aluminum foils. The papers or plastic sheet is firmly rolled in the form of a cylinder and is then enclosed into a plastic case.

Q.2 How electrolytic capacitor is important? *(K.B)*

Ans:

IMPORTANCE OF ELECTROLYTIC CAPACITOR

An electrolytic capacitors in important because it is often used to store large amounts of charge at relatively law voltages.

Q.3 Write any two uses of capacitor. *(A.B)*

Ans:

USES OF CAPACITOR

The uses of capacitor are as follows:

For Tuning Some Appliance:

They are used for turning transmitters, receivers and transistor radios.

Filter Circuit:

Capacitors are used in the resonant circuits that tune radios to particular frequencies. Such circuits are called filter circuit.

13.8 MULTIPLE CHOICE QUESTIONS

1. **In variable capacitors: *(K.B)***
   (A) Both the sets of plates are fixed
   (B) Both the sets of plates are moveable
   (C) One set of plates is fixed and the other is moveable
   (D) Both the sets of plates are neither fixed not moveable
2. **Variable capacitors are used in *(A.B)***
   (A) Radio only (B) Television only
   (C) Radio and television (D) None of the above
3. **A radio tuning capacitor is a *(K.B)***
   (A) Variable parallel plate capacitor (B) Variable cylindrical capacitor
   (C) Spherical capacitor (D) Tubular capacitor
4. **Which of the following is commercial type capacitor *(K.B)***
   (A) Tubular capacitor (B) Electrolytic capacitor
   (C) Miniature capacitors (D) All of the above
5. **Capacitor have different types depending upon: *(K.B)***
   (A) Their construction (B) Nature of dielectric
   (C) Both A and B (D) None of above
6. **In variable capacitors, the value of capacitance can be: *(K.B)***
   (A) Decrease (B) Increased
   (C) Both a and B (D) Fixed
7. **In fixed type of capacitors, the value of capacitance: *(K.B)***
   (A) Increase (B) Decrease
   (C) Cannot be changed (D) All of these
8. **It is a fixed capacitor: *(K.B)***
   (A) Paper capacitor (B) Mica capacitor
   (C) Both a and b (D) Capacitors in radio sets

9. In Mica capacitors the dielectric is: *(K.B)*

(A) Aluminum foils (B) Mica
(C) Copper (D) Polythene paper

10. Capacitors are used in: *(A.B)*

(A) Tuning Transmitters (B) Receiver
(C) Transistor radio (D) All of these

11. Capacitors are used in resonant circuit that tune radios to particular frequency: *(A.B)*

(A) Paper capacitor (B) Mica capacitor
(C) Electrolytic capacitor (D) Radio capacitor

13.9 APPLICATIONS OF ELECTROSTATICS
13.10 SOME HAZARDS OF STATIC ELECTRICITY LIGHTENING

LONG QUESTIONS

Q.1 Discuss in detail important application of electrostatic.
OR Write a note on the following *(K.B+U.B+A.B)*
(a) Electrostatic air cleaner **(LHR 2016, 2017)**
(b) Spray Painting

OR Discuss one application of static electricity. **(Review Question 13.18)**

Ans: **APPLICATION OF ELECTROSTATICS**

Static electricity has an important place in our everyday lives which include photocopying, car painting, and extracting dust from dirty carpets and from chimneys of industrial machinery.

Electrostatic Air Cleaner:

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

Working of Electric Static Air Cleaner:

Air mixed with dust and pollen enters the device across a positively charged mesh screen.

The airborne particles become positively charged when they make contact with the mesh. Then they pass through a second, negatively charged mesh screen.

The electrostatic force of attraction between the positively charged particles in the air and the negatively charged screen cases the particles to precipitate out on the surface of the screen. Through this process we can removes a very high percentage of contaminants form the air stream.

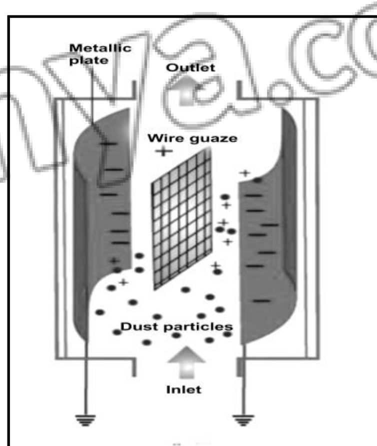


Figure: Electrostatic Air Cleaner

Spray Painting:

Automobile manufacturers use static electricity to paint new cars.

Working of Electrostatic Spray Painting:

The body of car is charged and then the paint is given the opposite charge by charging the nozzle of the sprayer.

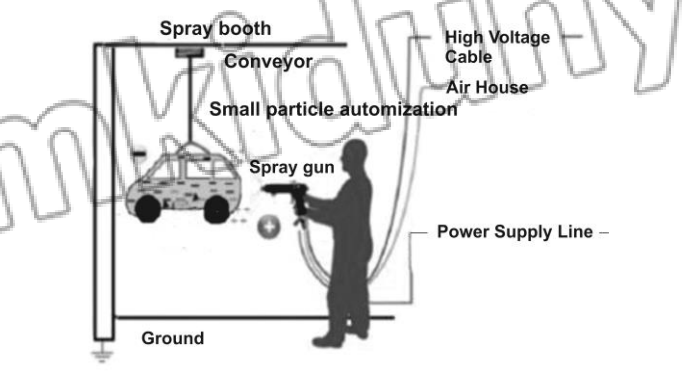


Figure: **Electrostatic Spray Painting**

Due to mutual repulsion charge particles pushed out of the nozzle form a fine mist and are evenly distributed on the surface of the object. The charged paint particles are stick to the body, just like a charged balloon sticks to a wall. Once the paint dries. It sticks much better to the car and is smoother because is the uniformly distributed. This is a very effective, efficient and economical way of painting automobiles on large scale.

Q.2 What are the hazards of static electricity? Explain them. ***(K.B)***

(Review Question 13.19)

HAZARD OF STATIC ELECTRICITY

There are so many hazards of static electricity. We are discussing only two of them.

- Lightening
- Fires or Explosions

Lightening:

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunderclouds. The thunderclouds are charged by friction between the water molecules in the thunderclouds and the air molecules. When the charge on the thunderclouds is sufficiently high, it induced opposite charge on the objects present on the ground giving rise to a strong electric field between the cloud and the ground. Suddenly, the charge in cloud jumps to the ground with a violet spark and explosion.

This explains why it is very dangerous to swim in the open sea, play in an open filed or hide under a tree during a thunderstorm.

Precaution or Prevention:

To prevent lightening from damaging tall buildings, lightening conductors are used. The purpose of the lightening conductor is to provide a safe discharge path for the large amount of negative charge in the air to flow form the top of the building to the Earth. In this way the chances of lightening damage due to sudden discharge can be minimized.

Fires or Explosions:

Static electricity is a major cause of fires and explosions at many places. A fire or an explosion may occur due to excessive build-up of electric charges produced by friction.

Production of Static Electricity:

Static electricity can be generated by the friction of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing. Static charge are dangerous. If static charges are allowed to discharge though the areas where there is petrol vapour a fire can occur.

The results are frightening and may be devastating.

Portable oil containers can build up a static electric charge during transport. Consequently, when the container is not placed on the ground for filling, its static electricity could be discharged and result in a fire when filling begins.

Precaution or Prevention

Precaution or prevention containers should be placed on the ground during filling and the nozzle should be kept in contact with the container. Containers should not to be filled while inside a vehicle.

13.9, 13.10 SHORT QUESTIONS

Q.1 How the phenomenon of lightening occurs? *(K.B)*

Ans: LIGHTENING

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunder clouds. The thunderclouds are charged by friction between the water molecules in the thunder clouds and the air molecules. When the charge on the thunder clouds is sufficiently high, it can produce positive and negative charges in the air. The huge amount of negative charge is discharged to the highest object on the ground and can harm them.

Q.2 How static charges are dangerous? *(U.B)*

Ans: DANGERS OF STATIC CHARGES

If static charges are allowed to discharge through the area where there is petrol vapours, a fire can occur. The results are frightening and may be devastating.

Q.3 Why it is very dangerous to swim in the open sea, play in an open field or hide under a tree during a thunderstorm? *(C.B+A.B)*

Ans: DANGER DURING THUNDERSTORM

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunderclouds. The thunderclouds are charged by friction between the water molecules in the thunderclouds and the air molecules. When the charge on the thunderclouds is sufficiently high, it can produce positive and negative charges in the air. The he amount of negative charge is discharged to the highest object on the ground and can harm them.

This explains why it is very dangerous to swim in the open sea, play in an open field or hide under a tree during a thunderstorm.

Q.4 How is Static electricity a major cause of fires and explosions at many places? *(A.B)*

Ans: FIRES AND EXPLOSIONS

Static electricity is a major cause of fires and explosions at many places. A fire or an explosion may occur due to excessive build-up of electric charges produced by friction.

Q.5 How automobile manufactures use static electricity to paint new cars? *(A.B)*

Ans: ELECTROSTATIC PAINTING

The body of car is charged and then the paint is given the opposite charge by charging the nozzle of the sprayer. Due to mutual repulsion charge particles coming out of the nozzle form a fine mist and are evenly distributed on the surface of the object.

Q.6 Why lightening conductors are used in tall buildings? *(A.B)*

Ans: LIGHTENING CONDUCTORS

The purpose of the lightening conductor is to provide a steady discharge path for the large amount of negative charge in the air to flow form the top of the building to the earth. In this way, the chances of lightening damage due to sudden discharge can be minimized.

Q.7 Write any two examples of practical application of electrostatic induction? *(A.B)*

Ans: **APPLICATION OF ELECTROSTATIC INDUCTION**

The applications of electrostatic induction are given as under:

- Separation of particles from smoke
- Electrostatic painting

Q.8 How static electricity can be generated? *(K.B)*

Ans: **PRODUCTION OF STATIC ELECTRICITY**

Static electricity can be generated by the frictions of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing static electric charge build up during transport.

Q.9 Rubber tires get charged from friction with the road. What is the polarity of the charge? *(K.B+U.B)*

Ans: **POLARITY OF THE CHARGE**

The charge produced on the rubber tyre due to friction between tyre and road is positive because electrons are lost by rubber tyre due to weaker bonding.

Q.10 Perhaps you have seen a gasoline truck trailing a metal chain beneath it. What purpose does the chain serve? *(U.B+A.B)* **(Conceptual 13.6)**

Ans: **PURPOSE OF METAL CHAIN**

This metal charging is used of the purpose of earthling. The static charge accumulated on the body of truck during transportation are discharged to the ground through this metal chain. This may avoid any chance of explosion or fire during filling or otherwise.

Q.11 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? *(U.B)* **(Conceptual 13.7)**

Ans: **HIGH VOLTAGE POWER LINE**

Similar to Faraday's cage, inside the car you are safe from the influence of external field. The charge is evenly distributed on the surface of the car and the electric field inside the car is zero. But if we touch the ground. While coming out of the car, the charge will be discharged to the ground through our body. Hence it may be fatal.

Q.12 During flight, body of aeroplane gets charged. How it is discharged safely when landed? *(U.B+C.B+A.B)*

(For your information Pg. # 85)

Ans: **DISCHARGING OF AEROPLANE**

During flight, body of aeroplane gets charged. As the aeroplane lands, this charge is transferred to ground and the charge of sparking is eliminated while fuel is filled in it.

Q.13 How can we avoid spark or explosion while putting fuel in car or aircraft? *(C.B+A.B)*

(For your information Pg. # 85)

Ans: **SPARK OR EXPLOSION**

Static electricity can spark a fire or explosions. Care must be taken to avoid sparks when putting fuel in cars or aircraft. Spark may be produced due to friction between the fuel and the pipe. This can cause a serious explosion. The spark can be avoided if the pipe nozzle is made to conduct by connecting an earthing strap to it. The earthing strap connects the pipe to the ground.

Q.14 How much damage or destruction can lightening do? *(K.B)*

(For your information Pg. # 85)

Ans: **LIGHTENING**

The energy in lightening is enough to crack bricks and stones in unprotected buildings, and destroy electrical equipments inside. Each bolt of lightning contains about 1000 million joules of energy. This energy is enough to boil a kettle continuously for about two weeks. A flash of lightening is brighter than 10^7 light bulbs each of 100 watt.

Q.15 How would you suspend 500,000 pounds of water in the air with no visible means of support? *(U.B+A.B)* **(Point to ponder Pg. # 84)**

Ans: **SUSPENDING OF WATER IN AIR**

As we know that,

1 kg = 2.2 pounds and 1 pound = $\frac{1}{2.2}$ kg

So, 500,000 pounds of water $=\frac{500,000}{2.2}=2.27\times10^{5}\text{kg}$

And, Energy required to vaporize 1 kg of water = 2260000 J
(2260000 J = specific latent heat of vaporization of water)

Energy to vaporize $\left(2.27\times10^{5}\text{kg}\right)$ or $\left(500,000\text{ pounds}\right)=2.27\times10^{5}\times2260000\text{J}$

$$=5.13\times10^{11}\text{J}$$

Hence, $5.13\times10^{11}\text{J}$ energy must be supplied to a boiler to evaporate 500,000 pounds of water into air that can be supported by air particles in air which not a visible mean.

13.9, 13.10 MULTIPLE CHOICE QUESTIONS

1 **Application of electrostatic is: *(A.B)***
(A) Photocopying (B) Car painting
(C) Extracting Dust (D) All of these

2. **Each bolt of lightning contains about: *(U.B)***
(A) 100 million J of energy (B) 50 million J of energy
(C) 100 billion J of energy (D) 50 billion J of energy

3. **How many bulbs (each of 100 W) equal to a flash of lightening? *(U.B)***
(A) 10 (B) 50
(C) 100 (D) 50

4. **100 million joules energy is enough to boil a kettle continuously for about: *(U.B)***
(A) 2 weeks (B) 1 month
(C) 1 year (D) 1 hour

MCQ'S ANSWER KEY (TOPIC WISE)

13.1 PRODUCTION OF ELECTRIC CHARGES

1	2	3	4	5	6	7	8	9	10	11	12
A	C	D	A	B	A	B	A	D	B	B	A
13	**14**	**15**	**16**	**17**	**18**						
B	A	C	C	A	B						

13.2 ELECTROSTATIC INDUCTION

1
A

13.3 ELECTROSCOPE

1	2
D	C

13.4 COULOMB'S LAW

1	2	3	4	5	6	7	8	9	10	11	12
D	C	A	B	B	A	D	C	D	B	D	B

13
B

13.5 ELECTRIC FIELD AND ELECTRIC FIELD INTENSITY

1	2	3	4	5	6	7	8	9	10	11	12
C	B	A	B	A	B	C	C	A	B	B	B

13	14	15
A	A	A

13.6 ELECTROSTATIC POTENTIAL

1	2	3	4	5	6	7	8	9	10	11
B	D	C	D	B	B	A	B	A	D	B

13.7 CAPACITORS AND CAPACITANCE, COMBINATION OF CAPACITOR

1	2	3	4	5	6	7	8	9	10	11	12
B	A	B	D	C	A	A	B	C	A	B	C

13	14	15
B	B	A

13.8 DIFFERENT TYPES OF CAPACITORS

1	2	3	4	5	6	7	8	9	10	11
A	A	B	D	C	C	C	C	B	D	D

13.9 APPLICATIONS OF ELECTROSTATICS

13.10 SOME HAZARDS OF STATIC ELECTRICITY LIGHETING

1	2	3	4
D	A	A	A

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. A Positive electric charge: *(K.B)* **(LHR 2014)**

(a) attracts other positive charge (b) repels other positive charge
(c) attracts a neutral charge (d) repels a neutral charge

ii. An object gains excess negative charge after being rubbed against another object: *(K.B)*

(a) neutral (b) negatively charged
(c) positively charged (d) either a, b or c

iii. Two uncharged objects A and B are rubbed against each other when object B is placed near a negatively charged object C, the two objects repel each other which of the following statements is true about object A? *(U.B)*

(a) remains uncharged (b) becomes positively charged
(c) becomes negatively charged (d) unpredictable

iv. When you rub a plastic rod against your hair several times and put it near some bits of paper the pieces of papers are attracted towards it. What does this observation indicates? *(K.B+U.B)*

(a) the rod and the paper are oppositely charged
(b) the rod acquires a positive charge
(c) the rod and the paper have the same charges
(d) the rod acquires a negative charge

v. According to coulomb's law, what happens to the attraction of two oppositely charged objects as their distance of separation increases? *(K.B)*

(a) increase (b) decreases
(c) remains unchanged (d) cannot be determined

vi. The coulomb's law is valid for the charges which are: *(K.B)*

(a) moving and point charges (b) moving and non-point charges
(c) stationary and point charges (d) stationary and large size charges

vii. A positive and a negative charge are initially 4 cm apart. When they are moved closer together so that they are now only 1 cm apart, the force between them is: *(U.B+A.B)*

(a) 4 times smaller than before (b) 4 times larger than before
(c) 8 times larger than before (d) 16 times larger than before

viii. Five joules of work is needed to shift 10C is charge form one place to another. The potential difference between the places is: *(U.B+A.B)*

(a) 0.5 V (b) 2 V
(c) 5V (d) 10V

ix. Two charged spheres are separated by 2mm. Which of the following would produce the greatest attractive force? *(U.B+A.B)*

(a) + 1q and +4q (b) – 1q and – 4q
(c) +2q and +2q (d) +2q and -2q

x. Electric field lines: *(K.B)*

(a) always cross each other
(b) never cross each other
(c) cross each other in the region of strong field
(d) cross each other in the region of weak field

xi. Capacitance is defined as: *(U.B+A.B)* **(GRW 2014 (R), LHR 2014, LHR 2015)**

(a) VC (b) Q/V
(c) QV (d) V/Q

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix	x	xi
b	a	b	a	b	c	d	a	d	b	b

REVIEW QUESTIONS

13.1. How can you show by simple experiments that there are two types of electric charges?

Ans: (See Topic 13.1, Long Question-1)

13.2. Describe the method of charging bodies by electrostatic induction.

Ans: (See Topic 13.2, Long Question-1)

13.3. How does electrostatic induction differ from charging by friction?

DIFFERENT METHODS OF CHARGING

Ans: In case of charging by friction, both the bodies are in contact with each other. While, in case of electrostatic induction both the bodies are not in contact with each other.

13.4. What is gold leaf electroscope? Discuss its working principle with a labeled diagram.

Ans: (See Topic 13.3, Long Question-1)

13.5 Suppose you have a glass rod which becomes positively charged when you rub it with wool. Describe how you would charge the electroscope.

(i) Negatively

(ii) Positively

Ans: (See Topic 13.3, Long Question-1)

13.6. With the help of electroscope how you can find presence of charge on a body.

Ans: (See Topic 13.3, Long Question-1)

13.7. Describe how you would determine the nature of the charge on a body by using electroscope.

Ans: (See Topic 13.3, Long Question-1)

13.8. Explain Coulomb's law of electrostatics and write its mathematical form.

Ans: (See Topic 13.4, Long Question-1)

13.9. What is meant by electric field and electric intensity?

Ans: (See Topic 13.5, Long Question-1)

13.10. Is electric intensity a vector quantity? What will be its direction?

Ans: **TYPE OF QUANTITY**

Electric field intensity is a vector quantity. It has the same direction as that of force acting on the positive test charge. If the test charge is free to move, it will move in the direction of electric intensity.

13.11. How would you define potential difference between two points? Define its unit.

Ans: *Given on Page # 170*

13.12. Show that potential difference can be described as energy transfer per unit charge between the two points.

Ans: **POTENTIAL DIFFERENCE**

Explanation:

A body in gravitational field always tends to move form a point of higher potential energy to a point of lower potential energy. Similarly, when a charge is released in a electric field, it moves form a point of higher potential say A to a point at lower potential say B.

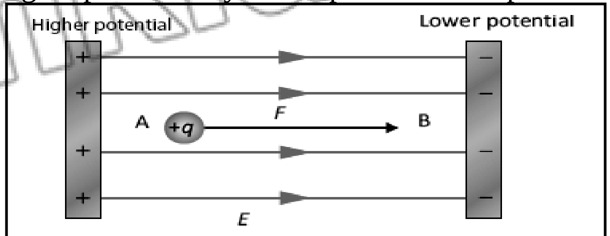


Figure: Potential Difference between Two Points

If the potential of point A is V_a and that of point B is V_b the potential energy of the charge at these points will be qV_a and qV_b respectively. The change in potential energy of the charge when it moves from point A to B will be equal to qV_a-qV_b. This energy is utilized in doing some useful work.

Thus Energy supplied by the charge = $q(V_a-V_b)$

If q is equal to one unit, then the potential difference between two points becomes equal to the energy supplied by the charge.

Conclusion:

Hence, potential difference is the energy transfer per unit charge between the two points.

13.13. What do you mean by the capacitance of a capacitor? Define units of capacitance.

Ans: *Given on Page # 174*

13.14. Derive the formula for the equivalent capacitance for a series combination of a number of capacitors.

Ans: (See Topic 13.7, Long Question-3)

13.15. Discuss different types of capacitors.

Ans: (See Topic 13.8, Long Question-1)

13.16. What is difference between variable and fixed type capacitor? *(K.B)*

Ans: **DIFFERENTIATE**

The difference between variable and fixed type capacitor are:

Fixed Capacitor	Variable Capacitor
Definition	
• A capacitor whose capacitance cannot be changed is called fixed capacitor.	• A capacitor whose capacitance can be changed is called variable capacitor.
Construction	
• It's both plates are immovable.	• It's one sets of plate is fixed and other is movable.
Examples	
• Mica capacitor • Paper capacitor	• Capacitor for the tuning of radio sets

13.17. Enlist some uses of capacitors.

Ans: (See Topic 13.8, Long Question-2)

13.18. Discuss one application of static electricity.

Ans: (See Topic 13.9, Long Question-1)

13.19. What are hazards of static electricity?

Ans: (See Topic 13.10, Long Question-1)

CONCEPTUAL QUESTIONS

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

Ans: **AN ELECTRIFIED ROD AND PIECES OF PAPER**

When a glass rod is rubbed with a silk cloth, it is positively charged. This electrified rod attracts pieces of paper. When the pieces of paper touch the rod, they give up some electrons to the glass rod and become positively charged. They are then flown away by the rod due to force of repulsion form the positive charge remaining on the rod.

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

Ans: **REMOVAL OF NEGATIVE CHARGE**

A charge of -75×10^{-11} C has been removed from a positively charged electroscope which has a charge of 7.5×10^{-11}C.

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

Ans: **MOVEMENT OF POSITIVE CHARGE**

A positive charge released in an electric field will move along the direction electric field i.e. from higher potential to the lower potential.

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

Ans: **CHARGE IN SERIES CONBINATION**

As in series combination each capacitor is connected side by side, so each capacitor carries equal magnitude of charge due to electrostatic induction.

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

Ans: **POTENTIAL DIFFERENCE IN PARALLEL**

In a parallel combination of capacitors, two plates of each capacitor are connected to the positive and negative terminals of a battery between the same two points. Hence potential difference between two plates of each capacitor is equal i.e equal to the potential difference of the battery.

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

Ans: *Given on Page # 189*

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?

Ans: *Given on Page # 189*

13.8 Explain why, a glass rod can be charged by rubbing when held by hand but an iron rod cannot be charged by rubbing, if held by hand?

Ans: **CHARGING OF GLASS ROD AND IRON ROD**

Because glass rod is an insulator, so charge developed on it during rubbing does not flow to the ground through the hand holding it. However, iron rod is a conductor and charge developed on it during rubbing can easily flow to the ground through the hand holding it. For this reason all metal objects used in electrostatic have insulating handles or stands.

NUMERICAL PROBLMES *(U.B+A.B)*

13.1 The charge of how many negatively charged particles would be equal to $100\mu C$. Assume charge on one negative particle is $1.6\times10^{-19}C$?

Solution:

Given Data:

Total Charge Q = 100 μC

= 100×10^{-6} C

Charge on an electron=e= 1.6×10^{-19} C

Required:

No. of negatively charged particles n =?

Formula:

$$Q = ne$$

Or $$n = \frac{Q}{e}$$

Calculations:

Putting the values from given data in the formula,

$$n = \frac{100\times10^{-6}C}{1.6\times10^{-19}C}$$

$$= \frac{10^2\times10^{-6}\times10^{19}}{1.6}$$

$$= \frac{10^{-6}\times10^{21}}{1.6}$$

$$= \frac{1}{1.6}\times10^{15}$$

$$= \frac{1}{16}\times10^{16} = 0.0625\times10^{16}$$

$n = 6.25 \times 10^{14}$ electrons

Result:

Hence, the wavelength of the radio waves transmitted by an FM station will be 3.33 m.

13.2 Two point charges $q_1 = 10\mu C$ and $q_2 = 5\mu C$ 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:

Given Data:

First point charge= $q_1 = 10\mu C = 10\times10^{-6} = 1\times10^{-5}C$

Second point charge = q_2 = 5 μC = 5×10^{-6} C

Distance between charges = r = 150 cm = $\frac{150cm}{100}$ = 1.5 m

Proportionality constant = k = 9×10^9 $Nm^2 C^{-2}$

Required:

(i) Magnitude of Coulomb's force F =?

(ii) Direction of Coulomb's force =?

Formula:

$$F = k\frac{q_1q_2}{r^2}$$

Calculations:

By putting the values from given data in the formula

$$F = \frac{9\times10^9 Nm^2C^{-2}\times1\times10^{-5}C\times5\times10^{-6}C}{(1.5m)^2}$$

$$= \frac{9\times10^9 Nm^2\times10^{-5}\times5\times10^{-6}}{2.25m^2}$$

$$= \frac{45\times10^{-2}N}{2.25}$$

$$= \frac{45}{225}N$$

F = 0.2 N

Result:

Hence, coulomb's force between the charges will be 0.2N. Since both charges are positive therefore nature of force will be repulsive.

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

Solution:

Given Data:

Force of repulsion = F = 0.8 N

Distance between the charges r = 0.1 m

Proportionality constant = k = $9 \times 10^9\ Nm^2C^{-2}$

Since the charges are identical, therefore, $q_1 = q_2 = q$

Required:

Value of each charger = q = ?

Formula:

$$F = \frac{kq_1q_2}{r^2}$$

Calculations:

Putting the values from given data in the formula.

$$0.8 = \frac{9\times10^9 q\times q}{(0.1)^2}$$

By putting the values

$$q^2 = \frac{0.8\times(0.1)^2}{9\times10^9}$$

$$= \frac{0.8\times0.01}{9\times10^9}$$

$$= 8.83\times10^{-13}$$

Taking square root on both sides

$$q = \sqrt{8.83\times10^{-13}}$$

$$q = 9.4\times10^{-7}\ C$$

Result:

Hence, value of each charge will be 9.4×10^{-7} C.

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

Solution:

Given Data:

First force of repulsion $=F_1=0.1N$

First distance $=r_1=5cm$

$r_1=0.05m$

Second distance$=r_2=2cm$

$r_2=0.02m$

Required:

Second force of repulsion $=F_2=?$

Formula Used:

$$F_1 = \frac{kq_1q_2}{r_1^2} \qquad \text{———— (1)}$$

$$F_2 = \frac{kq_1q_2}{r_2^2} \qquad \text{———— (2)}$$

Or dividing equation (1 and equation (2)

$$\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2} \qquad \text{———— (3)}$$

Calculations:

Putting the values from given data in the formula (3)

$$\frac{0.1N}{F_2} = \frac{0.02^2m^2}{0.05^2m^2}$$

$$F_2 = \frac{0.1\times0.05^2}{0.02^2}$$

$$F_2 = 0.625N$$

Result:

Hence, new force of repulsion between two charges will be 0.625N.

13.5 The potential at a point in an electric field is 10^4 V. If a charge of $+100\mu C$ is brought from infinity to this point. What would be the amount of work done on it?

Solution:

Given Data:

Electric potential=V= 10^4 V

Charge=q= +100 μC

= 100×10^{-6} C = 1×10^{-4} C

Required:

Work done=W =?

Formula:

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

Or $W = qV$

Calculations:

Putting the values from given data in the formula.

$$W = 10^{-4}\, C \times 10^4\, C$$

$$W = 1J$$

Result:

Hence, the amount of work done on the charge will be 1J.

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:

Given Data:

Charge= q = +2C

Potential at point A= V_A = 100 V

Potential at point B= V_B = 50 V

To Find:

Energy supplied by the charge E =?

Formula:

$$E = q(V_A - V_B)$$

Calculations:

Putting the values from given data in the formula

$$E = 2C(100V - 50V)$$

$$E = 100\ J$$

Result:

Hence, energy supplied by the charge will be 100J.

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

Solution:

Given Data:

Charge on a capacitor = Q = 0.06 C

Voltage V = 9V

Required:

Capacitance C = ?

Formula:

$$Q = CV$$

Or $$C = \frac{Q}{v}$$

Calculations:

Putting the values from given data in the formula

$$C = \frac{0.06C}{9v}$$

$$C = 6.67 \times 10^{-3}\ F$$

Result:

Hence, capacitance of the capacitor will be 6.67×10^{-3} 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? (LHR 2017)

Solution:

Given Data:

First Charge = Q_1 = 0.03C

First Voltage = V_1 = 6V

Second Charge = Q_2 = 2C

Required:

Second Voltage = V_2 = 6V

Formula:

$$C = \frac{Q_1}{V_1} \quad \text{______} \quad (1)$$

$$C = \frac{Q_2}{V_2} \quad \text{______} \quad (2)$$

Comparing equation (1) and equation (2)

$$\frac{Q_1}{V_1} = \frac{Q_2}{V_2} \quad \text{______} \quad (3)$$

Calculations:

Putting the values from given data in the formula (3)

$$\frac{0.03C}{6V} = \frac{2C}{V_2}$$

$$V_2 = \frac{12V}{0.03}$$

$$V_2 = 400V$$

Result:

Hence, 400 V would be required to hold 2C charge.

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

Solution:

Given Data:

Capacitance = C_1 = 6 μF = 6×10^{-6}F
Capacitance = C_2 = 12 μF = 12×10^{-6}F
Voltage = V = 12 V

Required:

(i) Equivalent capacitance = C_{eq} =?
(ii) Charge on each capacitor = Q =?
(iii) Potential difference across one capacitor = V_1 =?
Potential difference across second capacitor = V_2 =?

Formula:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \qquad \text{---------- (1)}$$

$$Q = CV \qquad \text{---------- (2)}$$

$$V_1 = \frac{Q}{C_1} \qquad \text{---------- (3)}$$

$$V_2 = \frac{Q}{C_2} \qquad \text{---------- (4)}$$

Calculations:

Putting the values from given data in the formula (1).

$$\frac{1}{C_{eq}} = \frac{1}{6\mu F} + \frac{1}{12\mu F}$$

$$\frac{1}{C_{eq}} = \frac{2+1}{12\mu F}$$

$$\frac{1}{C_{eq}} = \frac{3}{12\mu F}$$

$$C_{eq} = \frac{12\mu F}{3}$$

$$C_{eq} = 4\mu F$$

(ii) Putting the values from given data in the formula (2).

$$Q = 4 \times 10^{-6}\ F \times 12V$$
$$Q = 48 \times 10^{-6}\ FV$$
$$Q = 48\ \mu C$$

(iii) Putting the values from given data in the formula (3).

$$V_1 = \frac{48\mu C}{6\mu F} = 8V$$

Putting the values from given data in the formula (4).

$$V_2 = \frac{48\mu C}{12\mu F} = 4V$$

Result:

Hence,

- **Equivalent capacitance of series combination is 4μF.**
- **Charge on each capacitor is 48 μC.**
- **Potential difference across first capacitor is 8V.**
- **Potential difference across second capacitor is 4V.**

13.10 Tow capacitors of capacitances $6\mu F$ and $12\mu F$ are connected in parallel with a 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor. (LHR 2017)

Solution:

Given Data:

Capacitance of first capacitor = C_1 = 6μF
Capacitance of second capacitor = C_2 =12μF
Voltage = V = 12V

Required:

(i) Equivalent capacitance = C_{eq} =?
(ii) Charge on one capacitor = Q_1 =?
(iii) Charge on second capacitor = Q_2 =?
(iv) Potential difference across each capacitor = V =?

Formula:

$C_{eq} = C_1 + C_2$ ______________ (1)
$Q_1 = C_1V$ ______________ (2)
$Q_2 = C_2V$ ______________ (3)

Calculations:

(i) Putting the values from given data in the formula (1)
$C_{eq} = 6\mu F + 12\mu F$
$C_{eq} = 18\mu F$

(ii) Putting the values from given data in the formula (2)
$Q_1 = 6\mu F \times 12V$
$Q_1 = 72\mu C$ **Ans.**

(iii) Putting the values from given data in the formula (3
$Q_2 = 12\ \mu\ F \times 12\ V$
$Q_2 = 144\mu\ C$ Ans.

(iv) Since the capacitors are connected in parallel, therefore, potential difference across each capacitor will be 12V.

Result:

Hence,
- **Equivalent capacitance of parallel combination is 18μF.**
- **Charge on each first capacitor is 72 μC.**
- **Charge on each second capacitor is 144 μC.**
- **Potential difference across each capacitor is 12V.**

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. (6×1=6)

1. The value of Coulomb's constant "K" depends upon:
(A) System of units (B) Medium between charges
(C) Quantity of charges (D) Both A & B

2. The unit of electric intensity is:
(A) N (B) C
(C) NC^{-1} (D) NC

3. The equivalent capacitance of a parallel combination of capacitors, than any individual capacitance is:
(A) Smaller (B) Greater
(C) Same (D) None of these

4. The spacing between the field lines shows:
(A) Strength of electric field (B) Direction of Electric field intensity
(C) Both (A) & (B) (D) None of these

5. One coulomb charge has electrons:
(A) 6.25×10^{18} (B) 6.25×10^{15}
(C) 6.25×10^{14} (D) 6.25×10^{19}

6. Electric field lines:
(A) Always cross each other
(B) Never cross each other
(C) Cross each other in the region of strong field
(D) Cross each other in the region of weak field

Q.2 Give short answers to following questions. (5×2=10)

i. Define point charges.
ii. Write any three characteristics of charges.
iii. When a 10 μC charge is placed at a point, a force of 10^{-4} N acts on it. Find the amount of electric intensity at this point?
iv. Connect three capacitors in series and draw their circuit diagram.
v. In what direction will a positively charged particle move in an electric field?

Q.3 Answer the following questions in detail. (4+5=9)

a) How capacitors are connected in parallel combination, Also describe the characteristic features of this combination.
b) The force of repulsion between two identical positive charges is 0.8N, when the charges are 0.1m apart. Find the value of each charge?

<u>Note</u>:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.

UNIT 14

CURRENT ELECTRICITY

14.1 ELECTRIC CURRENT

LONG QUESTIONS

Q.1 Define and explain the term electric current. ***(K.B+U.B)*** **(LHR 2016)(Review Question 14.1)**

Ans: **ELECTRIC CURRENT**

Definition:

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

Mathematically:

If charges '**Q**' is passing through any area in time '**t**' the current '**I**' flowing through it will be given as:

$$\text{current} = \frac{\text{Charge}}{\text{Time}}$$

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

Unit:

SI unit of current is Ampere (A)

Ampere:

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

$$1\text{A} = \frac{1\text{COLOUMB}}{1\text{second}} = \frac{1\text{C}}{1\text{s}}$$

Smaller units of current are milli ampere (mA), micro ampere (μA), which are defined as:

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

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

Flow of Current:

Most of the electric charge around nuclei is bound in neutral atoms. It is not easy to overcome the electrostatic force of attraction between the nuclei and electrons in an atom. However, in metals some electrons are not tightly bound to nuclei and are free to move around randomly. They have weak force between them and the nucleus. Similarly, in solutions some positive and negative charges can freely move around randomly. When such free charges are exposed to an external electric field, they move in a specific direction, and thus constitute current.

Q.2 Explain battery as source of energy. ***(K.B+U.B+A.B)***

Ans: **BATTERY AS A SOURCE OF ENERGY**

Battery is one of the sources of current. The electrochemical reaction inside a battery separates positive and negative electric charges.

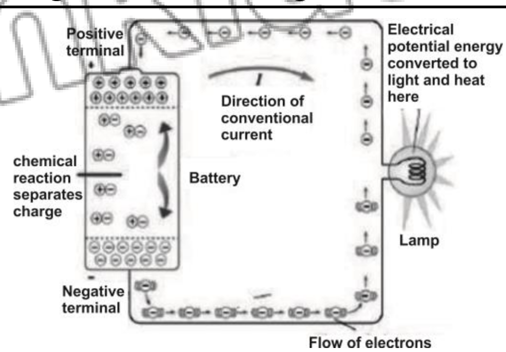


Figure: Schematic Diagram of Battery as a Current Source

This separation of charges set up potential difference between the terminals of the battery. When we connect a conducting wire across the terminals of the battery, the charges can move from one terminal to the other due to the potential difference.

Potential Energy per Unit Charge:

The chemical energy of the battery changes to electrical potential energy. The electrical potential energy decreases as the charges move around the circuit. This electric potential energy can be converted to another useful forms of energy (heat, light, sound etc.) it is only the energy which changes form but the number of charge carriers and the charge on each carrier always remains the same (i.e. charge are not used up.) instead of electrical potential energy we use the term electrical potential which is potential energy per unit charge.

Q.3 Define and explain the term conventional current. ***(K.B)*** **(GRW 2013)**

Ans: **CONVENTIONAL CURRENT**

Definition:

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

Conventional Mean:

Before the idea of free electrons which constitute in metals, it was thought that current in conductors flowed due to motion of positive charges. Therefore, this convention is still in used.

Explanation:

When the ends of heated copper wire are at different temperatures, heat energy flows from one end of higher temperature to the end of lower temperature. The flow stops when both ends reach the same temperature. Water in a pipe also flows from higher level to lower level. Similarly when a conductor is connected to a battery, it pushes positive charges to flow current from high potential to low potential.

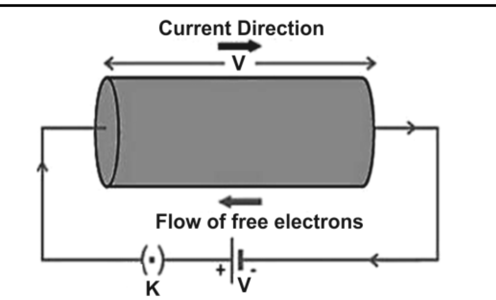


Figure: Conventional Current

The flow of current continues as long as there is a potential difference. Conventional current produces the same effect as the current flowing from negative terminal to the positive terminal due to flow of negative charges.

Q.4 How we can detect and measure the electric current? ***(K.B+A.B)***

Ans: **DETECTION AND MEASUREMENT OF CURRENT**

We use different electrical instruments which can detect and measure the current in the circuit.

Galvanometer:

"Galvanometer is a device which is used to detect the presence of electric current in any circuit".

Ammeter:

"Ammeter is a device which is used to measure the current in any circuit".

Importance of Galvanometer:

Galvanometer is very sensitive instruments and can detect small current in a circuit. A current of few milli amperes is sufficient to cause full scale deflection in it. Ideal galvanometer should have very small resistance to pass the maximum current in the circuit.

Polarity of Galvanometer:

While making the connections polarity of the terminals of the galvanometer should be taken into consideration. Generally the terminal of the galvanometer with red colour shows the positive polarity while that of with black colour shows negative polarity.

Conversion of Galvanometer into Ammeter:

After suitable modification galvanometer can converted into an ammeter. A suitable but small resistance is connected in parallel to the galvanometer, this circuit is called ammeter. A large current of the range such as 1A or 10 A can be measured by means of ammeter, like galvanometer ammeter is also connected in series, so that the current flowing in the circuit also passes through the ammeter.

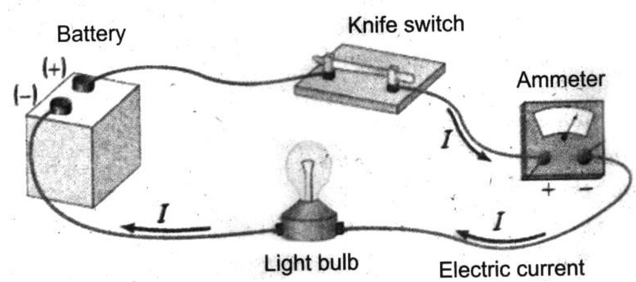


Figure: Schematic Diagram Showing the Measurement of Current

14.1 SHORT QUESTIONS

Q.1 Define electric current. *(K.B)* **(GRW 2014, 2015, LHR 2011, 2016)**

Ans: *Given on Page # 204*

Q.2 What is meant by conventional current? *(K.B)*

Ans: *Given on Page # 205*

Q.3 Which type of charge is responsible for the flow of current in metallic conductors? *(K.B)*

Ans: **CURRENT IN METALLIC CONDUCTOR**

In metals or metallic conductors, the current is reduced only due to the flow of free electrons i.e. negative charges.

Example:

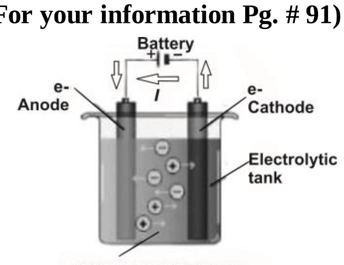
In a copper wire there are large number of free electrons which are in random motion. When we apply potential difference across the wire, these free electrons move through the wire.

Q.4 In electrolyte which charge are responsible for the flow of current? *(K.B)*

(For your information Pg. # 91)

Ans: **CURRENT IN ELECTROLYTE**

In electrolysis, current is produced due to flow of both positive and negative charges in the electrolyte, positive ions are attracted to the cathode and negative ions are attracted to the anode. This movement of ions within the electrolyte constitutes an electric current within the internal circuit.



Q.5 How energy is obtained due to flow of charges? ***(K.B)***

Ans: **ENERGY DUE TO FLOW OF CHARGES**

When a positive charge moves from a point of higher potential to the point of lower potential, it gains the energy from the electric field. During flow of electric current, positive charges flow continuously from a high potential to a low potential point. Thus the electric current becomes a continuous source of energy.

Q.6 How long does it take a current of 10 mA to deliver 30 C of charge? ***(U.B+A.B)***

(Quick Quiz Page No. 92)

Ans: **NUMERICAL**

Solution:

Given:

Current=I=10mA

$I=10\times10^{-3}A$

Charge=Q=30C

To Find:

Time=t=?

Formula Used:

I=Q/t

Or

t=Q/I

Calculations:

Putting the values into the formula from given data

$t = 30C/10\times10^{-3}A$

$t = 3\times10^{3}s$

t = 3000s

Result:

Hence, time To Find is 3000s.

Q.7 Define unit of current. ***(K.B+U.B)*** **(GRW 2014, LHR 2017)**

Ans: ***Given on Page # 204***

Q.8 Why there is no current in conductor in the absence of external source despite it has free electrons? ***(K.B)*** **(Connection Pg. # 92)**

Ans: **NO CURRENT IN THE ABSENCE OF EXTERNAL SOURCE**

In the absence of any external source no current passes through the conductor due to random motion of electrons.

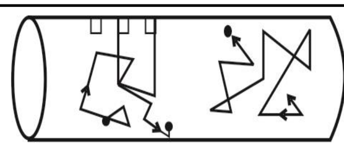


Figure: No Current in the Absence of External Source

Q.9 How a battery does raises electrical charge back up to higher voltage (energy)? *(U.B)*
(For you information Pg. # 92)

Ans: **BATTERY CHARGING**

A battery raises electric charge back up to higher voltage (energy) just like a pump which pushes water back up to high energy so it can flow and do work again.

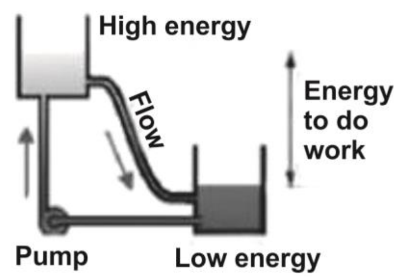


Figure: Battery Charging

Q.10 Define electric current with the help of diagram. *(K.B)* **(For you information Pg. # 91)**

Ans: **ELECTRIC CURRENT**

The current is the rate of flow of charges.

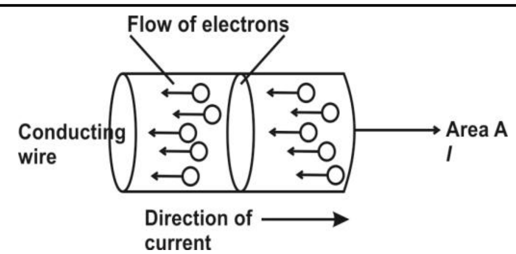


Figure: Electric Current

Q.11 Describe the flow of charge in a circuit. *(K.B)* **(Physics Insight Pg. # 93)**

Ans: **FLOW OF CHARGE**

The flow of charge in a circuit is like the flow of water in a pipe except that a return wire is needed in order to have a complete conducting path.

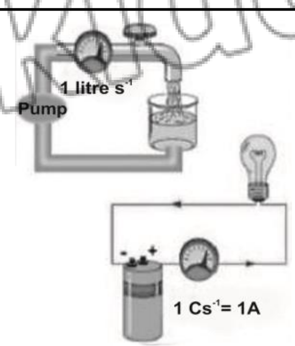


Figure: Flow of Charge

14.1 MULTIPLE CHOICE QUESTIONS

1. **In metals, current is produced only due to the flow of: *(K.B)***
   (A) Protons (B) Electrons
   (C) Free electrons (D) Neutrons
2. **In electrolyte, current is produced due to the flow of: *(K.B)***
   (A) Positive charge (B) Negative charges
   (C) Both positive and negative charges (D) None of these
3. **The rate of flow of electric charge through any cross-sectional area is called: *(K.B)***
   (A) Electrostatics (B) Electric current
   (C) e.m.f (D) Voltage
4. **The SI unit of electric current is: *(K.B)***
   (A) Volt (B) Farad
   (C) Capacitance (D) Ampere
5. **The equivalent current of positive charges which flows through a conductor is known as: *(K.B)***
   (A) Electronic current (B) Conventional current
   (C) Electrostatic (D) Ampere
6. **The current due to negative charges and an equivalent current due to positive charges always flow in the: *(K.B)***
   (A) Opposite direction (B) Same direction
   (C) Perpendicular to each other (D) None of these
7. **In electricity, we assume that electric current is always due to the flow of: *(K.B)***
   (A) Negative charges (B) Neutral particles
   (C) Positive charges (D) Both negative and positive charges
8. **The conventional current of positive charges flows from a point of: *(K.B)***
   (A) Higher potential to a point of lower potential
   (B) Lower potential to a point of higher potential
   (C) Lowe potential to a point of lower potential
   (D) Higher potential to a point of higher potential
9. **The current constituted by negative charges flows from a point of: *(K.B)***
   (A) Higher potential to a point of a lower potential
   (B) Lower potential to a point of higher potential
   (C) Lower potential to a point of lower potential
   (D) Higher potential to a point of higher potential
10. **When we connect a battery across a conductor, the energy is provided to the charges in the conductor by the? *(K.B)***
    (A) Magnetic field produced in the conductor
    (B) Electromagnetic field produced in the conductor
    (C) Electric field produced in the conductor
    (D) None of the above
11. **Energy is produced to transfer the electrons from positive terminal of the battery to the negative terminal by the: *(K.B)***
    (A) Electrical process (B) Chemical process
    (C) Thermal process (D) Magnetic process

12. The current through a metallic conductor is due to the motion of: *(K.B)*
(A) Protons (B) Neutrons
(C) Electrons (D) Free electrons

13. In liquids and gases, the current is due to the motion of: *(K.B)*
(A) Negative charges (B) Positive charges
(C) Both negative and positive charges (D) Neutral particles

14. Free electrons are: *(K.B)*
(A) Tightly bound (B) Fixed
(C) Loosely bound (D) Tightly fixed

15. The direction of conventional current flowing in a circuit is: *(K.B)*
(A) From negative to positive in the external circuit and from positive to negative within the source of potential difference (battery)
(B) From positive to negative in the external circuit and from negative to positive within the source of P.D.
(C) From positive to negative throughout the circuit.
(D) From negative to positive throughout the circuit

16. The direction of the electronic current in the closed circuit is: *(K.B)*
(A) Along the flow of electrons
(B) Opposite to the flow of electrons
(C) From positive to negative in the external circuit
(D) Along the direction of positive charges.

17. If a charge 'Q' flows through any cross-section of the conductor in time 't' second, the current 'I' is given by: *(U.B+A.B)*
(A) I = Qt (B) I = Q/t
(C) I = t/Q (D) I = Q2/t

18. One coulomb per second is equal to: *(K.B)*
(A) One volt (B) One Ampere
(C) One watt (D) One Ohm

19. Which of the following represents an electric current? *(K.B)*
(A) Erg C^{-1} (B) Cs^{-1}
(C) J S^{-1} (D) Dyne S^{-1}

20. If 1 ampere current flows through 2m long conductor, the charge flow through this in 1hour will be: *(U.B+A.B)*
(A) 3600 C (B) 7200 C
(C) 1C (D) 2C

21. Batteries convert: *(K.B+U.B)*
(A) Electrical energy into heat energy (B) Electrical energy into chemical energy
(C) Chemical energy into electrical energy (D) Heat energy into chemical energy

22. The electronic current is due to the flow of: *(K.B)*
(A) Negative charge (B) Positive charge
(C) Both (A) and (B) (D) None of the above

23. The conventional current is due to the flow of: *(K.B)*
(A) Negative charge carriers (B) Neutral charge
(C) Positive charge carriers (D) Both negative and positive charges carriers.

24. Electrical charges flow from: *(K.B)*
(A) High to low potential (B) Low to high potential
(C) Both a and b (D) None of these

EXAMPLE 14.1

If 0.5 C charge passes through a wire in 10s, then what will be the value of current flowing throuhg the wire? *(A.B+U.B)*

Solution:

Given data:

Amount of charge = Q = 0.5 C

Time = t = 10 s

To Find:

Value of current = I = ?

Formula:

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

Calculation:

By using formula, we have

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

$$I = \frac{0.5C}{10s} = 0.05A \Rightarrow 50mA$$

Result:

Hence, the value of current flowing through the wire is 50 mA.

14.2 POTENTIAL DIFFERENCE
14.3 ELECTROMOTIVE FORCE (e.m.f)

LONG QUESTIONS

Q.1 Define and explain the potential difference. *(K.B+U.B+A.B)* *(LHR 2014)*

Ans: **POTENTIAL DIFFERENCE**

Definition:

"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".

Explanation:

When one end *A* of conductor is connected to the positive terminal and its other end *B* is connected to the negative terminal of the battery then the potential of *A* becomes higher than the potential of *B*.

This cause a potential difference between the two ends of the conductor. The flow of current continues as long as there is a potential difference. The agency which provides the potential difference for the steady flow of current in the copper wire is the battery. As the current flows form higher potential to the lower potential through the conductor, the electrical energy (due to current) is converted into to other forms i.e. heat and light etc.

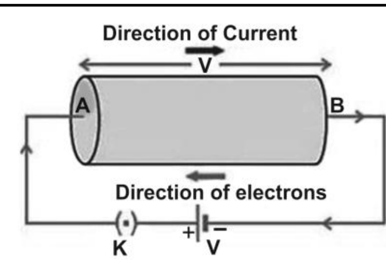


Figure: **Potential Difference**

When current flows through the conductor, it experiences a resistance in the conductor by collision with atom of the conductor. The energy supplied by the battery is utilized in overcoming this resistance and is dissipated as heat and other form of energy. The dissipation of this energy is accounted for by the potential difference across the two ends of the light bulb.

Unit:

SI unit of potential difference is volt.

Volt:

A potential difference of I volt across a bulb means that each coulomb of charge or 1 ampere of current that passes through the bulb consumes 1 joule of energy. When a bulb is lit, the energy is taken from the current and is transformed into light and heat energy.

Q.1 What is mean by electromotive force (e.m.f.)? Write its equation and explain its unit. *(K.B+U.B+A.B)*

(LHR 2015)

OR What do we mean by the term e.m.f? Is it really a force? Explain.(Review Question 14.3)

Ans:

ELECTROMOTIVE FORCE

Definition:

"It is the energy converted from non-electrical form to electrical form when one coulombs of positive charge passes through the battery**"**.

OR

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

Formula:

$$\text{e.m.f} = \frac{\text{Energy}}{\text{Charge}}$$

$$E = \frac{W}{Q}$$

Where E is the e.m.f., W is energy converted from non-electrical forms to electrical form and Q is a positive charge.

Unit of e.m.f:

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

Explanation:

When a conductor is connected to a battery, current flows through it due to potential difference. For the continuous flow of current through a wire, battery supplies energy to the charges. The positive charge leaves the positive terminal of the battery, passes through the conductor and reaches the negative terminal of the battery. As a positive charge enters the battery at its lower potential point (negative terminal), the battery must supply energy, say W to the positive charge to drive it to a point of higher potential i.e., positive terminal.

Sources of e.m.f: **(LHR 2013)**

Batteries, thermocouples and generators are the best examples of the sources of e.m.f. When a conductor is connected to battery current flows through it due to potential difference. A source of electromotive (e.m.f) converts non-electrical energy (chemical, thermal, mechanical) into electrical energy.

Q.2 How we measured the potential difference and e.m.f across a circuit?

Ans: **MEASUREMENT OF POTENTIAL DIFFERENCE**

The potential difference across a circuit component (e.g., light bulb) can be measured by a voltmeter connected directly across the terminal of the component. The positive terminal of the battery is connected to the positive terminal of the voltmeter and the negative terminal of the battery is connected to the negative terminal of the voltmeter.

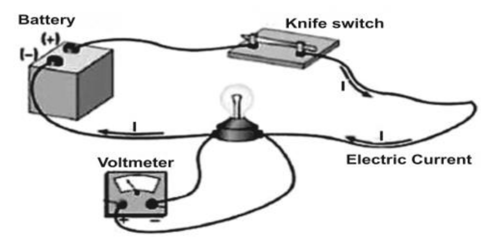


Figure: Schematic Diagram for Measuring Potential Difference in a Circuit

An ideal voltmeter should have very large value of resistance so that no current passes through it. Voltmeter is always connected in parallel with the device across which the potential difference is to be measured.

THE MEASUREMENT OF e.m.f

In general e.m.f refers to the potential difference across the terminals of the battery when it is not driving current in the external circuit. So in order to measure e.m.f of the battery we connect voltmeter directly with the terminals of the battery.

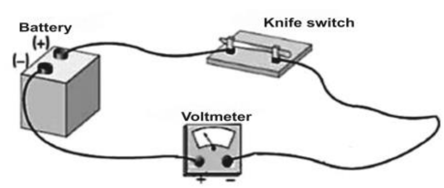
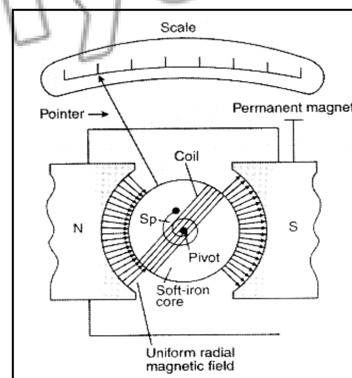


Figure: Schematic Diagram for Measuring e.m.f. of the Battery

14.3 SHORT QUESTIONS

Q.1 What is galvanometer? *(K.B)*

Ans: A galvanometer is very sensitive instrument and can detect a small current in a circuit. A current of few milliamperes is sufficient to cause full scale deflection in it. While making the connections polarity of the terminals of the galvanometer should be taken into consideration. Generally, the terminal of the galvanometer with red colour shows the positive polarity while that with black colour shows the negative polarity. An ideal galvanometer should have very small resistance to pass the maximum current in the circuit.



This Fig. has analogy with topic 15.2 and 15.3

Q.2 Construction and working of galvanometer. ***(Conceptual Base+A.B)***

Ans: The galvanometer consist of light coil of wire suspended from a metallic ribbon between the poles of a permanent magnet. The magnetic filed produced by a current passing through the coil reacts with the magnetic filed of permanent magnet, producing a torque, or twisting magnetic force. The coil, to which an indicating needle is attached is rotates under the action of torque and indicate electric current.

Q.3 What is Ammeter? ***(K.B)***

Ans: An ammeter is a measuring instrument used to measure the direct current and alternating current in a circuit. The ammeter is usually connected in series with the circuit in which the current is to be measured. An ammeter usually has low resistance so that it does not cause a significant voltage drop in the circuit being measured. It used to measure a large range of current between **1 A or 10 A.**

Q.4 What is voltmeter? ***(K.B)***

Ans: A voltmeter is an instrument used for measuring electric **potential difference** between two points in an electric circuit it is connected in **parallel**. It usually has a high resistance so that it takes negligible current from the circuit.

Q.5 What is difference between Ammeter and Voltmeter? ***(K.B)***

Ans:

DIFFERENCE

Ammeter	Voltmeter
• Ammeter is used to measure the electric current in electric circuit. • It is connected in series along with the circuit. • It has very low resistance so that the current flow through ammeter is maximum and potential drop is also maximum.	• Voltmeter is used to measure the potential difference or e.m.f. a cross to point in a electric circuit. • It is connected in parallel along with the circuit. • It has very high resistance so that the current flow through the voltmeter is minimum and potential drop is also minimum and can be measured.

Q.6 How a galvanometer is converted into voltmeter? ***(U.B)*** **(LHR 2014, GRW 2014, 2015)**

Ans:

CONVERSION OF GALVANOMERTER INTO VOLTMETER

The galvanometer is converted into voltmeter by connecting suitable resistance in series with it. The value of the resistance depends upon the range of the voltmeter. Usually its value is several thousand ohms. Thus the resistance of a voltmeter is very high.

Q.7 Why resistance of the ammeter is kept low? ***(K.B+U.B)***

OR How a galvanometer is converted into ammeter?

Ans:

CONVERSION OF GALVANOMERTER INTO AMMETER

Galvanometer can be converted into an ammeter by connecting a small resistance parallel to it. This small resistance is known as "shunt". Shunt provides an alternative path for the current to flow. The major part of the current passes through the shunt and small fraction of it flows through the galvanometer. Hence, it protects the galvanometer from burning.

Q.8 Why resistance of the voltmeter is kept high? ***(K.B+U.B)***

Ans:

HIGH RESISTANCE OF VOLTMETER

If the resistance of the voltmeter is comparatively low, it will draw more current from the circuit. Due to this, the potential difference across the resistance for the measurement of which the voltmeter was connected, would drop. Hence, resistance of voltmeter is kept high.

Q.9 On what factor reliability of voltmeter depend? *(U.B+K.B)*

Ans: **RELIABILITY OF VOLTMETER**

Higher the resistance of the voltmeter, more reliable would be its readings. Therefore a good voltmeter should have such a high resistance so that no or very little current could pass through it.

Q.10 How can we differentiate between electromotive force and potential difference? *(K.B)*

(Review Question 14.4)

Ans: **DIFFERENTIATION**

The differences between electromotive force and potential difference are as follows:

Potential Difference(V)	Electromotive Force(e.m.f)
Definition	
• 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.	• It is the energy supplied by a battery to a unit positive charge when it flows through the closed circuit.
Formula	
• ΔV=(Energy supplied by the charge)/q_0	• e.m.f.=Energy supplied by a battery /Charge
Connection	
• It is across the ends of the conductors	• It is across the terminals of the battery.

Q.11 What is the difference between a cell and a battery? *(K.B+Conceptual Base)*

(LHR 2017)(Conceptual Question 14.2)

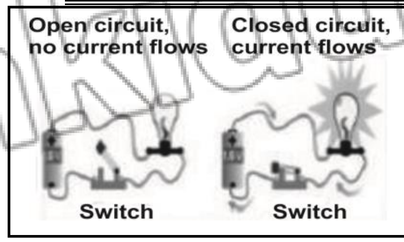
Ans: **DIFFERENTIATION**

The differences between electromotive force and potential difference are as follows:

Cell	Battery
Definition	
• A cell is a device which converts chemical energy into electrical energy.	• A battery is a combination of no. of cells connected in series.
No. of Electrode	
• It has two electrodes. One is cathode and other is anode.	• It has many electrode but in even numbers. i.e. 4, 6, 8 and so on.
Voltage	
• Voltage of a cell is the potential difference of the both electrodes and is always less than the voltage of a battery.	• Voltage of the battery is the sum of the voltages of the individual cell and always greater than voltage of each individual cell.
Charging	
• They may or may not charge.	• They are chargeable.

Q.12 Draw diagram of open circuit and closed circuit. *(K.B)*

Ans: **OPEN CIRCUIT AND CLOSED CIRCUIT**



Q.13 What is digital multimeter? *(K.B)* **(For your information Page # 96)**

Ans: **MULTIMETER**

Definition:

"A digital multimeter can be used to measure current, resistance and potential difference**"**. The multimeter is in voltmeter mood to measure the potential difference across a battery.

Q.14 Galvanometer named after which scientist? And which chance discovery, the invention of the chemical cell and the battery? *(K.B)* **(Do you know Pg. # 94)**

Ans: **CHANCE DISCOVERY**

The galvanometer has been named after Luigi Galvano (1737-1798). He, while dissecting a frog's leg, discovered that dissimilar metals touching the leg cause it to twitch. This chance discovery, the invention of the chemical cell and the battery.

Q.15 Volt is name after which physicist? And who developed the first practical electric battery? *(K.B)* **(Do you know Pg. # 95)**

Ans: **FIRST PRACTICAL ELECTRIC BATTERY**

The volt is named after the Italian physicist Alessandro Volta (1745-1827), who developed the first practical electric battery, known as a voltaic pile. Because potential difference is measured in units of volts, it is sometimes referred to as voltage.

Q.16 In which cell chemical energy changes into electrical energy? *(K.B)*

(For your information Pg. # 95)

Ans: **ENERGY**

In a dry cell chemical energy changes into electrical energy.

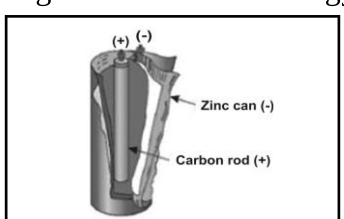


Figure: Dry Cell

14.3 MULTIPLE CHOICE QUESTIONS

1. **The energy To Find to move a charge from one point to another in the circuit is called: *(K.B)***
   (A) e.m.f (B) Potential difference
   (C) Resistance (D) Volt
2. **Volt is a unit of: *(K.B)***
   (A) Potential difference (B) e.m.f
   (C) Potential difference and e.m.f. (D) None of these
3. **The energy supplied in driving one coulomb of charge round a complete circuit in which the cell is connected is called: *(K.B)***
   (A) e.m.f (B) Potential difference
   (C) Resistance (D) Volt
4. **The instrument with which we can detect the presence of current in a circuit is knows as: *(K.B)***
   (A) Voltmeter (B) Ammeter
   (C) Galvanometer (D) Ohm meter
5. **In order to detect the current, galvanometer is connected: *(K.B)***
   (A) In parallel (B) In series
   (C) May be parallel or in series (D) Any where in the circuit
6. **If the needle of galvanometer shows some deflection, it would indicate the: *(K.B)***
   (A) Presence of current (B) Absence of current
   (C) A large current (D) None of these
7. **A galvanometer is a very: *(K.B)***
   (A) Large instrument (B) Small instrument
   (C) Insensitive instrument (D) Sensitive instrument
8. **A resistance which is connected with the galvanometer in order to convert it into ammeter should have: *(K.B)***
   (A) High resistance (B) Very high resistance
   (C) Low resistance (D) Very low resistance
9. **The resistance of an ammeter should be: *(K.B)***
   (A) Height (B) Very high
   (C) Low (D) Very low
10. **In order to measure the current in a circuit, ammeter should be connected: *(K.B)***
    (A) Parallel to battery (B) In series in the circuit
    (C) May be parallel or in series (D) None of these
11. **When ammeter is connected in the circuit, the positive terminal of ammeter should be connected with the? *(K.B)***
    (A) Negative terminal of the battery (B) Positive terminal of the battery
    (C) Any terminal of the battery (D) None of these

12. The potential difference can be directly measured by the instrument known as: *(K.B)*

(A) Ammeter (B) Potentio-meter
(C) Voltmeter (D) Ohm meter

13. Voltmeter is always connected in a circuit in: *(K.B)*

(A) Series (B) Parallel
(C) May be in series or parallel (D) None of these

14. A good voltmeter is that which draws: *(K.B)*

(A) No current (B) Small current
(C) Large current (D) Very large current

16. A galvanometer has been named after: *(K.B)*

(A) Luigi Galvano (B) Ampere
(C) Ohm (D) None of these

17. The unit of potential difference is named after: *(K.B)*

(A) Alessandro Volta (B) Christian Volta
(C) Ohms (D) None of these

14.4 OHM'S LAW

LONG QUESTIONS

Q.1 States and explain Ohm's law. What are its limitation? *(K.B+U.B+A.B)*

(GRW 2014)(Review Question 14.5)

Ans: **OHM'S LAW**

Statement:

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.

Explanation:

If '**V**' is the potential difference across the two ends of any conductor, then current I will flow through it. The value of the current '**I**' changes with the changes in potential difference 'V', hence by the definition of Ohm's law.

$V \propto I$ or $I \propto V$

$V = (\text{Constant})\, I$

$V = (R)I$

$V = IR$ …………..(1)

Where 'R' is the constant of proportionality, and is the resistance of the conductor. Its SI units is Ohm.

Resistance:

"The property of a substance which offers opposition to the flow of current through it is called its resistance**"**.

Reason:

This opposition comes from the collisions of moving electrons with atoms of the substance.

Unit:

SI unit of the resistance '**R**' is Ohm. It is denoted by the symbol, **(Ω)**.

Example:

If **V = 1 V**, and **I = 1 A**, the value of **R** will be **1Ω**.

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**"**.

Graphically Representation:

If a graph is plotted between the current *I* and the potential difference V, a straight line will be obtained.

Figure: Current Vs Voltage

Limitations of Ohm's Law:

Ohm's law is applicable when temperature of conductor is kept constant. It has been observed that only good conductors obey ohm's law as long as the electric current through them is not very large and the physical state of the conductor also remains the same.

Q.2 Verify the ohm's law with the help of an experiment. ***(U.B+A.B)***

Ans: **EXPERIMENT**

Take a nichrome wire of about 50 cm length and apply a potential difference of 1.5 V form a battery (a). Measure the current flowing through the wire using an ammeter connected to it in series. Also measure the potential difference across the wire using a voltmeter connected across it. Obtain a set of readings for I and V, by increasing the number of cells. Plot a graph between I and V. This will be a straight line (b).

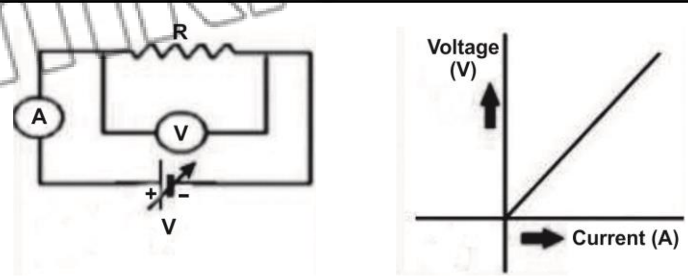


Figure: Current Vs Voltage

Conclusion:

- **If V is the potential difference across the two ends of any conductor, then current I will flow through it.**
- **The value of the current changes with the changes in potential difference.**
- **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.**

14.4 SHORT QUESTIONS

Q.1 State and explain Ohm's law. Write down its limitations. ***(K.B+U.B)***
(LHR 2016, GRW 2015, 2016)

Ans: ***Given on Page # 218***

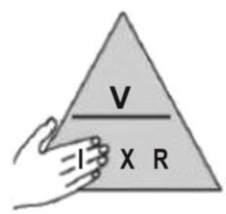
Q.2 Define resistance and its unit. ***(K.B)*** **(LHR 2014, 2016)(Review Question 14.6)**

Ans: ***Given on Page # 219***

Q.3 What is an easy method of learn relation between potential (V), current (I) and resistance (R) with the help of a figure. ***(K.B+U.B)*** **(Physics insights Pg. # 98)**

Ans: **EASY METHOD TO LEARN**

An easy method to learn the relation between potential (V), current (I) and resitance (R) is shown by the figure given below:



Cover *I* to find $I = \frac{V}{R}$

Q.4 Write down the uses of voltmeter and ammeter. ***(A.B)*** **(For your information Pg. # 98)**

Ans: **USES OF VOLTMETER AND AMMETER**

In order to measure current through a resistance, ammeter is always connected in series with the resistance. In order to measure potential difference across a resistance, voltmeter is always connected in parallel with the resistance.

14.4 MULTIPLE CHOICE QUESTIONS

1. **The relation V = IR represents:** ***(U.B+A.B)***
(A) Ampere law (B) Coulomb's law
(C) Faraday's law (D) Ohm's law

2. **Ohm's law is applicable to:** ***(A.B)***
(A) Liquids only (B) Gases only
(C) Liquid conductors only (D) Metallic conductors only

3. **Ohm is the unit of:** ***(K.B)***
(A) Current (B) Capacitance
(C) Electric intensity (D) Resistance

4. **Ohm is defined as: *(U.B)***
(A) Volt/Coulomb or VC^{-1} (B) Volt/Ampere or VA^{-1}
(C) Ampere/Volt or CV^{-1} (D) Ampere/Volt or AV^{-1}

5. **The resistance of a conductor through which a current of one ampere is flowing when the potential difference across its ends is one volt, is called: *(U.B)***
(A) One volt (B) One coulomb
(C) One Ohm (D) One ampere

6. **The graphical representation of Ohm's law is: *(K.B)***
(A) Hyperbola (B) Ellipse
(C) Parabola (D) Straight line

7. **The value of current passing through a conductor is directly proportional to the: *(K.B)***
(A) Resistance (B) Capacitance
(C) Potential difference (D) None of these

8. **The property of a substance which opposes the flow of current through it is called: *(K.B)***
(A) Conductivity (B) Capacitance
(C) Resistance (D) Conduction

9. **If a potential of 220V is applied across a conductor and a current of 2A flows through it. What would be the resistance of the conductor? *(U.B+A.B)***
(A) 210Ω (B) 440Ω
(C) 880Ω (D) 110 ohm

10. **The series resistance which is connected with galvanometer to convert it into voltmeter usually has value in: *(K.B)***
(A) Ohms (B) Several hundred ohms
(C) Several thousand ohms (D) Hundred thousand ohms

EXAMPLE 14.2

Reading on voltmeter connected across a heating element is 60 V. The amount of current passing through the heating element measured by an ammeter is 2A. What is the resitstance of the heating coil of the element? *(U.B+A.B)*

Solution:

Given data:

Voltmeter reading (potential) = V = 60 V

Ammeter readint (current) = I = 2A

To Find:

Resistance of heating coil = R = ?

Formula:

$$V = IR$$

Calculation:

By using formula, we have

$$V = IR$$

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

Or $$R = \frac{60V}{2A} = 30VA^{-1} \Rightarrow 30\Omega$$

Result:

Hence, the resistance of heating coil of the element will be 30Ω

14.5 CHARACTERISTICS OF OHMIC AND NON OHMIC CONDUCTORS

LONG QUESTIONS

Q.1 Explain the V-I characteristics of Ohmic and non Ohmic conductor. ***(K.B+A.B)***

Ans:

OHMIC CONDUCTORS

Definition:

Materials that obey Ohm's law, and hence have a constant resistance over a wide range of voltages, are said to be Ohmic.

V-I Characteristics of Ohmic Conductor:

Ohmic conductors have a linear current-voltage relationship over a large range of applied voltages. The straight line shows a constant ratio between voltage and current, So Ohm's law is obeyed.

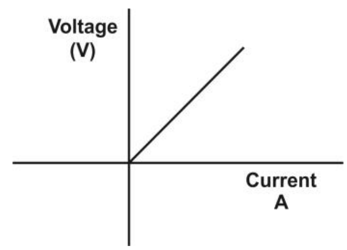


Figure: V-I Graph of Ohmic Conductor

Example:

Most metals show ohmic behavior.

NON-OHMIC CONDUCTOR

Definition:

"Materials having resistance that changes with voltage or current are non-ohmic".

V-I Characteristics of Non-Ohmic Conductor:

Non-ohmic materials have a non-linear current-voltage relationship.

Example:

- Filament lamp
- Thermister

Filament lamp:

The filament lamp shows the non-Ohmic materials properties. The resistance of filament rises (current decreases) as it gets hotter, which is shown by the gradient getting steeper.

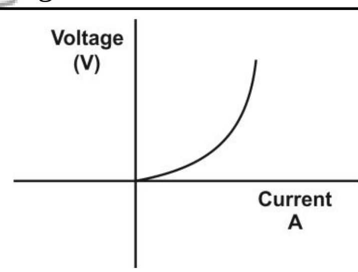


Figure: V-I Graph of Filament Conductor

Thermister:

A thermister (a heat sensitive resistor) behaves in the opposite way as that of filament lamp. Its resistance decreases (current increases) as it gets hotter.

This is because on heating, more free electrons become available for conduction of current.

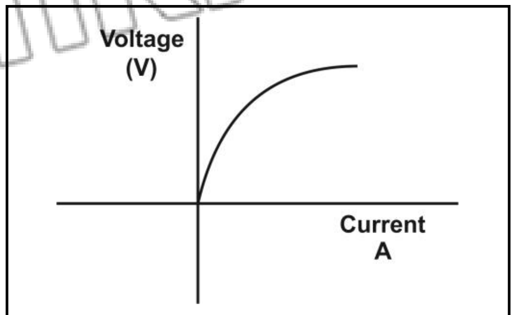
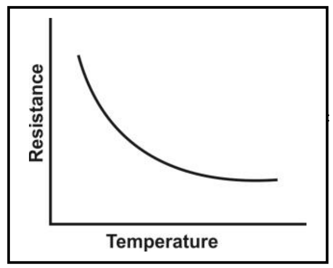


Figure: V-I Graph of Thermister

14.5 SHORT QUESTIONS



Q.1 Define Ohmic conductors. *(K.B)*

Ans: ***Given on Page # 222***

Q.2 Define thermister. *(K.B+A.B)* **98)**

Ans: **THERMISTER**

Definition:

"A thermister (a heat sensitive resistor) behaves in the opposite way because thermistor is made up of semi conductor of material. Its resistance decreases (current increases) as its temperature rises".

Use:

Thermister is used in a circuit that senses temperature changes.

Q.3 Define non-ohmic conductors. *(K.B)*

Ans: ***Given on Page # 222***

Q.4 The current versus voltage graph of a resistor is a straight line with a constant slope. The graph of a light bulb is curved with a decreasing slope. What can you infer from this? *(K.B)*

(Point to ponder Pg. # 99)

Ans: **GRAPH OF OHMIC & NON-OHMIC CONDUCTOR**

The resistor which has straight line graph with constant slope obeys Ohm's law and called as ohmic conductor. While the light bulb having curved graph does not obey Ohm's law and called as non-ohmic conductor.

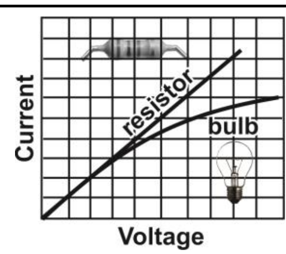


Figure: Graph of Ohmic & Non-Ohmic Conductor

Q.5 Define Resistance and its effect on temperature of conductor. ***(Conceptual Base)***

Ans: There is a heating effect whenever a current flows in a resistance. This principle is used in heating elements, and also in light lamps with filaments. The heating effect occurs because electrons collide with atoms as they pass through a conductor. The electrons lose energy. The atoms gain energy and vibrate faster. Faster vibrations mean a higher temperature.

14.5 MULTIPLE CHOICE QUESTIONS

1. Thermistor is: ***(K.B)***

(A) A heat sensitive resistor (B) potential divider
(C) constant resistor (D) An ordinary resistor

2. Materials that obey Ohm's law have constant: ***(K.B)***

(A) Resistance (B) Voltage
(C) Current (D) None of these

3. Materials having resistance that changes with voltage or current are called: ***(K.B)***

(A) Ohmic conductor (B) Non-Ohmic conductor
(C) Both a and b (D) None of these

4. The shape of the graph of Ohmic conductor is: ***(K.B)***

(A) Parabola (B) Straight line
(C) Circular (D) Both a and b

5 The shape of the graph of Ohmic conductor is: ***(K.B)***

(A) Non-linear (B) Linear
(C) Both a and b (D) None of these

14.6 FACTORS AFFECTING RESISTANCE

LONG QUESTIONS

Q.1 Define and explain the term specific resistance. Discuss different factors which affect the resistance of conductors. ***(K.B+A.B+U.B)*** **(GRW 2014)**

Ans: **SPECIFIC RESISTANCE**

Definition:

"The resistance of one meter cube of a substance is called its specific resistance".

Explanation:

A short pipe offers less resistance to water flow than a long pipe. A pipe with larger cross-sectional area offers less resistance than the pipe having smaller cross-sectional area.

Same is the case for the resistance of wire that carry current .the resistance of wire depends both on the cross-sectional area and length of the wire on the nature of the material of the wire.

Factors:

At specific temperature resistance depends upon the following factors.

- Length of conductor
- Cross-sectional area of conductor
- Nature of the conductor

Derivation of Specific Resistance:

At a certain temperature and for a particular substance resistance depends upon the following factors.

Length and Resistance:

The resistance '**R**' of wire is directly proportional to the length of the wire i.e.

$$\mathbf{R \propto L \rightarrow (i)}$$

It means if we double the length of wire its resistance will also be double and, if its length is halved its resistance would become one half.

Cross-sectional Area and Resistance:

The resistance '**R**' of the wire is inversely proportional to the area of cross-section '**A**' of the wire .i. c.

$$\mathbf{R \propto \frac{1}{A} \longrightarrow (ii)}$$

It means that a thick wire would have smaller resistance than a thin wire.

By combining these above relations.

$$R \propto L\frac{1}{A}$$

$$R \propto \frac{L}{A}$$

$$R = \rho\frac{L}{A} \longrightarrow (iii)$$

Where '$\boldsymbol{\rho}$' is the constant of proportionality, known as specific resistance.

Nature of Conductor (Specific Resistance):

Where ρ is the constant of proportionality known as specific resistance. Its value depends upon the nature of conductor i.e., copper, iron, tin and silver would each have a different values of ρ.

Unit of Specific Resistance:

If **L = 1 m** and **A = 1m^2** then **R = $\boldsymbol{\rho}$** i.e., the resistance of one meter cube of a substance is equal to its specific resistance. According to above equation the unit of $\boldsymbol{\rho}$ is ohm-meter **(Ωm)**.

14.6 SHORT QUESTIONS

Q.1 What are the factors upon which the resistance of a conductor depends? ***(K.B)*** **(GRW 2016)**

Ans: ***Given on Page # 224***

Q.2 Write down the specific resistance of the following metals: ***(K.B)***

- **Silver**
- **Copper**
- **Aluminum**
- **Tangston**
- **Platinum**
- **Iron**
- **Nichrome**
- **Graphite**

Ans: **SPECIFIC RESISTANCE**

Specific resistance of metals are given in the following table.

(Table for MCQs)

Metal	Specific resistance (10^{-8}Ω m)
Silver	1.7
Copper	1.69
Aluminium	2.75
Tungsten	5.25
Platinum	10.6
Iron	9.8
Nichrome	100
Graphite	3500

Q.3 Upon which factor does resistivity depend? *(K.B)*

Ans: **DEPENDENCE OF RESISTIVITY**

Its value depends upon the nature of conductor i.e., copper, iron, tin, and silver would each have a different values of '**ρ**'.

Q.4 Why does the resistance of a conductor increase with the rise of its temperature? *(K.B+U.B)*

Ans: **EFFECT OF TEMPERATURE ON RESISTANCE**

When the temperature of the conductor rises, average speed of the random motion of the free electrons increases which enhances the rate of collision of electrons and atoms. This causes an increase in the resistance of the conductor.

14.6 MULTIPLE CHOICE QUESTIONS

1. **The resistance of a meter cube of the substance is called: *(K.B)***
   (A) Conductivity (B) Permittivity
   (C) Resistivity (D) Susceptibility
2. **At a certain temperature, the resistance of a wire is directly proportional to its: *(K.B+U.B)***
   (A) Length (B) Area of cross-section
   (C) Shape (D) Colour
3. **At a certain temperature, the resistance of a wire is inversely proportional to its: *(K.B+U.B)***
   (A) Length (B) Area of cross-section
   (C) Temperature (D) Colour
4. **If we increase the length of a wire to four times of its original length, what will be its resistance? *(K.B+U.B)***
   (A) The same (B) Doubled
   (C) Four times (D) Eight times
5. **If we increase the cross-sectional area of the wire to double of its original area, its resistance will become: *(K.B+U.B)***
   (A) The same (B) Halved
   (C) One fourth (D) Doubled
6. **If L is the length and A is the cross-sectional area of a wire, then its resistance is gives by the relation: *(K.B+U.B)***
   (A) $R = \frac{1}{\rho}\frac{L}{A}$ (B) $R = \frac{1}{\rho}\frac{A}{L}$
   (C) $R = \rho\frac{A}{L}$ (D) $R = \rho\frac{L}{A}$
7. **The SI unit of specific resistance is: *(K.B)***
   (A) $\Omega - m^2$ (B) $\Omega - m$
   (C) $\Omega - m^{-1}$ (D) $\Omega - m^{-2}$
8. **If we increase the temperature of a conductor, its resistance will: *(U.B)***
   (A) Increase (B) Decrease
   (C) Remains the same (D) None of these
9. **The resistance of a conductor does not depend on its: *(K.B)***
   (A) Length (B) Cross sectional area
   (C) Resistivity (D) Mass

EXAMPLE 14.3

If the length of copper wire is 1m and its diameter is 2mm, then find the resistance of this copper wire. *(A.B+U.B)* **(LHR 2017)**

Solution:

Given Data:

Length of copper wire = L = 1m

Diameter of copper wire = d = 2mm

Specific resistance of copper

= ρ = $0.54\times10^{-4}\Omega m$

To Find:

Resistance of copper wire = R = ?

Formula:

$$A = \frac{\pi \times d^2}{4} \quad \text{..............(1)}$$

$$R = \frac{\rho \times L}{A} \quad \text{................(2)}$$

Calculation:

Putting the values from given data in the formula (1)

$$A = \frac{3.14 \times (2\times10^{-3})^2}{4}$$

$$A = 3.14 \times 10^{-6} m^2$$

Putting the values from given data in the formula (2)

$$R = \frac{1.69\times10^{-8}\times1}{3.14\times10^{-6}}$$

$$R = 5.4\times10^{-3}\Omega$$

Result:

Hence, resistance of copper wire is $5.4\times10^{-3}\Omega$

14.7 CONDUCTORS
14.8 INSULATORS

LONG QUESTIONS

Q.1 What is the difference between the conductors and insulators? *(K.B)*

(LHR 2016)(Review Question 14.7)

Ans: **DIFFERENTIATION**

The differences between the conductors and insulators are as follows:

Conductors	Insulators
Definition	
• The substances which conduct electricity and heat are called conductors.	• The substances which do not conduct electricity and heat is called non-conductors or insulators.
Examples	
• All metals are conductor • Graphite is also a conductor	• Wood • Plastic • Rubber
Free Electrons	
• It has free electrons which are responsible of conduction.	• It has no free electrons
Graph	
• Its I-V graph is linear	• Its I-V graph is curved.

14.7 SHORT QUESTIONS

Q.1 Why do we always use metal wires for conduction of electricity? ***(K.B+U.B+A.B)***

Ans: **USE OF METALLIC WIRES FOR CONDUCTION**

Because, they are good conductors of electricity and offer less resistance to the flow of current. Metals like silver and copper have excess of free electrons which are not held strongly with any particular atom of metals. These free electrons move randomly in all direction inside metals. When we apply external electric field these electrons can easily move in a specific direction. This movement of free electrons in particular direction under the influence of external field causes flow of current in metal wires.

Q.2 What do you mean by insulators? ***(K.B)***

Ans: **INSULATRORS**

Definition:

"The substances through which almost no current flow are called insulators**"**.

Insulators have very large value of resistance. Insulators can be easily charged by friction and the induced charged remains static on their surface.

Examples:

- Glass
- Wood
- Plastic
- Fur
- Silk

Q.3 Why insulator are non-conductors of electricity? ***(K.B)***

Ans: **NON-CONDUCTOR OF EELCTRICITY**

The insulators are non-conductors of electricity because electrons are not free to move their tightly bound inside atoms

Q.4 Why metals are good conductors of electricity? ***(K.B)***

Ans: **METALS ARE GOOD CONDUCTORS**

Metals are good conductors of electricity because they have excess of free electrons which are not held strongly with any particular atom of metal. These free electrons move randomly in all direction inside metals. When we apply external electric field these electrons can move easily move in specific direction. This movement of free electrons in a particular direction under the influence of an external field causes the flow of current in metal wires.

Q.5 How can a jeweler tell about a fake and real diamond? ***(K.B+U.B)***

(Interesting Information Pg. # 100)

Ans: **REAL OR FAKE DIAMOND**

Diamond does not conduct electricity, because it has no free electrons. However, it is very good at conducting heat because its particles are very firmly bonded together. Jewellers can tell if a diamond is a real diamond or a fake one made from glass, by holding it to their lips. A real diamond feels very cold due to good ability of transferring heat four or five times better than copper.

14.7 MULTIPLE CHOICE QUESTIONS

1. **When the temperature of a conductor is raised, its resistance:** ***(K.B)***
   (A) Always decreases (B) Always increases
   (C) Remains the same (D) First increases and then decrease
2. **The electrons in the insulator are:** ***(K.B)***
   (A) Loosely bounded (B) Tightly bounded
   (C) Both a and b (D) None of these
3. **The electrons in the conductor are:** ***(K.B)***
   (A) Loosely bounded (B) Tightly bounded
   (C) Both a and b (D) None of these
4. **Who are responsible for the conduction of electricity conductor?** ***(K.B)***
   (A) Negative ions (B) Positive ions
   (C) Free electrons (D) All of these
5. **In the absence of external source, electrons of the conductor move:** ***(K.B)***
   (A) Randomly (B) Unidirectional
   (C) Stationary (D) All of these

14.9 COMBINATION OF RESISTOR

LONG QUESTIONS

Q.1 How resistance are connected in series? Describe the characteristics features of this combination. What is meant by equivalent resistance of a series combination? Find its value. ***(K.B+U.B+A.B)*** **(LHR 2017)**

OR Determine the equivalent resistance of series combination of resistors.

(Review Question 14.11)

Ans: **SERIES COMBINATION**

Definition:

"In series combination, resistors are connected end to end and electric current has a single path through the circuit. This means that the current passing through each resistor is the same".

Characteristics of Series Combination:

The total voltage in a series circuit divides among the individual resistors so the sum of the voltage across the resistance of each individual resistor is equal to the total voltage supplied by the source. Thus, we can write as:

$$V = V_1 + V_2 + V_3$$

Where V is the voltage across a battery, and V_1, V_2 and V_3 are the voltages across resistors R_1, R_2 and R_3 respectively.

If I is the current passing through the resistors, then from Ohm's law

$$V = IR_1 + IR_2 + IR_3$$

$$V = I(R_1 + R_2 + R_3) \quad \ldots\ldots\ldots \quad (1)$$

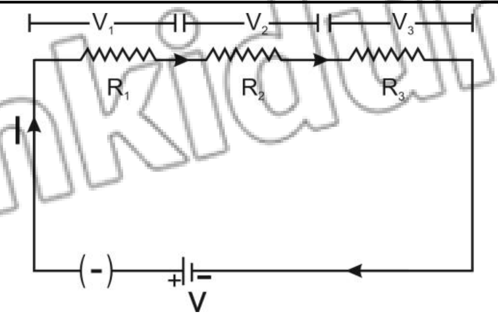


Figure: **Series Combination of Resistors**

Equivalent Resistance of Series Combination:

The equivalent resistance R_e of a series combination is that resistance which is substituted in place of the combination, the same current passes through the circuit. The equivalent resistance Re. The battery is sending the same current, which it was sending when the combination was connected in the circuit. By Ohm's law,

$$V = IR_e$$

By substituting the value of V in equation (1), we have

$$IR_e = I(R_1 + R_2 + R_3)$$

$$R_e = R_1 + R_2 + R_3$$

If resistances R_1, R_2, R_3, ……, R_n are connected in series then their equivalent resistance can be determined by the following equation.

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

Conclusion:

Thus the equivalent resistance of a series combination is equal to the sum of the individual resistances of the combination.

Q.2 How resistance are connected in parallel? Describe the characteristics features of this combination. What is meant by equivalent resistance of a parallel combination? Find its value. ***(K.B)*** **(GRW 2015, LHR 2014, 2015, 2017)**

OR Discuss the main features of parallel combination of resistors. **(Review Question 14.10)**

Ans:

PARALLEL COMBINATION

Definition:

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.

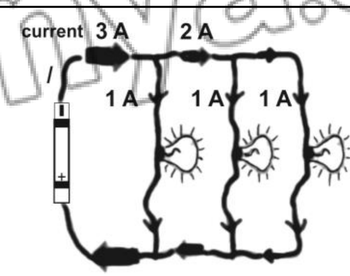


Figure: **Parallel Circuit Current Divides into Branches**

The voltage is same across each resistor which is equal to the voltage of the battery i.e.,

$$V = V_1 = V_2 = V_3$$

Features of Parallel Combination:

In this combination, the potential drop across all the resistances is the same. The potential drop across each of the resistance in the figure will be V.

The sum of the current flowing through the various resistances of this combination is equal to the total of the circuit.

$$I = I_1 + I_2 + I_3 \quad \ldots\ldots\ldots \quad (1)$$

As the potential drop across each resistance is V. So by Ohm's law

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

By substituting the values of I_1, I_2, I_3 in equation (1), we have

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

Or

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) \quad \ldots\ldots\ldots \quad (2)$$

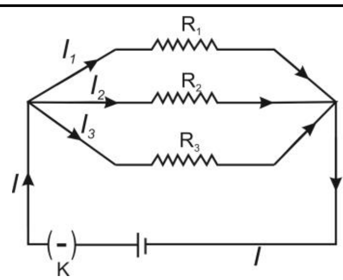


Figure: Parallel Combination of Resistors

The combination of resistors can be replaced with a single resistor called the equivalent resistors R_e. The equivalent resistance R_e of the parallel combination is that resistance which when substituted in place of the parallel combination does not alter the total current of the circuit.

By Ohm's law $I = \frac{V}{R_e}$

By putting the value of I in equation (2), we have

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

Or

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

If resistances R_1, R_2, R_3, ……, R_n are connected in parallel then their equivalent resistance can be determined by the following equation.

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots + \frac{1}{R_n}$$

Conclusion:

Thus, the reciprocal of equivalent resistance of a parallel combination is sum of the reciprocals of the individual resistances, which is less than the smallest resistance of the combination.

Advantages of Parallel: **(LHR 2014)**

Parallel circuits have two big advantages over series circuits.

1. Each device in the circuit receives the full battery voltage.
2. Each device in the circuit may be turned off independently without stopping the current flowing to the other devices in the circuit.

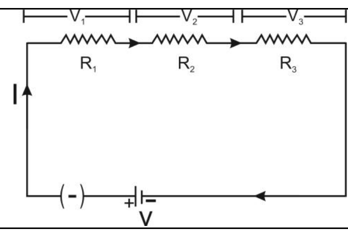
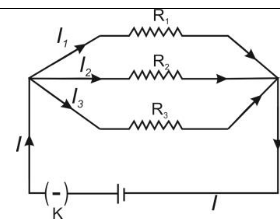
This principle is used in household wiring.

Q.3 Differentiate between series combination and parallel combination. ***(K.B)***

Ans:

DIFFERENTIATION

The differences between series combination and parallel combination are as follows:

Series Combination	Parallel Combination
Definition	
• In series combination, resistors are connected end to end and electric current has a single path through the circuit. This means that the current passing through each resistor is the same.	• 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.
Diagram	
	
Voltage	
• $\mathbf{V = V_1+V_2+V_3}$	• $\mathbf{V_1= V_2= V_3}$
Current	
• $\mathbf{I_1= I_2= I_3}$	• $\mathbf{I = I_1+I_2+I_3}$
Equivalent Resistance	
• The equivalent resistance of a series combination is equal to the sum of the individual resistances of the combinations and is always greater than the resistance of individuals. $R_e = R_1 + R_2 + R_3 + \ldots + R_n$	• The reciprocal of equivalent resistance of a parallel combination is sum of the reciprocals of the individual resistances, which is less than the smallest resistance of the combination. $\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \frac{1}{R_n}$

14.9 SHORT QUESTIONS

Q.1 What are the advantages of parallel combination over series combination? ***(K.B+A.B)***

Ans:

ADVANTAGES OF PARALLEL COMBINATION

Parallel circuits have two big advantages over series circuits.

- Each device in the circuit receives the full battery voltage.
- Each device in the circuit may be turned off independently without stopping the current flowing to the other devices in the circuit. This principle is used in household wiring.

Q.2 Which metal is used as the filament of an electric bulb? Explain with reason. ***(K.B)***
(Quick Quiz Pg. # 101)

Ans: **METAL USED IN FILAMENT**

A metal of high resistance (such as tungsten) is used as the filament of electric bulb. When electrons pass through the filament, they feel larger resistance due to which filament is heated and starts glowing.

Q.3 What do you know about a circuit diagram? ***(K.B)*** **(For your information Pg. # 103)**

Ans: **CIRCUIT DIAGRAM**

Definition:

"A circuit diagram is a symbolic method of describing a real circuit. The electric symbols used in circuit diagrams are standard, so anyone familiar with electricity can interpret a circuit diagram**"**.

Q.4 How can you determine the overall resistance of all the resistors having same resistance connected in parallel combination? ***(U.B)*** **(For your information Pg. # 104)**

Ans: **OVERALL RESISTANCE**

If the values of all the resistors in a parallel circuit are the same, the overall resistance can be determined by:

$$\frac{1}{R_e} = \frac{N}{R} \text{ i.e. } R_e = \frac{R}{N}$$

Where N is the total number of resistors and R is the resistance of each individual resistor.

Q.5 What would be the effect on the brightness of three bulbs connected in parallel to a small 2.5 V battery? Does the brightness of the bulbs differ from the bulbs connected in the series with the battery? Explain. ***(K.B+U.B)*** **(Activity 14.2 Pg. # 104)**

Ans: **EFFECTS ON BRIGHTNESS**

- Connecting batteries in parallel will not change the voltage but as we go on increasing the number of bulbs in parallel, the resistance of circuit decreases so current drawn from battery will increase which will drain out battery quickly but brightness of bulbs in parallel combination will remain same as long as battery does not sun short of some threshold level of energy.
- In series combination as potential will divide so current will also decrease on increasing resistance hence brightness will decrease.

14.9 MULTIPLE CHOICE QUESTIONS

1. The resistances are connected end to end and provide only one path for current in: ***(K.B)***
(A) Parallel circuit (B) Series circuit
(C) Both parallel and series circuit (D) None of these

2. The potential drop across each of resistors will be same in: ***(K.B)***
(A) (B) Series circuit
(C) Both parallel and series circuit (D) None of these

3. In series circuit, the magnitude of current that flows through each resistor is: ***(K.B)***
(A) Very small (B) Very large
(C) Same (D) Different

4. **In parallel circuit, the magnitude of current that flows through each resistor will be: *(K.B)***

(A) Very small (B) Very large
(C) Same (D) Different

5. **In series combination of resistors, the expression of equivalent voltage is given by: *(U.B+A.B)***

(A) $V = V_1 + V_2 + V_3$ (B) $V = \frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}$
(C) $V = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$ (D) $\frac{1}{V} = \frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}$

6. **The equivalent resistance for series combination of 3 resistors is given by: *(U.B+A.B)***

(A) $\frac{1}{\mathrm{R_e}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (B) $\frac{1}{\mathrm{R_e}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
(C) $\mathrm{Re} = R_1 + R_2 + R_3$ (D) $\mathrm{R_e} = VR_1 + VR_2 + VR_3$

7. **The equivalent resistance for parallel combination of 3 resistors is given by: *(U.B+A.B)***

(A) $\frac{1}{\mathrm{R_e}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (B) $\frac{1}{\mathrm{R_e}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$
(C) $\mathrm{Re} = R_1 + R_2 + R_3$ (D) $\mathrm{R_e} = VR_1 + VR_2 + VR_3$

8. **The expression for total current through parallel combination is: *(U.B+A.B)***

(A) $I = I_1 = I_2 - I_3$ (B) $I = I_1 + I_2 + I_3$
(C) $I = I_1 - I_2 - I_3$ (D) $I = 2_1 - 2I_2 - 2I_3$

9. **If three resistances of $6\,\Omega$ each are connected in series combination, what will be the equivalent resistance? *(U.B+A.B)***

(A) $6\,\Omega$ (B) $12\,\Omega$
(C) $18\,\Omega$ Q (D) $24\,\Omega$

10. **When resistors are connected in series, the equivalent resistance is equal to? *(K.B)***

(A) Sum of the reciprocals of the individual resistance
(B) Product of the reciprocals of the individual resistances
(C) Sum of the individual resistances
(D) Product of the individual resistan1ce

11. **If the resistors are connected in parallel, then: *(K.B)***

(A) The current through each is the same
(B) The total resistance is the sum of individual resistance
(C) The voltage across each is the same
(D) The total resistance is the product of individual resistance

12. If the resistance of 2 ohm and 4 ohm are connected in parallel, the equivalent resistance will be: *(U.B+A.B)*

(A) 11.0 ohms (B) 1.33 ohms
(C) 3.0 ohms (D) 5.0 ohms

13. Three resistance 5000, 500 and 50 ohms are connected in series across 555 volts mains. The current flowing through them will be: *(U.B+A.B)*

(A) 1A (B) 100 mA
(C) 10 mA (D) 10A

EXAMPLE 14.4

If two resistors of $6k\Omega$ and $4k\Omega$ are connected in series across a 10 V battery, then find the follwoing quantities. *(U.B+A.B)*
(a) Equivalent resistnace of the series combination
(b) The current flowing through each of the resistance
(c) Potential difference across each of the resistances

Solution:

Given data:

Resistnace of 1st resistor $= R_1 = 6k\Omega$

Resistance of 2nd resistor $= R_2 = 4k\Omega$

Voltage of battery = V = 10 V

To Find:

(a) Equivalent resistnace of the series combination = ?
(b) The current flowing through each of the resistance = ?
(c) Potential difference across each of the resistances = ?

Formula:

(a) $R_e = R_1 + R_2$

(b) $I = \dfrac{V}{R_e}$

(c) $V_1 = IR_1$ and $V_2 = IR_2$

Calculation:

(a) Equivalent resistnace of the series combination

$$R_e = R_1 + R_2$$

Or $R_e = 6k\Omega + 4k\Omega \Rightarrow 10k\Omega$

(b) The current flowing through each of the resistance

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

Or $I = \dfrac{10V}{10k\Omega} = \dfrac{10V}{10\times10^3\Omega} = 1.0\times10^{-3}A \Rightarrow 1mA$ $\therefore (10^{-3} = \text{mili})$

(c) Potential difference across R_1:

By using the formula, we have

$$V_1 = IR_1$$

Or $V_1 = 1.0 \times 10^{-3} A \times 6k\Omega = 6V$

Potential difference across R_2:

By using the formula, we have

$$V_2 = IR_2$$

Or $V_2 = 1.0 \times 10^{-3} A \times 4k\Omega = 4V$

Result:

> **Hence, in series combination of given resistances equivalent resistance, current and potential difference across each resistor will be $10k\Omega$, 1 mA, 6 V and 4 V respectively.**

EXAMPLE 14.5

If in the circuit (Figure), $R_1 = 2\Omega, R_2 = 3\Omega, R_3 = 6\Omega$ and $V = 6V$, then find the following quantities. ***(U.B+A.B)***

(a) Equivalent resistance of the circuit

(b) Current passing through each resistance

(c) The total current of the circuit

Solution:

Given data:

Resistance of 1st resistor $= R_1 = 2\Omega$

Resistance of 2nd resistor $= R_2 = 3\Omega$

Resistance of 3rd resistor $= R_3 = 6\Omega$

Voltage of battery = V = 6V

To Find:

(a) Equivalent resistance of the circuit $= R_e = ?$

(b) Current passing through each resistance $= I_1, I_2$ and $I_3 = ?$

(c) The total current of the circuit $= I = ?$

Formula:

(a) $\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

(b) $I_1 = \frac{V}{R_1}$, $I_2 = \frac{V}{R_2}$ and $I_3 = \frac{V}{R_3}$

(c) $I = I_1 + I_2 + I_3$

Calculation:

(a) Equivalent resistance of the circuit

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Or $\frac{1}{R_e} = \frac{1}{2\Omega} + \frac{1}{3\Omega} + \frac{1}{6\Omega}$

Or $\frac{1}{R_e} = \left[\frac{1}{2}+\frac{1}{3}+\frac{1}{6}\right] \times \frac{1}{\Omega} = \frac{6}{6\Omega}$

Or $\frac{1}{R_e} = \frac{1}{1\Omega} \Rightarrow R_e = 1\Omega$

This value is smaller than the lowest value of the resistanc ein the comibination which is always the case in parallel cases.

(b) Current passing through each resistance

In paralle combination, the potential difference across each of the resitance is same and is equal to the potential of the battery, which is 6V. Therefore,

$I_1 = \frac{V}{R_1}$

Or $I_1 = \frac{6V}{2\Omega} \Rightarrow 3A$

And $I_2 = \frac{V}{R_2}$

$I_2 = \frac{6V}{3\Omega} \Rightarrow 2A$

And $I_3 = \frac{V}{R_3}$

$I_3 = \frac{6V}{6\Omega} \Rightarrow 1A$

(c) The total current of the circuit

Sum of the currents passing through the resistances in parallel combination is equal to the total current I of the circuit. Therefore,

$\text{Total current} = I = I_1 + I_2 + I_3$

Or $I = 3A + 2A + 1A = 6A$

Result:

Hence, the equivalent resistance (R_e), current through each resistor (I_1), (I_2), (I_3) and total current of the circuit will be 1Ω, 3A, 2A, 1A and 6A respectively.

14.10 ELECTRICAL ENERGY AND JOULE'S LAW

LONG QUESTIONS

Q.1 State and explain joule's law. Derive its formula. ***(K.B+U.B+A.B)*** **(LHR 2014)**

Ans: **JOULE'S LAW**

Statement:

The amount of heat energy generated in a resistance due to flow of charges in equal to the product of square of current '**I**' resistance '**R**' and the time during '**t**'.

Explanation:

Turbine runs generator to produce electrical energy when water falls on it form higher gravitational potential to lower gravitational potential.

Similarly when charge moves form a higher electrical potential to a lower potential, it delivers electric current.
Hence the electric current, during when charges continuously move form a higher potential to a lower potential, becomes a continuous source of electrical energy.

Mathematical Formula:

Consider two point with a potential difference of **V** volts. If one coulomb of charge passes between these points. The amount of energy delivered by the charge would be **V** joule, when '**Q**' coulomb of charge flows between these two points, then we get **QV** joule of energy. It is represented by **W**. Electrical energy supplied by **Q** charge.

$$W = QV \text{ joules} \rightarrow \text{(i)}$$

When charge 'Q' flow in time 't' then by definition of current, we have

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

$$\Rightarrow \quad Q = It \rightarrow \text{(ii)}$$

So the energy supplied by Q charge in t second.
Put eq (ii) in eq (i)

$$W = I \times t \times V \rightarrow \text{(iii)}$$

This electrical energy can be converted into heat and other forms in the circuit.
By Ohms law, we have

$$V = IR \rightarrow \text{(iv)}$$

Put eq.(iv) in eq (iii) we get

$$W = It\,(IR)$$

So energy supplied by 'Q' charge in given as:

$$W = I^2\,Rt = \frac{V^2 t}{R}$$

This equation is called joules law.

Importance:

The heat energy produced can be utilized for different useful purposes e.g.

- Bulb converts this energy into light and heat
- Heater and iron convert this heat energy into heat.
- Electric fans convert into mechanical energy.

14.10 SHORT QUESTIONS

Q.1 State Joule's Law. ***(K.B+U.B+A.B)*** **(GRW 2013, LHR 2014, 2017)**

Ans: ***Given on Page # 237***

Q.2 How do we use the heating effect of current for different purposes? ***(A.B)***
(Do you know Pg. # 101)

Ans: **USES OF HEATING EFFECTS**

We use heating effect of an electric current for different purposes.

Examples:

- When a current flows through the filament of a bulb, it glows white hot and gives out light.
- Electric heaters have very thin wires that glow red hot when a current flows.

14.10 MULTIPLE CHOICE QUESTIONS

1. **When Q coulomb of charge flows between the two points having potential difference of V volts then the energy in joules is represented by?** ***(A.B+U.B)***
   (A) $W = \frac{Q}{V}$ (B) $W = \frac{V}{Q}$
   (C) $W = QV$ (D) W = F.S

2. **If a current I ampere flows through a resistance R in time seconds, then the energy supplied will be:** ***(A.B+U.B)***
   (A) W = IRt (B) $W = I^2Rt$
   (C) $W = IR^2t$ (D) $W = IRt^2$

3. **The energy supplied $W = I^2Rt$ is the mathematical expression for:** ***(K.B)***
   (A) Ohm's law (B) Fleming's law
   (C) Faraday's law (D) Joule's law

4. **Heat energy dissipated in a resistor R when connected to a battery of V volts and current I ampere flowing through it for time t is given by:** ***(U.B)***
   (A) I^2R (B) IRt
   (C) Vlt (D) I^2Rt

EXAMPLE 14.6

If a current of 0.5 A passes through a bulb connected across a battery of 6 V for 20 seconds, then find the rate of energy transferred to the bulb. Also find the resistance of the bulb. ***(A.B+U.B)***

Solution:

Given data:

Current passing through a bulb $= I = 0.5A$

Voltage of battery = V = 6 V

Time = t = 20 s

To Find:

(a) Rate of energy transferred = W/t = ?

(b) Resistance of the bulb = R = ?

Formula:

(a) Rate energy transfer = W/t = ?

(b) $W = I^2RT$

Calculation:

(a) Rate energy transfer = W/t = ?

To find the rate of energy transfer, first we have to find energy. SO by using formula, we have

$W = VIt$

Or $W = 6V \times 0.5A \times 20s$

Or $W = 60J$

(b) Resistance of the bulb = R = ?

$W = I^2RT$

Or $R = \frac{W}{I^2 \times t}$

Or $R = \frac{60}{20 \times (0.5)^2} = \frac{60}{20 \times 0.25}$

$R = 12\Omega$

Result:

Hence, the rate of energy transferred to the bulb and resistance of bulb will be 3 watt and 12Ω respectively.

14.11 ELECTRIC POWER

LONG QUESTIONS

Q.1 What is electric power? How it is calculate and write its unit. ***(K.B+A.B+U.B)*** **(LHR 2015, 2016)**

Ans: **ELECTRIC POWER**

Definition:

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

Mathematical Formula:

If the work done by the electric current in time t is W then P is determined by the formula.

$$\text{Electric power} = \frac{\text{electrical energy}}{\text{time}}$$

$$P = \frac{W}{t} \longrightarrow \text{(i)}$$

Where W is the electrical energy given as:

$$W = QV \rightarrow \text{(ii)}$$

$$P = \frac{QV}{t} \rightarrow \text{(iii)}$$

By definition of current

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

Hence eq. (iii) becomes

$$P = IV \rightarrow \text{(iv)}$$

By Ohm's law

$$V = IR \rightarrow \text{(iv)}$$

Hence equation (iv) can be written as:

Electrical power = P = I (IR)

Electrical power = P = I^2R

Conclusion:

When current I is passing through resistor R, the electric power that generates heat in the resistance is given by I^2R.

Unit:

The unit of electric power is watt which is equal to one joule per second ($1Js^{-1}$). It is represent by the symbol W.

Examples:

Electric bulbs commonly used in houses consume 25w, 40w, 60w, 75w, and 1000 w of electric power.

Q.2 What is kilowatt hour? How the cost of electricity in a house can be a calculated? ***(K.B+A.B+U.B)***

Ans: **KILOWATT HOUR**

Definition:

The amount of energy delivered by a power of one kilowatt in one hour is called kilowatt hour.

Explanation:

Electric energy is commonly consumed in very large quantity for the measurement of which joule is a very small unit hence a very large unit of electric energy is needed which is called kilowatt hour.

$$\begin{aligned}\text{One kilowatt hour} &= 1\text{ Kwh}\\ &= 1000W \times (3600s)\\ &= 36 \times 10^5\text{ Ws}\\ &= 3.6 \times 10^6\text{Ws}\end{aligned}$$

$$\therefore 10^6 = \text{Mega} = M,\ Ws = J$$

Hence,

One kilowatt hour = 3.6MJ

Formula:

$$\text{The amount of energy in kwh} = \frac{\text{Power(watt)} \times \text{time of use in hours}}{1000}$$

Or

$$\text{No. of units consumed} = \frac{\text{Power(watt)} \times \text{time of use in hours}}{1000}$$

Calculation for cost of Electricity in House:

The electric meter installed in our houses measures the consumption of electric energy in units of kilowatt hour according to which we pay our electricity bills. If the cost of one kilowatt-hour i.e., one unit is known then cost of electricity is calculated as:

Formula:

Cost of electricity = number of units consumed × cost of one unit

$$\text{Cost of electricity} = \frac{\text{Power(watt)} \times \text{time of use in hours}}{1000} \times \text{cost of one unit}$$

14.11 SHORT QUESTIONS

Q.1 Define electric power. ***(K.B+U.B+A.B)*** **(LHR 2014)**

Ans: ***Given on Page # 240***

Q.2 Define kilowatt hour? ***(K.B+U.B+A.B)*** **(LHR 2014)**

Ans: ***Given on Page # 240***

Q.3 How will you calculate the cost of electricity? ***(U.B+A.B)***

Ans: **COST OF ELECTRICITY**

Cost of electricity can be calculated by the following formula

Cost of electricity = number of units consumed × cost of one unit

$$\text{Cost of electricity} = \frac{\text{Power(watt)} \times \text{time of use in hours}}{1000} \times \text{cost of one unit}$$

Q.4 A light bulb is switched on for 40s. If the electrical energy consumed by the bulb during this time is 2400 J, find the power of the bulb. (*U.B+A.B*)

(Self-Assessment Pg. # 107)

Ans: **NUMERICAL**

Solution:

Given Data:

Time = t = 40s

Electrical Energy = w = 2400 J

To Find:

Power of the bulb =P = ?

Formula:

$$\text{Power} = \frac{\text{Electric energy}}{\text{time}}$$

Calculations:

$$P = \frac{2400\,J}{40\,s} = 60Js^{-1}\ 60W$$

Result:

Hence, power of bulb is 60W.

What information do we get from the power rating of an electrical appliance? ***(K.B)***

(For your information Pg. # 105)

Ans: **POWER RATING OF AN ELECTRICAL APPLIANCE**

All electrical appliances have power rating given in watts or kilo watts. An appliance with a power rating of 1W transfers 1J of electrical energy each second. So a 60W light bulb converts 60J of electrical energy each second into light energy and heat energy. To find out the total energy an appliance transfers from the mains, we need to know the number of joules transferred each second and the number of seconds for which the appliance is ON.

Q.5 How does an energy saver save energy? ***(K.B)***

(For your information Pg. # 105)

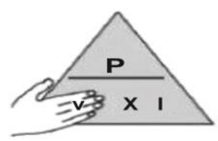
Ans: **ENERGY SAVER**

Energy saver light bulbs transform much more of the electrical energy into light and much less into wasted heat energy. An energy saver light bulb that uses 11J of electrical energy each second gives the same amount of light as an ordinary incandescent bulb that uses 60J of electrical energy each second.

Q.6 Describe the easy method to remember the power formula with help of a figure. ***(K.B)***

(Remembering power formula Pg. # 106)

Ans: **POWR FORMULA**



Cover V to find $V = \frac{P}{I}$

Q.7 What would be the unit of time and power to work out the energy? ***(K.B)***

(Remember Pg. # 107)

Ans: **UNIT OF TIME AND POWER**

To work out the energy transferred, the time must be in seconds and the power in watts.

Q.8 What would be the unit of power and time to work out the cost? ***(K.B)***

(Remember Pg. # 107)

Ans: **UNIT OF TIME AND POWER**

To work out the cost, the power must be in kilowatts and the time must be in hours.

Q.9 Write down the typical power rating of the following appliances. ***(K.B)***

(For your information Pg. # 104)

- **Electric stove**
- **Electric heater**
- **Hair dryer**
- **Iron**
- **Washing machine**
- **Light bulb**
- **Small fan**
- **Clock radio**

Ans: **POWER RATING OF APPLIANCES**

(Table for MCQs)

Appliances	Power (watts)
Electric stove	5,000
Electric heater	1,500
Hair dryer	1,000
Iron	800
Washing machine	750
Light bulb	100
Small fan	50
Clock radio	10

14.11 MULTIPLE CHOICE QUESTIONS

1. **The amount of energy supplied by current in unit time is known as: *(K.B)***
   (A) Electrical energy (B) Electrical power
   (C) Electrical work (D) Potential difference
2. **When current I is flowing through a resistance R the electrical power that generates heat in the resistance is given by: *(U.B)***
   (A) IR (B) I/R
   (C) I^2R (D) IR^2
3. **The SI unit of electrical power is: *(K.B)***
   (A) Watt (B) Joule
   (C) Ampere (D) Volt
4. **One watt is equal to: *(K.B+U.B)***
   (A) Js (B) Js^{-1}
   (C) J^2s (D) sJ^{-1}
5. **How will you calculate power from current (I) and voltage (v)? *(U.B)***
   (A) Power =I/V (B) Power = VI
   (C) Power = V^2 I (D) Power = VI^2
6. **Which one of the following bulbs has least resistance? *(U.B)***
   (A) 100 watt (B) 200 watt
   (C) 500 watt (D) 1000 watts
7. **Electrical energy is measured in: *(K.B)***
   (A) Watt (B) Horse power
   (C) Kilo watt (D) Kilowatt hour
8. **Electrical energy is commonly consumed in very large quantity and hence a large unit of energy is To Find which is known as: *(K.B)***
   (A) Watt-hour (B) Milli-watt hour
   (C) killowatt-hour (D) Megawatt - hour
9. **One kilowatt-hour is equal to: *(K.B)***
   (A) 13.6 MJ (B) 13.6 kJ
   (C) 3.6 kJ (D) 3.6 MJ
10. **We can calculate the amount of electricity bill by the following formula: *(U.B)***
    (A) $\frac{\text{watt}\times\text{time}\left(\text{in hours}\right)}{1000}\times$ cost of one unit (B) $\frac{\text{watt}\times 1000}{\text{time}\left(\text{in hours}\right)}\times$ cost of one unit
    (C) $\frac{1000\times\text{time}\left(\text{in hours}\right)}{\text{Watt}}\times$ cost of one unit (D) $\frac{1000\times\text{watt}\times\text{time}\left(\text{in hours}\right)}{\text{cost of one unit}}$
11. **1Kilowatt – hour is a unit of: *(U.B)***
    (A) Power (B) Work
    (C) Energy (D) Current

EXAMPLE 14.7

The resistance of an elctric bulb is 500Ω. Find the power consumed by the bulb when a potential difference of 250 V is applied across its ends. ***(A.B+U.B)***

Solution:

Given data:

Resistance of electric bulb = R = 500Ω

Potential difference applied = V = 250 V

To Find:

Power consumed by the bulb = P = ?

Formula:

$$P = I^2R$$

Calculation:

To find the power consumed by the bulb, first we have to find the value of current. So by using formula, we have

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

Or $I = \frac{250V}{500\Omega} \Rightarrow 0.5A$

And Power $= P = I^2R$

Or $P = (0.5\,A)^2 \times 500\Omega$

$P = 125W$

Result:

Hence, the power consumed by the bulb will be 125 W.

EXAMPLE 14.8

Calculate the one month cost of using 50 W energy saver for 8 hours daily in your study room. Assume that the price of a unit is Rs. 12. ***(A.B+U.B)***

Solution:

Given data:

Power of energy saver $= P = 50W$

Usage time $= t = 8\,\text{hours} \times 30\,\text{days} = 240\,\text{Hrs}$

Price of a unit = Rs. 12

To Find:

One month cost = ?

Formula:

One month cost = No. Of units consumed × cost of one unit

Calculation:

To find one month cost first we have to find the no. Of units consumed, so by using formula, we have

$$\text{No. of units consumed} = \frac{\text{Power}(\text{watt}) \times \text{time of use in hours}}{1000}$$

Or $= \frac{50 \times 240}{1000} = 12\,\text{units}$

Therfore,

Total cost = No. of units consumed × cost of one unit

= 12 × 12 = Rs. 144

Result:

Hence, the total cost of using 50 W energy saver for 8 hours daily per month in study room will be Rs. 144.

14.12 DIRECT CURRENT AND ALTERNATING CURRENT

LONG QUESTIONS

Q.1 How electricity is distributed in our house? How electrical appliances are connected in houses? *(K.B)*

Ans: **SUPPLY TO HOUSES**

The electric power enters our house through three wires.

- Earthwire or Ground wire (E)
- Livewire (L)
- Neutral Wire (N)

Earthwire (E):
The earthwire is connected to a large metal plate buried deep in the ground near the house. This wire carries no electricity.

Neutral Wire (N):
The other wire is maintained at zero potential by connecting it to the Earth at the power station itself and is called neutral wire (N). This wire provides the return path for the current.

Livewire (L):
The third wire is at a high potential and is called livewire (L).

Potential Difference between Livewire and Neutral wire: **(GRW 2014)**
The electric power enters our houses through wires, the potential difference between the livewire and neutral wire is 220V.

Dangers:
Our body is a good conductor of electricity through which current can easily pass. Therefore, if a person holds livewire current will start flowing to the ground while passing through his body which may prove fatal for the person.

Connection of Electrical Appliances:
All electrical appliances are connected across the neutral and livewires. The same potential difference is therefore applied to all of them and hence these are connected in parallel to the power source.

Q.2 Explain the circuit of house wiring. *(K.B+U.B)*

Ans: **HOUSE WIRING**

The wires coming from power sub-station are connected to electricity meter installed in house. The output power from the electric meter is taken to the distribution board and then to the domestic electric circuit.

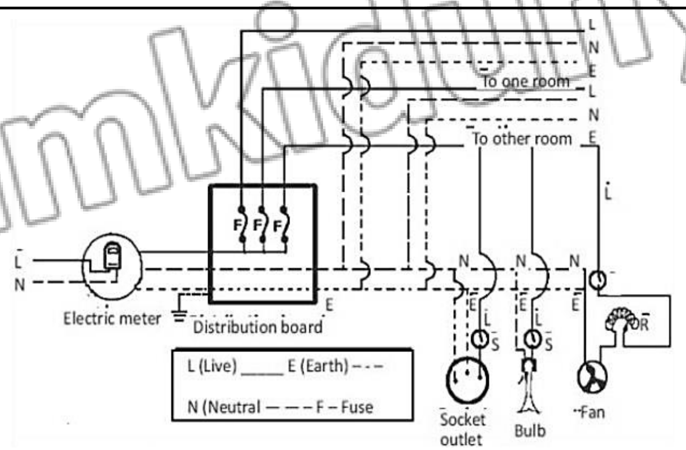


Figure: Wiring System of Household Electriccity

The main box contains fuses of rating about 30A.A separate connection is taken from the livewire for each appliance. Terminal of the appliance is connected to the livewire through a separate fuse and a switch. If the fuse of the one appliance burns out, it does not affect the other appliances.

Connection of Appliances:

In house wiring all appliances are connected in parallel with each other. This means they get the full mains voltage and one can turn ON any appliance without having to turn ON another.

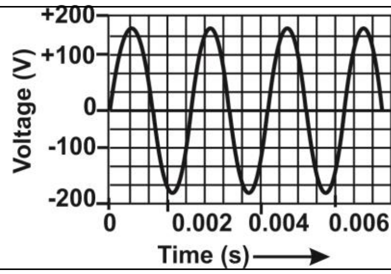
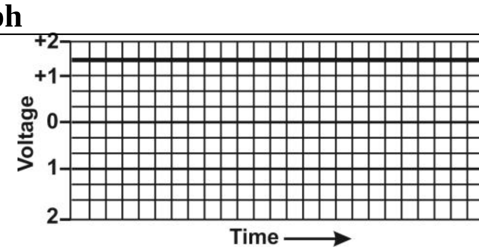
14.12 SHORT QUESTIONS

Q.1 What is difference between D.C. and A.C.? *(K.B)*

(GRW 2013, LHR 2013, 2016)(Review Question 14.9)

Ans: **DIFFERENTIATION**

The differences between direct current and alternating current are as follows:

Alternating Current	Direct Current
Definition	
• A current that changes direction after equal intervals of time is called alternating current or a.c.	• The current derived from a cell or a battery is direct current (d.c.). **OR** • The current which does not change its direction after equal interval of time is called direct current.
Graph	
	
Polarity	
• It changes its polarity with equal intervals of time.	• It has fixed polarity.
Frequency	
• Its frequency is 50 Hz.	• Its frequency is zero.
Source	
• Its source is generator	• Its sources are battery and cell.

Q.2 What are live and neutral wires? *(K.B)* **(GRW 2013)**

Ans: Electricity is distributed to various houses in a city from a power station by means of two wires.

- Neutral wire
- Livewire

NEUTRAL WIRE

Definition:

One wire is earthed at the power station, so it is at zero potential. This wire is called neutral wire.

Purpose:

This wire provide the return path of current.

Color Code:

It is black or blue in color.

LIVEWIRE

Definition:
The third wire is at a high potential and is called livewire.
Potential Difference between Live and Neutral Wire:
The potential difference between both wire is 220 V.
Color Code:
It is red or brown in color.

Q.3 What is earthwire? *(K.B)*

Ans: **EARTHWIRE**

Definition:
The earthwire is connected to a large metal plate buried deep in the ground near the house.
Color Code:
It is green or yellow in color.

Q.4 A bird can sit harmlessly on high tension wire. But it must not reach and grab neighboring wire. Do you know why? *(U.B+K.B)* **(Point to Ponder Pg. 102)**

Ans: **BIRD SITTING ON A HIGH TENSION WIRE**

A bird can sit harmlessly on high tension wire as no current passes through its body, since the potential of the wire is constant. However, if the bird grabs the neighbouring wire, then due to potential difference of two wires, current will flow through the body of the bird and can be fatal.

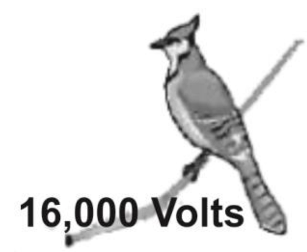


Figure: Bird Sitting on a High Tension Wire

Q.5 What is electrical grounding? *(K.B)* **(Electrical ground Pg. # 106)**

Ans: **ELECTRICAL GROUNDING**

Definition:
"If a charged object is connected with the Earth by a piece of metal, the charge is conducted away from the object to the Earth. This convenient method of removing the charge from an object is called grounding the object".
Purpose of Grounding:
As a safety measure, the metal shells of electrical appliances are grounded through special wires that give electric charges in the shells paths to the Earth. The round post in the familiar three-prong electric plug is the ground connection.

Q.6 Incandescent light bulb fluctuates 50 times but we do not feel it why? *(K.B+U.B)*
(Do you know Pg. # 106)

Ans: **INCANDESCENT LIGHT BULB**

Although the light intensity from a 60 W incandescent light bulb appears to be constant, the current in the bulb fluctuates 50 times each second between -0.71 A and 0.71 A. The light appears to be steady because the fluctuations are too rapid for our eyes to perceive.

Q.7 What would be the effect of following currents on the body? *(K.B)*

(Effects of electric currents on the body Pg. # 108)

- **0.001 A**
- **0.005 A**
- **0.010 A**
- **0.015 A**
- **0.070 A**

Ans: **EFFECTS OF CURRENTS**

(Table for MCQs)

Effect of electric currents on the body	
0.001 A	Can be felt
0.005 A	Is painful
0.010 A	Causes involuntary muscle contractions (spasms)
0.015 A	Causes loss of muscle control
0.070 A	Goes through the heart; causes serious disruption; probably fatal if current lasts for more than 1 s.

Q.8 Draw the correct way of wiring of a three pin main plug. Also describe the importance of fuse in it. *(K.B)* **(For your information Pg. # 109)**

Ans: **CORRECT WAY OF WIRING**

This is the correct way of wiring of a three pin main plug. Put everything in proper place. Fuse is placed for safety purpose. In case of excess current, it will burn out and will break the circuit.

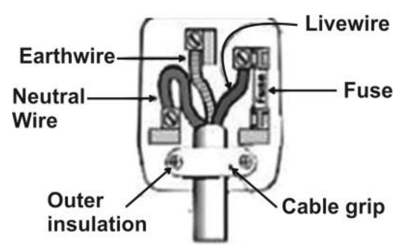


Figure: Correct Way of Wiring

14.12 MULTIPLE CHOICE QUESTIONS

1. The current which always flows in one direction is called: *(K.B)*

(A) Alternating current (B) Direct current
(C) Stationary current (D) Multi-directional

2. The current which changes its direction again and again is called: *(K.B)*

(A) Alternating current (B) Direct current
(C) Multi-directional current (D) Uni – directional current

3. The time interval after which the voltage repeats its value is known as: *(K.B)*

(A) Frequency (B) Wavelength
(C) Time period (D) None of these

4. The number of cycles completed by current in one second is called its: *(K.B)*

(A) Time period (B) Frequency
(C) Wavelength (D) Amplitude

5. The frequency of a.c used in our houses is: *(K.B)*

(A) 30 cycles / second (B) 50 cycles/ second
(C) 60 cycles/ second (D) 100cycles/ second

14.13 HAZARDS OF ELECTRICITY

LONG QUESTIONS

Q.1 Describe briefly the hazards of household electricity. ***(K.B)*** **(Review Question 14.12)**

Ans:

HAZARDS OF ELECTRICITY

Major dangers of electricity are electric shock and fire. Here we discuss some faults in electrical circuits that may cause electricity hazards.

Insulation Damage:

There are three reasons of insulation damage.

- Excess of current due to short circuit
- Friction
- Moisture

Excess of Current due to Short Circuit:

All electrical wires are well insulated with some plastic cover for the purpose of safety. But when electrical current exceeds the rated current carrying capacity of the conductor, it can produce excess current that can damage insulation due to overheating of cables. This results into a short circuit which can severely damage electrical devices or persons. A short circuit occurs when a circuit with a very low resistance is formed. The low resistance causes the current to be very large. When appliances are connected in parallel, each additional appliance placed in circuit reduces the equivalent resistance in the circuit and increases the current through the wires. This additional current might produce enough thermal energy to melt the wiring's insulation which causes a short circuit, or even starts a fire. Short circuit can also occur when the livewire and the neutral wires come in direct contact.

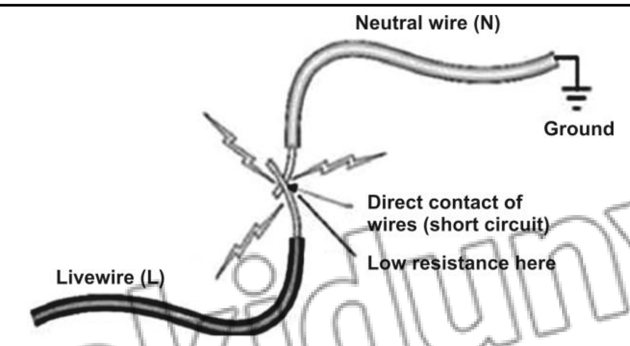


Figure: Short Circuit

Prevention:

- In order to avoid such situations, the wires carrying electricity should never be naked. Rather they should be covered with good insulator. Such an insulation covered wire is called cable.

Friction:

Constant friction may also remove the insulation from the wire

Prevention:

- In such a situation, it is advisable to use a cable with two layers of insulation.

Moisture:
Too much moisture also damages the insulation.

Damped Condition:
Dry human skin has a resistance of 100, 000 ohms or more! But under damp conditions (wet environment) resistance of human skin is reduced drastically to few hundred ohms.

Prevention:
- Never operate any electrical appliance with wet hands.
- Keep switches, plugs sockets and wires dry.

14.13 SHORT QUESTIONS

Q.1 How electricity is dangerous for us? *(K.B)*

Ans: **DANGERS OF ELECTRICITY**

Our body is a good conductor of electricity through which current can easily pass. Therefore if a person holds livewire, then because of the presence of voltage in it, current will start flowing to ground through the human body which may prove fatal for the person.

Q.2 What is the resistance of dry and wet skin of a human body? *(K.B+U.B)*

Ans: **RESISTANCE OF HUMAN BODY**

Dry human skin has a resistance of 100, 000 ohms or more! But under damp conditions (wet environment) resistance of human skin is reduced drastically to few hundred ohms.

Prevention:
- Never operate any electrical appliance with wet hands.
- Keep switches, plugs sockets and wires dry.

Q.3 Identify the following precautionary symbols. *(K.B)* **(Precautionary Symbols Pg. # 110)**

Ans: **PRECAUTIONARY SYMBOLS**

Figure: Precautionary Symbols

Q.4 Why flying kites near electricity lines is hazardous? *(K.B)*(For your information Pg. # 110)

Ans: **HAZARDOUS EFFECT OF FLYING KITES**

Do not fly kites near electricity lines. It may cause some fatal accident.

Figure: Hazardous Effect of Flying Kites

14.13 MULTIPLE CHOICE QUESTIONS

1. **Resistance of dry skin is:** ***(K.B)***
   (A) 1000Ω (B) 10000Ω
   (C) 100000Ω (D) None of these
2. **Resistance of wet skin is:** ***(K.B)***
   (A) 1000Ω (B) 10000Ω
   (C) 100000Ω (D) None of these
3. **A short circuit occurs when a circuit is formed with:** ***(K.B)***
   (A) High resistance (B) Very low resistance
   (C) Very high resistance (D) None of these
4. **A short circuit occurs when a livewire comes in direct contact with:** ***(K.B)***
   (A) Neutral wire (B) Earthwire
   (C) Livewire (D) None of these

14.14 SAFE USE OF ELECTRICITY IN HOMES

LONG QUESTIONS

Q.1 Write a note on fuse. ***(K.B+U.B)***

Ans:

FUSE

Definition:

A fuse is a safety device that is connected in series with the livewire in the circuit to protect the equipments when excess current flows.

Construction:

Fuse is made of a short and thin piece of metal wire that melts when large current passes through it.

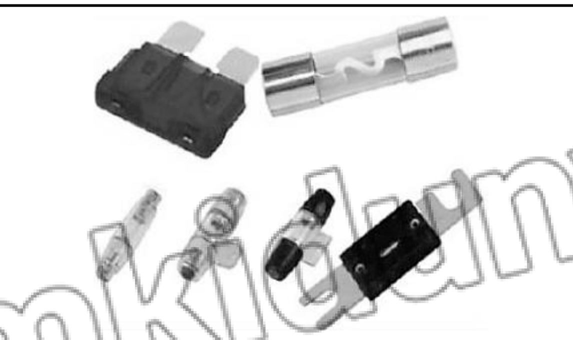


Figure: Different Types of Fuses

Working:

If a large, unsafe current passes through the circuit, the fuse melts and breaks the circuits before the wires becomes very hot and cause fire.

Fuse Rating:

Fuse are normally rated as 5A, 10A, 13A and 30 A etc.

We can determine the fuse rating of circuit, let use determine the fuse rating of air conditions of power 3000W.

P = 3000W.

V = 240 Volt

I = ?

P = VI

$\Rightarrow \quad I = \frac{P}{V}$

$I = \frac{300}{240} = 12.5A$

Hence suitable fuse for this circuit would be 13A.

Safety Measures: **(GRW 2015)**

Following safety measures should be taken while using fuses in house hold electrical circuits.

(i) Fuses to be used should have slightly more rating than the current which the electrical appliance will draw under normal conditions.

Example:

For a lightening circuit choose a 5A fuse as the current drawn by each lamp is very small (about 0.4A) for a 100 W lamp. In such circuit, 10 lamps of 100 W can be safely used because the total current drawn is only 4A which can be calculated using the formula P = VI

(ii) Fuses should be connected to the livewire so that the appliance will not become live after the fuse has blown.

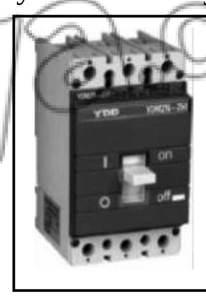
(iii) Switch off the main before changing any fuse.

Q.2 What is the principle of circuit breaker? *(K.B+A.B+U.B)* **(GRW 2013)**

Ans: **CIRCUIT BREAKER**

Definition:

The circuit breaker acts as a safety device. It disconnects the supply automatically if current exceeds the normal value.



Construction:

It consists of:

- Electromagnet
- Iron strip
- Spring

Working Principle:

The working principle of circuit breaker is electromagnetic induction.

Working:

When the normal current passes through the livewire the electromagnet is not strong enough to separate the contacts. If something goes wrong with the appliance and large current flows through the livewire, the electromagnet will attract the iron strip to separate the contacts and break the circuit.

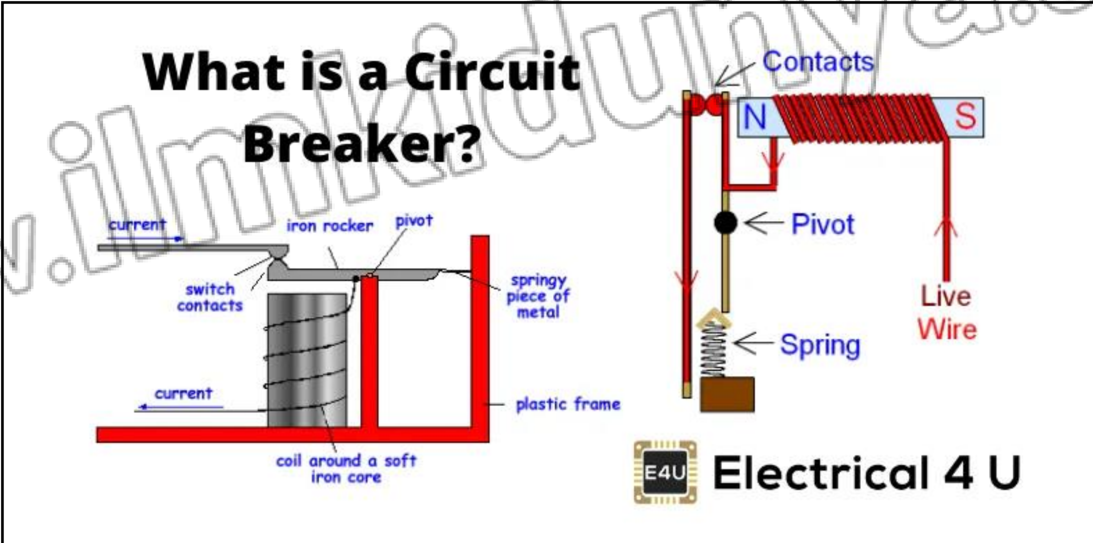


Figure: **Working Principle of Circuit Breaker**

The spring then keeps the contacts apart. After the fault is repaired, the contacts can then be pushed back together by pressing a button on the outside of the circuit breaker box.

Q.3 Explain the importance of Earthwire. ***(A.B)*** **(LHR 2016)**

Ans:

IMPORTANCE OF EARTHWIRE

Sometimes, even the fuse cannot capture the high currents coming from the livewire into the household appliance. Earthing further protects the user form electric shock by connecting the metal casing of the appliance to earth (a wired connection to the bare ground) many electrical appliances have metal cases, including cookers, washing machines and refrigerators, the earthwire provides a safe route for the current to flow through, if the livewire touches the casing.

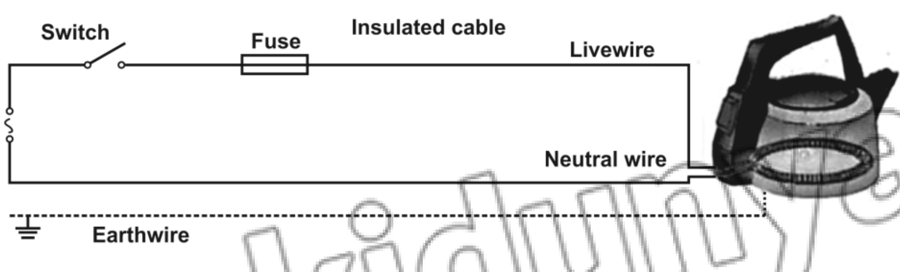


Figure: **Earthwire**

We will get an electric shock if the livewire inside an appliance comes loose and touches the metal casing, However, the earth terminal is connected to the metal casing, so the current goes though the earthwire instead of passing through our body and causing an electric shock, A strong current passes through the earthwire because it has a very low resistance. This breaks the fuse and disconnects the appliance.

Working:

Whenever the metal casing of the appliance, due to faulty insulation, gets connected with the livewire, the circuit shorts and a large current would immediately flow to ground through the earthwire and causes the fuse wire to melt or the circuit breaker breaks the circuit. Therefore, the person who is using the appliance is saved.

14.14 SHORT QUESTIONS

Q.1 Briefly describe the importance of safety devices. ***(K.B)*** **(GRW 2014)**

Ans: **IMPORTANCE OF SAFETY DEVICE**

Definition;

"The electrical devices which prevent the damage of electrical circuits appliances and property are called safety devices".

Examples:

(i) Fuse
(ii) Circuit Breaker
(iii) Earthwire

Importance:

In order to protect persons, devices and property form the hazards of electricity. There is a need of extensive safety measures in household electricity. Safety devices prevent circuit form overloading that can occur when too many appliances are turned on at the same time or when a short circuit occurs in one appliance.

Q.2 What is cable? And how it should be used? ***(K.B)***

Ans: **CABLE**

Definition:

An insulated covered wire is known as cable.

Safe Use of Cable:

Cable should be used keeping the following things in mind:

- Layer of insulation in the cable is perfect and is not damaged.
- Sometimes a heavy current flow through the wire and it gets so hot that its insulation is burnt out and the wire becomes naked and it becomes dangerous.
- Constant friction also removes the insulation from the wire whereas too much moisture also damages the insulation. In such a situation it is advisable to use a cable with two layers of insulation.

Q.3 Define fuse and write down its principle. ***(K.B)***

Ans: **FUSE**

Definition:

A fuse is a safety device that is connected in series with the livewire in the circuit to protect the equipments when excess current flows.

Principle:

A specified amount of current can safely pass through it. When the current following through it exceeds this limit, it gets so hot that it melts and breaks the circuit.

Q.4 What do you know about Fuse rating? ***(U.B)***

Ans: **FUSE RATING**

We can determine the To Find fuse rating for a circuit. Suppose we want to insert a fuse for an air-conditioner or heater of power 3000W. If voltage supply is of 240V, then according to relation P =V x I, we get I = 12.5A. The available fuses in the market are usually of rating 5A, 10A, 13A, 30A etc. Hence, suitable fuse for this circuit would be of 13A.

Q.5 What is Circuit Breaker? Also write down its principle? ***(K.B)***

Ans: **CIRCUIT BREAKER**

Definition:

The circuit breaker acts as a safety device. It disconnects the supply automatically if current exceeds the normal value.

Working Principle:

The working principle of circuit breaker is electromagnetic induction.

Q.6 What is the function of Earthwire? *(A.B+K.B)*

Ans: **FUNCTION OF EARTHWIRE**

Whenever the metal casing of the appliance, due to faulty insulation, gets connected with the livewire, the circuit shorts and a large current would immediately flow to ground through the earthwire and causes the fuse wire to melt or the circuit breaker breaks the circuit. Therefore, the person who is using the appliance is saved.

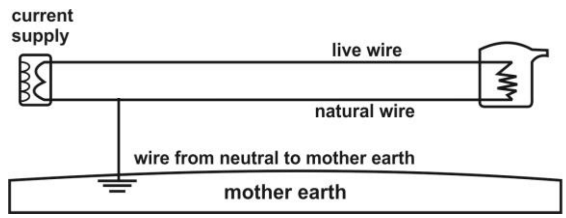


Figure: Function of Earthwire

Q.7 Identify circuit components from the symbols given below: *(K.B)*

(Identifying circuit diagram Pg. # 111)

Ans: **IDENTFYING CIRCUIT COMPONENTS**

Circuit Components			
Wires crossed not joined	or	**Time-varying or AC supply**	or v (t)
Wires crossed at a junction		**Ammeter**	A
Variable resistor	or	**Voltmeter**	V
Fixed resistor	or	**Ohmmeter**	Ω
Diode	Or	**Thermister or temperature dependent resistor**	
Earth or ground		**Switch**	(open) or (closed)
Battery or DC supply	or	**Lamp / Bulb**	
Capacitor	+ or		

14.14 MULTIPLE CHOICE QUESTIONS

1. All electrical appliances are connected in parallel to each other between the main live and neutral wire to get: *(K.B)*

(A) Same current (B) Same current and potential difference
(C) Different currents and potential differences (D) Same potential differences

2. Insulated covered wire is called: *(K.B)*

(A) Extension (B) Cable
(C) Lead (D) None of these

3. **The wire at certain potential is called: *(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

4. **The wire at zero potential is called: *(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

5. **The wire grounded in the earth is called: *(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

6. **A small wire connected in series with the livewire is called: *(K.B)***
(A) Neutral wire (B) Earthwire
(C) Fuse (D) Circuit breaker

7. **Safety device used in place of fuse is: *(A.B)***
(A) Socket (B) Earthwire
(C) Plug (D) Circuit breaker

8. **Circuit breaker works on the principle of: *(K.B)***
(A) Electric current (B) Joule's law
(C) Electromagnetism (D) None of them

9. **An additional wire used in devices having the metallic bodies is: *(K.B)***
(A) Livewire (B) Neutral wire
(C) Earthwire (D) Ground wire

MCQ'S ANSWER KEY (TOPIC WISE)

14.1 ELECTRIC CURRENT

1	2	3	4	5	6	7	8	9	10	11	12
C	C	B	D	B	A	D	A	B	C	B	D
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	
C	C	B	A	B	B	B	A	C	A	C	

14.2 POTENTIAL DIFFERENCE

14.3 ELECTROMOTIVE FORCE (e.m.f)

1	2	3	4	5	6	7	8	9	10	11	12
B	C	A	B	B	A	D	D	D	B	B	C
13	**14**	**15**	**16**								
B	B	A	A								

14.4 OHM'S LAW

1	2	3	4	5	6	7	8	9	10
D	D	D	B	C	D	C	C	D	C

14.5 CHARACTERISTICS OF OHMIC AND NON OHMIC CONDUCTORS

1	2	3	4	5
A	A	B	B	B

14.6 SPECIFIC RESISTANCE (RESISTIVITY)

1	2	3	4	5	6	7	8	9
C	A	B	C	B	D	B	A	D

14.7 CONDUCTORS

14.8 INSULATORS

1	2	3	4	5
B	B	A	C	A

14.9 COMBINATION OF RESISTOR

1	2	3	4	5	6	7	8	9	10	11	12
B	A	C	D	A	C	A	B	C	C	C	B

13
B

14.10 ELECTRICAL ENERGY AND JOULE'S LAW

1	2	3	4
C	B	D	D

14.11 ELECTRIC POWER

1	2	3	4	5	6	7	8	9	10	11
B	C	A	B	B	A	D	C	D	A	C

14.12 DIRECT CURRENT AND ALTERNATING CURRENT

1	2	3	4	5
B	A	C	B	B

14.13 HAZARDS OF ELECTRICITY

1	2	3	4
C	A	B	A

14.14 SAFE USE OF ELECTRICITY IN HOMES

1	2	3	4	5	6	7	8	9
D	B	A	B	C	C	D	C	C

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

Choose the correct answer form the following choices: *(K.B)*

i. An electric current in conductors in due to the flow of:

(a) positive ions (b) negative ions
(c) positive charges (d) free electrons

ii. What is the voltage across a 6 Ω resistor when 3A of current passes through it? *(A.B+U.B)*

(a) 2V (b) 9V
(c) 18V (d) 36V

iii. What happens to the intensity or the brightness of the lamps connected in series as more and more lamps are added? *(K.B)*

(a) increases (b) decreases
(c) remains the same (d) cannot be predicted

iv. Why should household appliances be connected in parallel with the voltage source? *(K.B)*

(a) to increase the resistance of the circuit
(b) to decrease the resistance of the circuit
(c) to provide each appliance the same voltage as the power source
(d) to provide each appliance the same current as the power source

v. Electric potential and e.m.f: *(K.B)*

(a) are the same terms (b) are the different terms
(c) have different units (d) both (b) and (c)

vi. When we double the voltage in a simple electric circuit, we double the: *(K.B)*

(a) current (b) power
(c) resistance (d) both (a) and (b)

vii. If we double both the current and the voltage in a circuit while keeping its resistance constant, the power: *(K.B)*

(a) remains unchanged (b) halves
(c) doubles (d) four times

viii. What is the power rating of a lamp connected to a 12V source when it carries a current of 2.5A? *(U.B+A.B)*

(a) 4.8 W (b) 14.5 W
(c) 30 W (d) 60 W

ix. The combined resistance of two identical resistors, connected in series is 8Ω. Their combined resistance in a parallel arrangement will be: *(U.B+A.B)*

(a) 2Ω (b) 4Ω
(c) 8Ω (d) 12 Ω

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
d	c	b	c	b	a	d	c	a

REVIEW QUESTIONS

14.1 Define and explain the term electric current. ***(K.B)***

Ans: (See Topic 14.1, Long Question-1)

14.2 What is the difference between electronic current and conventional current? ***(K.B)***

Ans: **<u>DIFFERENTIATION</u>**

The differences between electronic current and conventional current are as follows:

Electronic Current	Conventional Current
• The rate of flow of electrons through any cross-sectional area is called electronic current • It flows from negative to positive terminal of the battery	• The rate of flow of positive charges through any cross-sectional area is called conventional current. • It flows from positive to negative terminal of the battery.

14.3 What do we mean by the term e.m.f? Is it really a force? Explain. ***(K.B)***

Ans: (See Topic 14.2 & 14.3, Long Question-2)

14.4 How can we differentiate between e.m.f and potential difference? ***(K.B)***

Ans: (See Topic 14.2 & 14.3, Short Question-5)

14.5 Explain Ohm's law. What are its limitations? ***(K.B+A.B)***

Ans: (See Topic 14.4, Long Question-1)

14.6 Define resistance and its units. ***(K.B+A.B)***

Ans: (See Topic 14.4, Short Question-2)

14.7 What is the difference between conductors and insulators? ***(K.B)***

Ans: (See Topic 14.7, Long Question-1)

14.8 Explain the energy dissipation in a resistance. What is Joule's law? ***(K.B+U.B+A.B)***

Ans: **<u>ENERGY DISSIPATION</u>**

When electric charge move from higher potential to lower potential it delivered electric current, during this process some of the energy is utilized attain the internal resistance of a conductor. In this process some of the energy will lost. This is called, powered dissipation.

(Joule's law is given on Page # 240)

14.9 What is difference between D.C. and A.C? *(K.B)*

Ans: (See Topic 14.12, Short Question-1)

14.10 Discuss the main features of parallel combination of resistors. *(K.B)*

Ans: (See Topic 14.9, Long Question-2)

14.11 Determine the equivalent resistance of series combination of resistors. *(U.B)*

Ans: (See Topic 14.9, Long Question-1)

14.12 Describe briefly the hazards of household electricity? *(K.B)*

Ans: (See Topic 14.13, Long Question-1)

14.13 Describe four safety measures that should be taken in connection with the household circuit. *(K.B)*

Ans: <u>**SAFETY MEASURES**</u>

Following safety measures should be taken in connection with the house hold circuits.

(i) Use fuse and circuit breakers in an electric circuit as safety devices. They prevent circuit overloads that can occur when too many appliances are turned ON at the same time or when a short circuit occurs in one appliance.

(ii) Separate connection is taken from livewire is from each appliance.

(iii) The terminal of the appliance is connected to the livewire through a separate fuse or a circuit breaker and a switch.

(iv) Earthing protects the user from electric shock by connecting the metal casing of the appliance to earth. Many electric appliances have metal cases included cookers, washing machines and refrigerator. The earthwire provides a save route for the current to flow through, if the livewire touches the casing.

14.14 Design a circuit diagram for a study room that needs the following equipment in parallel. *(K.B+U.B)*

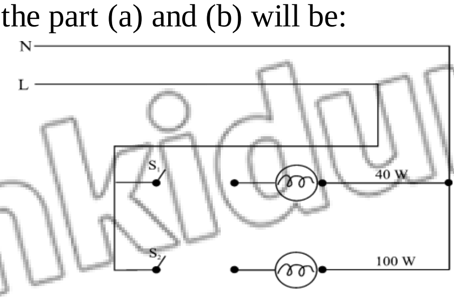
(a) One 100 W lamp operated by one switch.

(b) One reading lamp fitted with a 40 W bulb which can be switched ON and OFF from two points.

(c) What is the advantage of connecting the equipment in parallel instead of in series combination?

Ans: <u>**CIRCUIT DIAGRAM**</u>

The circuit diagram of the part (a) and (b) will be:



(c) <u>**ADVANTAGES OF PARALLEL COMBINATION**</u>

Parallel circuits have two big advantages over series circuits.

- Each device in the circuit receives the full battery voltage.
- Each device in the circuit may be turned off independently without stopping the current flowing to the other devices in the circuit. This principle is used in household wiring.
-

CONCEPTUAL QUESTIONS *(A.B)*

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

Ans: **TRANSFER OF CHARGE**

Heavy positively charged protons in conductors (metals) are bound in the nuclei of atoms. Therefore, they are not free to move inside the conductors. Electrons present at the larger distance form the nuclei of atoms of conductor are loosely bound. These electrons are called free electrons which can move freely inside the conductor and are means of charge transfer in conductors.

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

Ans: (See Topic 14.2 & 14.3, Short Question-6)

14.3 Can current flow in a circuit without potential difference?

Ans: **FLOW OF CURRENTN& POTENTIAL DIFFERENCE**

According to Ohm's law (v = IR), current passing through a conductor is directly proportional to the potential difference across the two ends of the conductor. Hence, when potential difference in a circuit is zero no current will flow through it.

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

Ans: **FLOW OF CHARGE BETWEEN TWO POINTS**

If object is a conductor and its two points are at different electric potentials, the charge will necessarily flow between these points. If objects is an insulator and its two points are at different electric potentials, the charge will not flow between these points.

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

Ans: **CONNECTION OF AMMETER IN A CIRCUIT**

In order to measure current, ammeter is always connected in series with the circuit so that all the current to be measured must flow through it (due to its low resistance). If it is connected in parallel, we cannot measure the actual current flowing through the circuit as some current will flow along the other parallel path.

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

Ans: **CONNECTION OF VOLTMETER IN A CIRCUIT**

In order to measure voltage in a circuit, voltmeter is always connected in parallel with the circuit. In this way, voltmeter does not disturb the current and hence the voltage of the circuit. Due to high resistance of voltmeter, no current passes through it and hence voltage of the circuit remains unaffected.

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

Ans: **CONVERSION OF JOULES INTO WATT-HOUR**

As we know,

$$1 \text{ watt} \times 3600\text{s} = 1 \text{ watt-hour}$$

3600 Ws = 1 watt-hours

3600 Joules = 1 watt-hours

1 joules = $\frac{1}{3600}$ watt-hours

1000 joules = $\frac{1}{3600} \times 1000$ watt-hours

1000 joules = 0.28 watt –hours

Result:

Hence there are 28×10^{-2} watt-hours in 100 joules.

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

Ans: **HEADLAMPS IN SERIES**

Head lamps of automobiles are connected in parallel because of the following reasons

- The potential difference between headlamps remains same. (Both have same brightness)
- If one head-lamp is out of order the other lamps still glow. Also we can turn ON or OFF any individual head lamp independently, which is only possible if they are connected in parallel.

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?

Ans: **FLASH LIGHT**

To get the brighter light and discharge the battery first, we have to use bulbs of resistance 5 ohm, Lower resistance of bulb means, larger current will pass through the filament of the bulb and hence it will flow more brightly as compared to that of 10 Ohm bulb. When larger current passes through the circuit, battery will be discharged quickly.

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

Ans: **IMPRACTICABLE CONNECTION**

When appliances are connected in series, total resistance of circuit increases. This decreases the current and hence the power through each appliance. Also if one appliance stops working due to some fault, other will also not run.

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

Ans: **FUNCTION OF FUSE**

Fuse in a circuit is used to control the current in the circuit. When current exceeds the limited value as allowed by the fuse, it burns out, stops the current and beaks the circuit.

14.12 Why the house wiring is always do in parallel combination?

Ans: For domestic circuits parallel arrangement is always used because. In parallel circuit, each electrical appliance has own switch due to which it can be turn off or on independently, without effecting other appliances. In parallel circuits, each electrical appliance gets same voltage as that of the power supply line. And in parallel combination the combine resistance of circuit is very very low.

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots\dots\dots + \frac{1}{R_n}$$

NUMERICAL PROBLMES *(U.B+A.B)*

14.1 A current of 3mA is flowing through a wire for 1 minute. What is the charge flowing through the wire?

Solution:

Given:

Current=I=3mA

$I=3\times10^{-3}A$

Time=t=1min

t=60s

To Find:

Charge=Q=?

Formula:

$Q=I\times t$

Calculations:

Putting the values from given data into the formula

$Q=3\times10^{-3}A\times60s$

$Q=180\times10^{-3}C$

Result:

Hence, the charge flowing through the wire will be 180×10^{-3}C.

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:

Given:

Resistance of dry body=R_1=100,000Ω

Resistance of wet body=R_2=1000Ω

Voltage=V=12V

To Find:

Current through dry body=I_1=?

Current through wet body=I_2=?

Formula:

I=V/R

Calculations:

Current through dry body:

Putting the values from given data into the formula

I=12V/100,000 Ω

$I=1.2\times10^{-4}A$

Current through wet body:

Putting the values from given data into the formula

I=12V/1000 Ω

$I=1.2\times10^{-2}A$

Result:

Hence, current through dry body is 1.2×10^{-4}A and through wet body will be 1.2×10^{-2}A.

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:

Given:

Resistance of a conductor wire=R=10M Ω

R=10×10^{6} Ω

Voltage=V=100V

To Find:

Current=I=?

Formula:

I=V/R

Calculations:

Putting the values from given data into the formula

$I=100V/10\times10^{6}\ \Omega$

$I=10^{2-1-6}A$

$I=10^{-5}A$

$I=10^{-2}\times10^{-3}A$

I=0.01mA

Result:

Hence, current through the conductor wire will be 0.01mA.

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

Given:

Potential difference=ΔV=10V

Current=I=1.5A

Time=t=2min

t=2×60=120s

To Find:

Energy=E=W=?

Formula:

E=VIt

Calculations:

Putting the values from given data into the formula

E=10V×1.5A×120s

E=1800J

Result:

Hence, 1800J energy would be

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:

Given:

First resistance $=R_1=2k\Omega$

$R_1=2\times10^3\ \Omega$

Second resistance $=R_2=8k\ \Omega$

$R_2=8\times10^3\ \Omega$

Potential difference $=\Delta V=10V$

To Find:

Equivalent resistance $=R_e=?$

Current through first resistance $R_1=I_1=?$

Current through second resistance $R_2=I_2=?$

Potential difference across $R_1=V_1=?$

Potential difference across $R_2=V_2=?$

Formula:

Since resistors are connected in series combination therefore

$R_e=R_1+R_2$…………………(1)

And,

$I_1=I_2=I=V/R_e$………….(2)

$V_1=IR_1$…………………..(3)

$V_2=IR_2$…………………..(3)

Calculations:

Putting the values from given data into the formula (1)

$R_e=2k\Omega+8k\Omega$

$R_e=10k\Omega$

Putting the values from given data into the formula (2)

$I_1=I_2=I=10V/10\times10^3\Omega$

$I_1=I_2=I=1\times10^{-3}A$

$I_1=I_2=I=1mA$

Putting the values from given data into the formula (3)

$V_1=1\times10^{-3}A\times2\times10^3\ \Omega$

$V_1=2V$

Putting the values from given data into the formula (4)

$V_2=1\times10^{-3}A\times8\times10^3\ \Omega$

$V_2=8V$

Result:

Hence,
Equivalent resistance $=R_e=10k\Omega$
Current through first resistance $R_1=I_1=1mA$
Current through second resistance $R_2=I_2=1mA$
Potential difference across $R_1=V_1=2V$
Potential difference across $R_2=V_2=8V$

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:

Given:

First resistance=R_1=6kΩ

$R_1=6\times10^3\ \Omega$

Second resistance=R_2=12k Ω

$R_2=12\times10^3\ \Omega$

Potential difference=ΔV=6V

To Find:

Equivalent resistance=R_e=?

Current through first resistance $R_1=I_1$=?

Current through second resistance $R_2=I_2$=?

Potential difference across $R_1=V_1$=?

Potential difference across $R_2=V_2$=?

Formula:

Since resistors are connected in parallel combination therefore

$1/R_e=1/R_1+1/R_2$……………….(1)

And,

$V_1=V_2=V$………….(2)

$I_1=V/R_1$…………………..(3)

$I_2=V/R_2$…………………..(4)

Calculations:

Putting the values from given data into the formula (1)

$1/R_e=1/6k\Omega+1/12k\Omega$

$1/R_e=(2+1)/\ 12k\Omega$

$1/R_e=3/\ 12k\Omega$

$1/R_e=1/\ 4k\Omega$

$R_e=4k\Omega$

Putting the values from given data into the formula (2)

$V_1=V_2=6V$

Putting the values from given data into the formula (3)

$I_1 = 6V/(6\times10^3\ \Omega)$

$I_1 = 1\times10^{-3}$ A

$I_1 = 1mA$

Putting the values from given data into the formula (4)

$I_2 = 6V/(12\times10^3\ \Omega)$

$I_2 = 0.5mA$

Result:

Hence,

Equivalent resistance=R_e=4kΩ

Current through first resistance R_1=I_1=1mA

Current through second resistance R_2=I_2=0.5mA

Potential difference across R_1=V_1=6V

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

Given:

Voltage=V=220V
Power=P=100W
Time=t=5 hours
No. of days=30 days

To Find:

Resistance of the bulb=R=?
Energy in kWh=E=?

Formula:

$P=V^2/R$…………………(1)
Energy (kWh)=Power(watt)×time(hours)×days/1000…………(2)

Calculations:

Putting the values from given data into the formula (1)
$100=220^2/R$
$R=220^2/100$
R=484Ω
Putting the values from given data into the formula (2)
Energy=100×5×30/1000
Energy=15kWh

Result:

Hence, resistance of the bulb is 484Ω and energy consumed in 30 days will be 15kWh.

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:

Given:

Resistance of the bulb=R=95 Ω

Power of the bulb=P=150W

To Find:

Is it designed for 120V or 220V=?

Formula:

$P=V^2/R$

Or

$V^2=P\times R$

Calculations:

Putting the values from given data into the formula

$V^2=150\times 95$

$V^2=1450$

Taking square root on both sides

V=120V

Result:

Hence, the bulb is designed 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:

Given:

Power of each bulb=60W

No. of bulbs=10

Total power of bulbs=P_1=10×60

P_1=600W

Time for bulbs= t_1=5 hours daily

Power of each fan=75W

No. of fans=4

Total power of bulbs=P_2=4×75

P_2=300W

Time for fans=t_2=10 hours daily

Power of each T.V. =100W

No. of T.V.=1

Total power of T.V.=P_3=1×100

P_3=100W

Time for T.V.=t_3=5 hours daily

Power of each electric iron =1000W

No. of electric iron =1

Total power of electric iron =P_4=1×1000

P_4=1000W

Time for electric iron =t_4=2 hours daily

Cost of one unit of electricity=Rs.4 per unit

No. of days=30 days

To Find:

Expenditure of electricity=?

Formula:

Units (kWh)= Power(watts)×time(hours)×days/1000…………..(1)

Cost of electricity=units ×cost per unit………………………..(2)

Calculations:

Putting the values from given data into the formula (1)
Units consumed by bulbs= 600×5×30/1000
Units consumed by bulbs=90 units
Units consumed by fans= 300×10×30/1000
Units consumed by fans=90 units
Units consumed by T.V.= 100×5×30/1000
Units consumed by T.V.=15 units
Units consumed by electric iron= 1000×2×30/1000
Units consumed by electric iron=60 units
Total units consumed in 30 days= 90+90+15+60
Total units consumed in 30 days=255 units
Putting the values from given data into the formula (2)
Cost of electricity=255 ×4
Cost of electricity=Rs.1020

Result:

Hence, cost of electricity will be Rs.1020.

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:

Given:

Power of a lamp=P_1=100W

Power of a water heater=P_2=4kW

P_2=4000W

Voltage=V=250V

To Find:

Current through a lamp=I_1=?

Current through a water heater=I_2=?

Resistance across a lamp=R_1=?

Resistance across a water heater=R_2=?

Formula:

I=P/V…………………(1)

R=V/I…………………(2)

Calculations:

For lamp:

Putting the values from given data into the formula (1) and (2) respectively

I=100/250

I=0.4A

And,

R=250/0.4

R=625 Ω

For water heater:

Putting the values from given data into the formula (1) and (2) respectively

I=4000/250

I=16A

And,

R=250/16

R=15.625 Ω

Result:

Hence, cost of electricity will be Rs.1020.

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.

(C) Give the reason of difference between these two quantities.

Solution:

Given:

Resistance=R=5.6 Ω

Voltage=V=3.0V

Current=I=0.5A

To Find:

Power dissipated in the resistor=P_1=?

Power produced by the battery=P_2=?

Formula:

$P_1=I^2R$………………(1)

$P_2=VI$……………….(2)

Calculations:

Putting the values from given data into the formula (1)

$P_1=0.5^2\times5.6$

$P_1=1.4W$

Putting the values from given data into the formula (2)

$P_2=3\times0.5$

$P_2=1.5$ W

Result:

Hence, total power produced by the battery will be 1.5W while power dissipation by the resistor is 1.4W. There is a difference of 0.1W because some power will be lost by the internal resistance of the battery.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. What is the power rating of a lamp connected to 12 V source when it carries 2.5 A?
(A) 60 W (B) 30 W
(C) 14.5 W (D) None of these

2. The resistance of dry human skin is (Ω):
(A) 1000 (B) 10000
(C) 100000 (D) None of these

3. The color code of neutral wire is:
(A) Black (B) Red
(C) Blue (D) Both (B) and (D)

4. Specific resistance of copper is ($\times 10^{-8}$ Ω m) :
(A) 1.69 (B) 1.54
(C) 2.73 (D) None of these

5. The combined resistance of two identical resistors, connected in series is 16 Ω. Their combined resistance in a parallel arrangement will be:
(A) 2 Ω (B) 4 Ω
(C) 8 Ω (D) None of these

6. Example of ohmic conductors is:
(A) Thermistor (B) Plastic
(C) Wood (D) None of these

Q.2 Give short answers to following questions. **(5×2=10)**

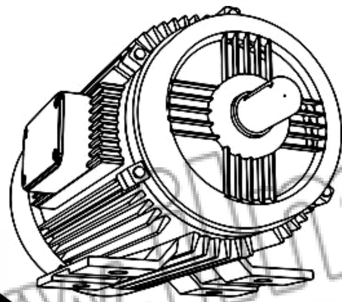
i. Why in conductors charge is transferred by free electrons, rather than by positive charges?
ii. What do you mean by conventional current?
iii. Define unit of resistance.
iv. What are the advantages of parallel combination?
v. Differentiate between A.C and D.C.

Q.3 Answer the following questions in detail. **(4+5=9)**

a) Define and explain the term specific resistance. Discuss different factors which affect the resistance of conductors.
b) An incandescent light bulb with an operating resistance of 95 Ω is labelled "150 W". Is the bulb designed for use in a 120 V or 220 V circuit?

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.



UNIT 15

ELECTROMAGNETISM

15.1 MAGNETIC EFFECTS OF A STEADY CURRENT
15.2 FORCE ON A CURRENT – CARRYING CONDUCTOR PLACED IN MAGNETIC FIELD

LONG QUESTIONS

Q.1 Demonstrate by an experiment that a magnetic field is produced around a straight current carrying conductor also state the rule by which direction of the lines of force of magnetic field around a current carrying conductor can be determined? Also described clockwise and anticlockwise direction of magnetic field. ***(K.B+U.B+A.B)*** **(FSD 2016), (Review Ex. 15.1)**

Ans: **MAGNETIC EFFECTS OF A STEADY CURRENT**

Introduction:

Ampere discovered that when a current passes through a conductor it produces magnetic field around it.

Experiment:

To demonstrate this, we take straight, conductor wire and pass it vertically through a cardboard. Now connect the two ends of the conductor wire with the terminals of the battery so that current flows through the circuit in the clock wise direction. The lines of force of the magnetic field produced around the wire would be in the form of concentric circles. If we place compass needle at different points in the region of magnetic field, it will align along the direction of magnetic field. Also if we sprinkle some iron filings on the cardboard around the wire, they will align themselves in concentric circles in the clockwise direction.

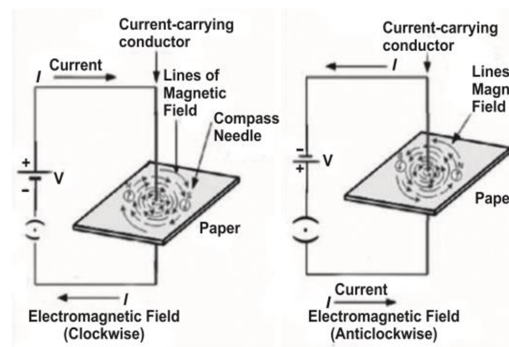


Figure: Electromagnetic Field (Clockwise) & (Anticlockwise)

If we reverse the direction of the current by reversing the terminals of the battery, the compass needle also reverses its direction. Now the magnetic field lines will align in the anticlockwise direction. The magnetic field produced is stronger near the current–carrying conductor and weaker farther away from it.

Direction of Magnetic Field:

The direction of the magnetic field is governed by the direction of the current flowing through the conductor. A simple method of finding the direction of magnetic field around the conductor is the Right Hand Grip Rule.

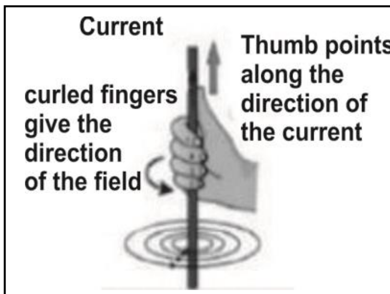


Figure: Right Hand Grip Rule

Right Hand Grip Rule:

"Grasp a wire with your right hand such that, your thumb is pointed in the direction of the (positive) current. Then curling fingers of your hand will point in the direction of the magnetic field**"**.

Q.2 What is solenoid? Explain magnetic field produced in current carrying solenoid. ***(K.B+U.B)***

OR

Explain magnetic field produced solenoid in resents to bar magnet. **(FSD 2016)**

Ans: **SOLENOID**

Definition:

"A long coil of wire consisting of many loops is called a solenoid".

MAGNETIC FIELD OF A SOLENOID

The field from each loop in a solenoid adds to the fields of the other loops and creates greater total field strength. Electric current in the solenoid of wire produces magnetic field which is similar to the magnetic field of a permanent bar magnet. When this current – carrying solenoid is brought close to a suspended bar magnet, one end of the solenoid repels the north pole of the bar magnet. Thus, the current – carrying solenoid has a north and a south pole and use itself a magnet.

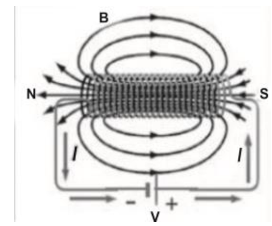


Figure: **Magnetic Field due to a solennoid**

Electromagnet:

"The type of temporary magnet, which is created when current flows through a coil, is called an electromagnet".

Direction of the Magnetic Field:

The direction of the field produced by a coil due to the flow of conventional current can be found with the help of right hand grip rule.

Right Hand Grip Rule:

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 of the coil.

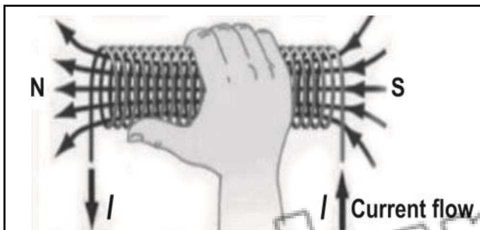


Figure: **Right Hand Grip Rule for a Coil**

Q.3 Explain When a straight current-carrying conductor is placed in a magnetic field, it experiences a force. State the rule by which the direction of this force can be found out. ***(K.B+U.B+A.B)***

Force on a current-carrying conductor placed in a magnetic field:

Ans: **FORCE ON A CURRENT – CARRYING CONDUCTOR**

Electric current produces a magnetic field similar to that of a permanent magnet. Since a magnetic field exerts a force on a permanent magnet, it implies that current-carrying wire should also experience a force when placed in a magnetic field.

Explanation:

The force on a wire in a magnetic field can be demonstrated using the arrangement. A battery produces current in a wire placed inside the magnetic field of a permanent magnet. Current-carrying wire produces its own magnetic field which interacts with the field of the magnet. As a result a force is exerted on the wire. Depending on the direction of the current, the force on the wire either pushes or pulls it towards right or toward left.

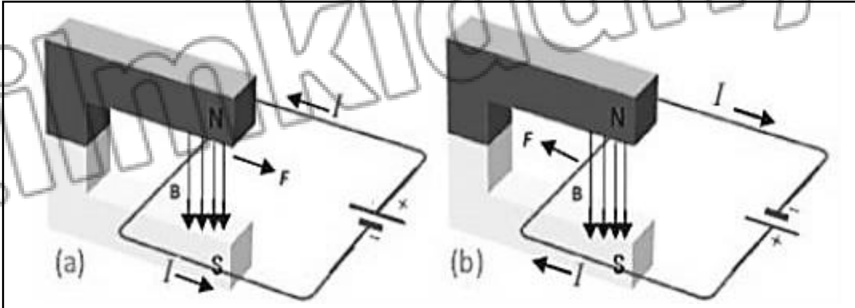


Figure: **Force on a Current-Carrying Wire in Magnetic Field**

Michael Faraday discovered that the force on the wire is at right angles to both the direction of the magnetic field and the direction of the current.

Factor Affecting the Force:

The force is increased if

- The current in the wire is increased
- Strength of magnetic field is increased
- The length of the wire inside the magnetic field is increased

Determining the Direction of Force:

Faraday's description of the force on a current-carrying wire does wire does not completely specify the direction of force because the force can be towards left or towards right. The direction of the force on a current – carrying wire in a magnetic field can be found by using Fleming's left hand rule started as:

Fleming's 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**"**.

The force acting on the conductor is at right angle to both the direction of current and magnetic field according to flaming left hand rule.

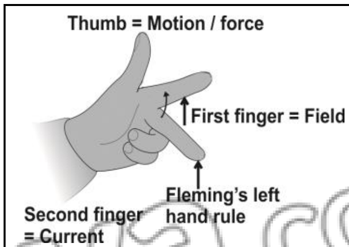


Figure: **Fleming's Left Hand Rule**

15.1, 15.2 SHORT QUESTIONS

Q.1 How magnetic lines of force are formed in the straight current carrying conductor? *(K.B)*

Ans: **FORMATION OF MAGNETIC LINES**

When current passes through a conductor, a magnetic field is produced around it. If the conductor is a straight wire, the lines of force of this magnetic field would be in the form of concentric circles. These lines of force can be traced on a piece of cardboard with the help of a compass needle. It will align along the direction of magnetic field.

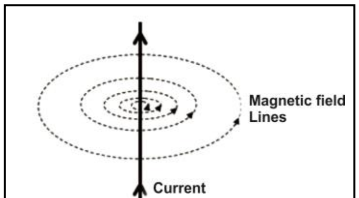


Figure: **Direction of Magnetic Field Lines**

Q.2 What is Right Hand Grip Rule? ***(K.B)***

OR State and explain the rule by which the direction of the lines of force of the magnetic field around a current-carrying conductor can be determined.

(LHR 2015, 2016, FSD 2016, 17, SGD 2016, DGK 2016), (Review Ex. 15.2)

Ans: *Given on Page # 274*

Q.3 Write down the rules to find the polarity of solenoid. ***(K.B)*** **(RWP 2016)**

Ans: *Given on Page # 275*

Q.4 State Fleming's Left Hand Rule. ***(K.B)***

OR You are given an unmarked magnetized steel bar and bar magnet, its north and south ends are marked N and S respectively. State how you would determine the polarity at each end of the unmarked bar?

(GRW 2015, FSD 2016, 2017, SGD 2016, MTN 2016) , (Review Ex. 15.4)

Ans: *Given on Page # 276*

Q.5 When the force on the current carrying conductor in a magnetic field is maximum and when it is minimum? ***(K.B)***

Ans:

MAGNITUDE OF FORCE

When the current carrying conductor makes an angle of 90^0 with the magnetic field or it is perpendicular to the field, force on it is maximum. If the conductor is placed along or parallel to the magnetic field, no force acts on the conductor.

Q.6 What is difference between magnetism and electricity? ***(K.B)***

(Interesting information Pg. # 119)

DIFFERENTIATION

Ans: Following are the differences between Magnetism and Electricity.

Electricity	Magnetism
Separation	
• Electric charges can be separated into a single type.	• Magnetic poles cannot be separated.
Example	
• We have a single negative charge or a single positive charge.	• It is not possible to have a magnetic north pole without a magnetic south pole.

Q.7 What is MRI? ***(A.B)*** **(Interesting information Pg. # 119)**

Ans:

MRI

Weak ionic current in our body that travels along the nerves can produce the magnetic effect. This forms the basis of obtaining images of different parts of body. This is done using the technique called Magnetic Resonance Imaging (MRI). Heart and brain are two main organs where significant magnetic fields can be produced. Using MRI doctors can diagnose the disorders of brain and heart etc.

Q.8 What is an electromagnet? ***(K.B)*** **(LHR 2017, GRW 2016, 2017, RWP 2016, MTN 2016)**

Ans:

ELECTROMAGNET

"The type of temporary magnet, which is created when current flows through the coil, is called an electromagnet**"**.

CONSTRUCTION

- Solenoid
- Iron core
- Battery

Q.9 What is meant by electromagnetism and write its applications? *(K.B+A.B)*

Ans: **ELECTROMAGNETISM**

"Electromagnetism is the study of magnetic effects of current".

Ans: **APPLICATIONS**

The practical applications of electromagnetism are:

- Motors and electric meters are based on the effect or magnetism produced by the electric current in wires.
- Generators produce electric current due to the movement of wires near very large magnets.

Q.10 What is Solenoid? *(K.B)* **(FSD 2017)**

Ans: *Given on Page # 275*

Q.11 What was the discovery of Ampere? *(K.B)*

Ans: **DISCOVERY OF AMPERE**

Ampere discovered that when a current passes through a conductor it produces magnetic field around it.

Q.12 Illustrate diagrammatically the similarity between magnetic field of a bar magnet and that of a coil. *(K.B)* **(For your information Pg. # 121)**

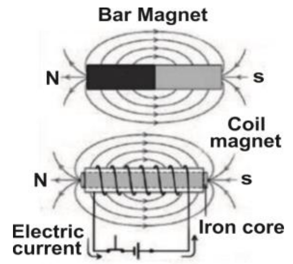


Figure: **Magnetic Field due to a solennoid**

Ans:

Q.13 What are the factors which increase force on a current carrying conductor? *(K.B)*

Ans: **FORCE ON A CURRENT CARRYING**

The force is increased if:

- The current in the wire is increased
- Strength of magnetic field is increased
- The length of the wire inside the magnetic field is increased.

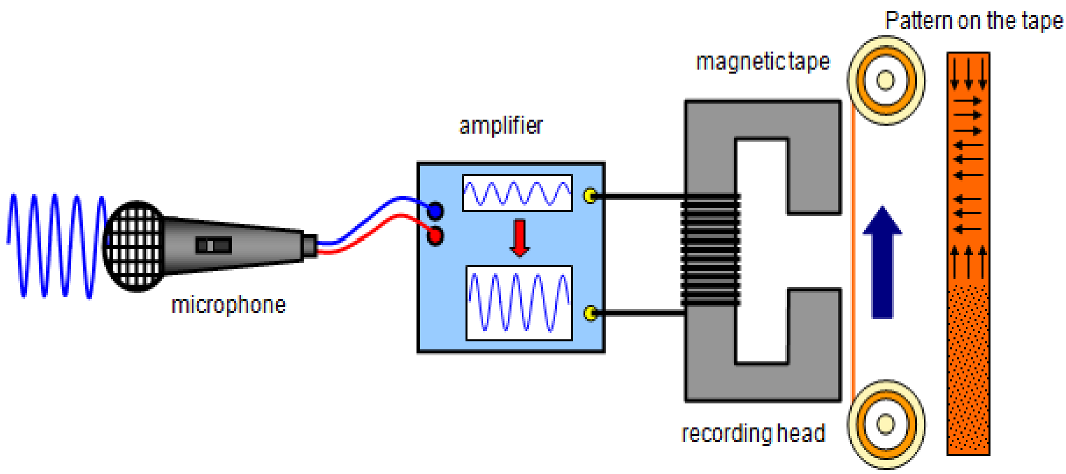
Q.14 What is difference between hard magnetic material and soft magnetic material?

Ans: **DIFFERENTIATION**

Hard Magnetic Material	Soft Magnetic Material
• A hard magnetic material (for example, steel) is one which, when magnetized, does not readily lose its magnetism.	• A soft magnetic material (for example, iron) quickly loses its magnetism when the magnetizing field is removed.

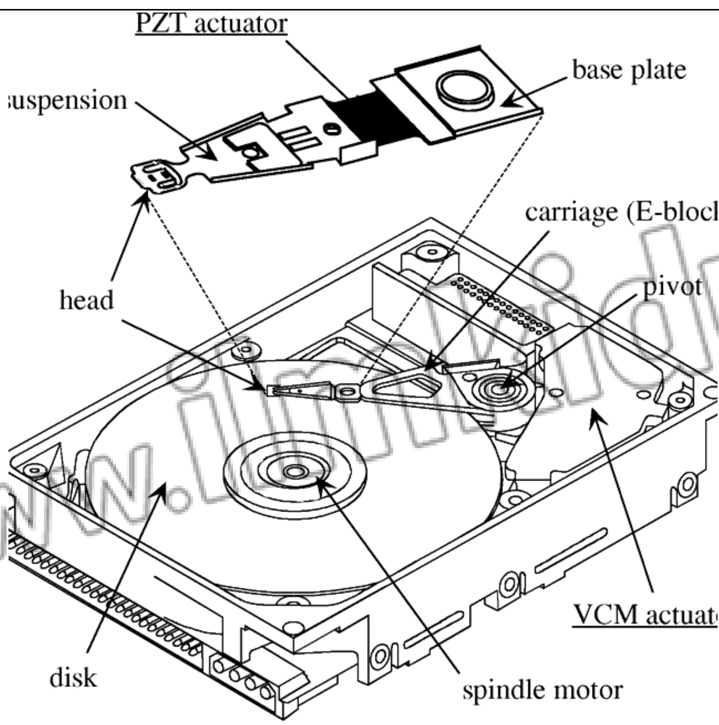
Q.15 What is magnetic storage?

Ans: TV studios use magnetic tape, in cassettes, for recording pictures and sounds. The tape consists of a long, thin plastic strip, coated with a layer of iron oxide or similar material. Magnetically, iron oxide is between soft and hard. Once magnetized it keeps its magnetism, but is relatively easy to demagnetize, ready for another recording. The diagram below shows a simple system for recording sound on tape. The hard drive in a computer also stores data as a pattern of varying magnetism. In both examples, an electromagnet creates the varying magnetic field need for recording. Later, a play back head can read the pattern to give a varying current.



<u>Recording on Magnetic Tape:</u>

The incoming sound waves are used to vary the current in a tiny electromagnet in the recording head. As the tape moves past the head, a track of varying magnetism is created along the tape.



<u>Computer hard drive:</u>

The recording head is at the end of the arm. It contains a tiny electromagnet which is used to create tracks of varying magnetism on a spinning disc. The disc is made of aluminium or glass, and is coated with a layer of magnetic material similar to that on a tape.

Q.16 How to make a magnet and demagnetize a magnet?

Ans: **DIFFERENTIATION**

Making a Magnet	Demagnetizing a magnet
• A steel bar has been placed in a solenoid. When a current is passed through the solenoid, the steel becomes magnetized and makes the magnetic field much stronger than before. And when the current is switched off, the steel stays magnetized. Nearly all permanent magnets are made in this way.	• A magnet is slowly being pulled out of a solenoid through which an alternating current is passing. Alternating current (a.c) flows backwards, forwards, backwards, forwards…. And so on. It produces a magnetic field which changes direction very rapidly and throws the atoms in the magnet out of line.

Q.17 What is difference between permanent magnetic field and electromagnetic field?

Ans: **DIFFERENTIATION**

Permanent Magnetism	Electromagnetism
• Magnetism is permanent unless it damaged. • Magnetism is weaker as compared to electromagnetism. • Its strength cannot be changed.	• Magnetism is temporary and can be switched on or off. • Magnetism is much stronger as compared to permanent magnetism. • Its strength can be changed. • Electromagnetism is more beneficial in our daily life.

15.1, 15.2 MULTIPLE CHOICE QUESTIONS

1. **____________ is a study of magnetic effects of current:** ***(K.B)***
   (A) Electrostatics (B) Electricity
   (C) Electromagnetism (D) Electronics
2. **Who discovered that when current passes through a conductor it produces a magnetic field around it:** ***(K.B)***
   (A) Lenz (B) Coulomb
   (C) Ampere (D) Faraday
3. **When current passes through straight conductor it produce magnetic field in the form of:** ***(K.B)***
   (A) Straight line (B) Concentric circles
   (C) Rectangular form (D) Parabolic shape
4. **The magnetic field produced in straight current carrying conductor is stronger:** ***(K.B)***
   (A) Near pole (B) Near current carrying conductor
   (C) Away from current carrying conductor (D) None of these
5. **The magnetic field produced in straight current carrying conductor is weaker:** ***(K.B)***
   (A) Near pole (B) Near current carrying conductor
   (C) Away from current carrying conductor (D) None of these
6. **Weak ionic current that travel along the nerve can produce the __________.** ***(K.B)***
   (A) Electric effect (B) Magnetic effect
   (C) Electric and Magnetic field (D) All of these

7. MRI stands for: *(K.B)*
(A) Magnetic resonance imagining (B) Magnetic resistance and current
(C) Magnetic resistance imaginary (D) None of these

8. The magnetic lines of force can be traced on cardboard by using: *(K.B)*
(A) Cardboard (B) Compass Needle
(C) Paper (D) Magnet

9. Shape of magnetic lines of force in straight conductor are: *(K.B)*
(A) Straight (B) Elliptical
(C) Circular (D) All of them

10. Direction of magnetic lines of force in straight conductor is found by: *(K.B)*
(A) Right hand rule (B) Left hand rule
(C) Both a & b (D) None of them

11. If the current is flowing from bottom to top then the direction of magnetic lines of force will be: *(K.B)*
(A) Anti-Clockwise (B) Clockwise
(C) Straight (D) None of them

12. If the current is flowing from top to bottom then the direction of magnetic lines of force will be: *(K.B)*
(A) Anti-Clockwise (B) Clockwise
(C) Straight (D) None of them

13. Magnetic field in most part of the coil is: *(K.B)*
(A) Circular (B) Straight
(C) Uniform (D) Non-Uniform

14. A closely wound cylindrical coil of insulated wire is: *(K.B)*
(A) Cylindrical coil (B) Solenoid
(C) Cable (D) All of them

15. Magnetic lines of force in solenoid are: *(K.B)*
(A) Circular (B) Parallel
(C) Non-Uniform (D) Uniform

16. Lines of force in solenoid resemble the pattern of lines of force due to: *(K.B)*
(A) Electromagnet (B) Horseshoe magnet
(C) Bar magnet (D) All of them

17. The polarity of current carrying solenoid is found by: *(K.B)*
(A) Right Hand Rule (B) Left Hand Rule
(C) Both a & b (D) None of them

18. Hold down the end of the current carrying solenoid in front of you, if the direction of current flow through this end is anti-clock wise it would be: *(K.B)*
(A) North Pole (B) South Pole
(C) Any of them (D) None of them

19. Hold down the end of the current carrying solenoid in front of you, if the direction of current flow through this end is clockwise it would be: *(K.B)*
(A) North Pole (B) South Pole
(C) Any of them (D) None of them

20. Who discovered left hand rule? *(K.B)*
(A) Einstein (B) Simon
(C) Fleming (D) Faraday

15.3 TURNING EFFECT ON CURRENT CARRYING COIL IN MAGNETIC FIELD
15.4 D.C MOTOR

LONG QUESTIONS

Q.1 State that a current carrying coil in a magnetic field experiences a torque.
(K.B+U.B+A.B)
(MTN 2016, DGK 2016) (Review Ex. 15.5)

Ans: **CURRENT – CARRYING COIL IN A MAGNETIC FIELD**

If instead of a straight conductor, we place a current, carrying loops inside the magnetic field, the loop will rotate due to the torque acting on the coil. This is also the working principle of electric motors.

Explanation:

Consider a rectangular coil of wire with sides PQ and RS, lying perpendicular to the field, placed between the two poles of a permanent magnet.

Now if the ends of the coil are connected with the positive and negative terminals of a battery, a current would start flowing through the coil. The current passing through the loop enters from one end of the loop and leaves from the other end.

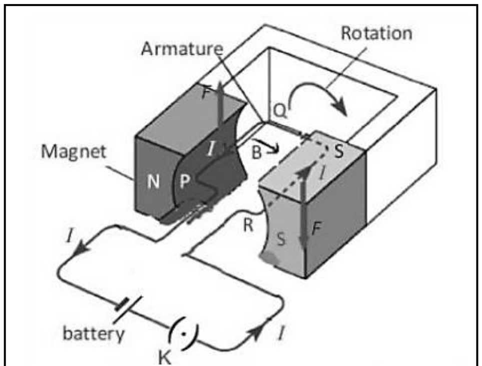


Figure: A Current- Carrying Coil in a Magnetic Field

Now apply Fleming's left hand rule to each side of the coil. We can see the PQ side of the loop force acts upward, while on the RS side of the loop force acts downward. It is because the direction of the current through the two sides of the loop facing the two poles is at right angles to the field but opposite to each other. The two forces which are equal in magnitude but opposite in direction form a couple. The resulting torque due to this couple rotates the loop, and the magnitude of the torque acting on the loop is proportional to the magnitude of the current passing through the loop. If we increase the number of loops, the turning effect is also increased. This is the working principle of electric motors.

Q.2 What is electric motor? Explain its construction and working principle.
(K.B+A.B+U.B)
(LHR 2016, DGK 2016, BHP 2016) (Review Ex. 15.6)

Ans: **ELECTRIC MOTOR**

"It is an electrical apparatus (device) that converts electrical energy into rotational kinetic energy".

Working Principle:

When a current-carrying coil is placed in magnetic field, it experiences a couple due to which the coil begins to rotate. A D.C motor operates on this principle.

Construction of D.C Motor:

D.C motor consists of a rectangular coil PQSR mounted on a shaft or axle. Coil is placed in a field of permanent magnet or in a field which is produced by an electromagnet, called a field coil. There are two carbon brushes which are usually pieces of graphite, these brushes are made the contact with copper ring. This ring is split into two halves, called a split ring commentators.

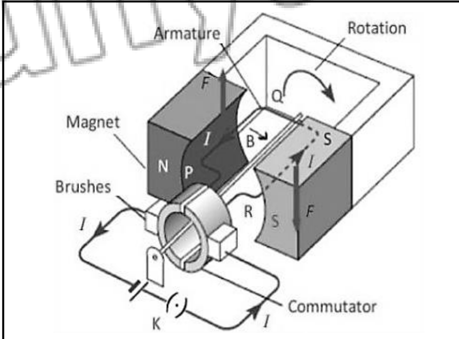


Figure: Working Principle of D.C Motor

Working of D.C Motor:

When the coil of the motor is connected to the battery, the current starts flowing through it. The simple coil placed in a magnet cannot rotate more than 90^o. The forces push the PQ side of the coil up and the RS side of the loop down until the loop reaches the vertical position. In this situation, plane of the loop is perpendicular to the magnetic field and the net force on the coil is zero. So the loop will not continue to turn because of the forces are still up and down and hence balanced.

Function of Commutator:

The coil can be rotate continuously by reversing the direction of the current just as the coil reaches its vertical position. This reversal of current will allow the coil to rotate continuously. To reverse direction of current, the connection to coil is made through an arrangement of brushes and a ring that is split into two halves, called a split ring commutator. Brushes, which are usually pieces of graphite, make contact with the commutator and allow current to flow into the loop. As the loop rotates, so does the commutator. The split ring is arranged so that each half of the commutator changes brushes just as the coil reaches the vertical position. Changing brushes reverse the current in the loop.

As a result, the direction of the force on each side of the coil is reversed and it continues to rotate. This process repeats at each half-turn, causing coil to rotate in the magnetic field continuously. The result is an electric motor, which is a device that converts electric energy into rotational kinetic energy.

In a practical electric motor the coil, called a armature, is made of many loops mounted on a shaft or axle. The magnetic field is produced either by permanent magnets or by an electromagnet, called a field coil. The torque on the armature, and as a result, the speed of the motor, is controlled by varying the current through the motor.

Factors Increasing Force on Armature:

The total force acting on the armature can be increased by:

- Increasing the number of turns on the coil
- Increasing the current in the coil
- Increasing the strength of the magnetic field
- Increasing the area of the coil

15.3, 15.4 SHORT QUESTIONS

Q.1 Which device converts electrical energy into mechanical energy and what is its working principle? *(K.B)* **(2017 LHR)**

OR What is D.C. Motor? *(K.B)*

OR Define Electric Motor. *(K.B)* **(RWP 2016)**

Ans: ***Given on Page # 282***

Q.2 How can we make the coil of D.C motor rotate continuously? *(K.B)*

Ans: **CONTINUOUS ROTATION OF COIL**

The coil can be rotate continuously by reversing the direction of the current just as the coil reaches its vertical position. This reversal of current will allow the coil to rotate continuously. To reverse direction of current, the connection to coil is made through an arrangement of brushes and a ring that is split into two halves, called a split ring commutator. Brushes, which are usually pieces of graphite, make contact with the commutator and allow current to flow into the loop. As the loop rotates, so does the commutator. The split ring is arranged so that each half of the commutator changes brushes just as the coil reaches the vertical position. Changing brushes reverse the current in the loop. As a result, the direction of the force on each side of the coil is reversed and it continues to rotate.

Q.3 What is the function of split rings in D.C. motor? *(K.B+A.B+U.B)* **(RWP 2017)**

Ans: **FUNCTION OF SPLIT RINGS**

The functions of split rings in D.C. motor are as follows:

- Split rings connect the coil to the battery through carbon brushes.
- When coil rotates between the pole pieces of a magnet, split rings keep the current in the same direction in the rotating coil.
- Split rings change the direction of current in the sides of coil after every half cycle, so the direction of force is changed after every half cycle.

Q.4 How the total force acting on the armature can be increased? *(K.B)*

Ans: ***Given on Page # 283***

Q.5 What is the function of carbon brushes in D.C. motor? *(K.B+A.B)*

Ans: **FUNCTION OF CARBON BRUSHES IN D.C. MOTOR**

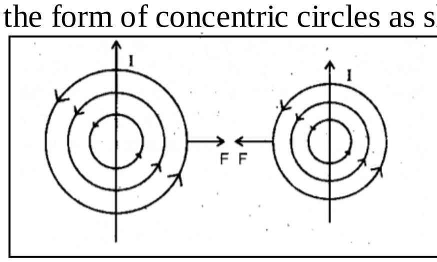
The function of carbon brushes in D.C. motor are:

Two carbon brushes are used to press slightly against the split rings by means of springs and give continuous passage of current to the coil.

Q.6 Suppose the direction of current passing through two straight wires is same. Draw the pattern of magnetic field of current due to each wire. Would the wires attract or repel each other? *(K.B)* **(Activity Page 123)**

Ans:

When current flows through wires in the upward direction, the magnetic field lines around each wire are in the form of concentric circles as shown in figure.



The magnetic field lines of two wires cancel the effect of each the in the space between them. Hence, the two wires attract each other due to weak magnetic field between them and the stronger magnetic field on the other sides of the wires.

Q.7 How ATM card works? *(U.B)* **(Do you know Pg. # 124)**

Ans: **WORKING OF ATM CARDS**

Bank credit card have a magnet strips engraved on them. On this strip account information of the user are stored which are read by the ATM machine.

Q.8 What is connection of magnetic and electric field lines? *(U.B)* **(Connection Pg. # 125)**

Ans: **MAGNETIC AND ELECTRIC FIELD LINES**

Magnetic field lines help us to visualize the magnitude and direction of the magnetic field vectors, just as electric field lines do for the magnitude and direction of E.

15.3, 15.4 MULTIPLE CHOICE QUESTIONS

1. Force on current carrying conductor in a magnetic field is found by: *(K.B)*

(A) Right Hand Rule (B) Left Hand Rule
(C) Both a & b (D) None of them

2. A device which is used to convert electrical energy into rotational kinetic energy: *(K.B)*

(A) Transformer (B) A.C Generator
(C) D.C Motor (D) All of them

3. Which part of DC motor reverses the direction of current through coil every half cycle? *(K.B)* **(SGD-G2),(RWP-G2)-2017**

(A) Armature (B) Commutator
(C) Brushes (D) Split rings

4. In D.C motor coil can rotate in magnetic field by an angle of: *(K.B)* **(DGK-G1)-2017**

(A) 30° (B) 45°
(C) 60° (D) 90°

5. Which device is based on the principle of electromagnetism? *(K.B)*

(A) Mechanical energy into electrical energy (B) Mechanical energy into chemical energy
(C) Electrical energy into mechanical energy (D) Electrical energy into chemical energy

15.5 ELECTROMAGNETIC INDUCTION,
15.6 DIRECTION OF INDUCED E.M.F – LENZ'S LAW
15.7 A.C GENERATOR

LONG QUESTIONS

Q.1 Describe by an experiment to demonstrate that changing magnetic field can induced e.m.f in a circuit? *(K.B, U.B, A.B)* **(Review Ex. 15.7)**

OR What is electromagnetic induction? Explain with experiment that a changing magnetic field can induce an e.m.f in circuit?

Ans: **ELECTROMAGNETIC INDUCTION**

"The process of generating an induce current in a circuit by changing the number of magnetic lines of force passing through it is called electromagnetic induction".

Explanation:

Hans Christian Oersted and Ampere discovered that an electric current through a conductor produces a magnetic field around it. Michael Faraday thought that the reverse must also be true; that a magnetic field must produce an electric current. Faraday found that he could induced electric current by moving the wire through the magnetic field. In the same year Joseph Henry also showed that a changing magnetic field could produce electric current.

Strength of Magnetic Field:

The number of magnetic lines of force passing through any surface is known as strength of magnetic field.

How e.m.f. is Induce in the Coil?

Strength of the magnetic field is maximum when the surface is held perpendicular to the magnetic lines of force.

Strength of the field is minimum when surface is held parallel to the magnetic lines of force.

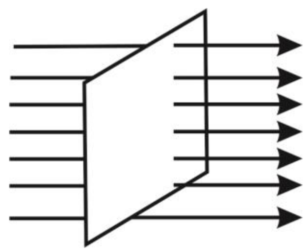


Figure: Maximum Strength of Magnetic Field

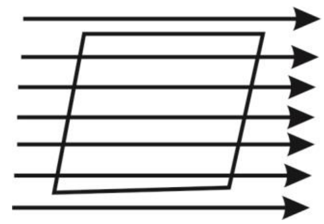


Figure: Minimum Strength of Magnetic Field

Magnetic Field of a Bar Magnet through Coil:

In case of a bar magnet the lines of force are emerging from North Pole of a magnet. If we place a coil in the magnetic field of a bar magnet, some of the magnetic lines of force will pass through it.

When the Coil is Far Away from the Magnet:

If the coil is far away from the magnet, only a few lines of force will pass through the coil.

When the Coil is Closed to the Magnet:

If the coil is close to the magnet, a large number of lines of force will pass through it, in this way we can change the number of magnetic lines of force through a coil by moving it in the magnetic field. This change in the number of magnetic field lines will induce and e.m.f in the coil.

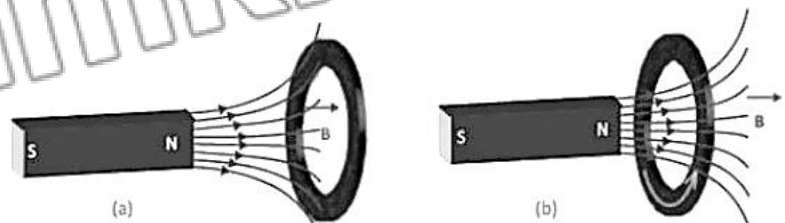


Figure: Variation of Magnetic Field Lines of Force through a Coil Placed at Different Distances From the Magnet

Note: This is the basic principle of production of electricity and working of A.C generator.

Experiment:

Take a rectangular loop of wire and connect its two ends with a galvanometer. Now hold the wire stationary or move it parallel to the magnetic field of a strong U-shaped magnet. Galvanometer shows no deflection and hence there is no current. Now move the wire downward through the field, current is induced in one direction as shown by the deflection of the galvanometer. Now move the wire upward though the field, current is induced in the opposite direction.

It implies that an electric current is generated in a wire only when the wire cuts magnetic field lines. This induced current is generated by induced e.m.f. in the circuit. Faraday found that to generate current, either the conductor must move through a magnetic field or a magnetic field must change across the conductor.

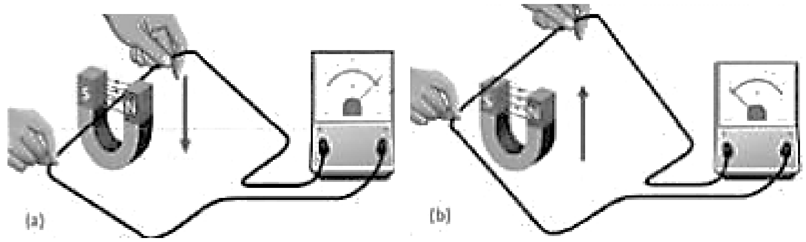


Figure: Demonstration of Electromagnetic Induction by the Movement of a Wire Loop in the Manget Field

Conclusion:

It is concluded that an electric current is generated in a wire only when the wire cuts magnetic field lines. This induced current is generate by the induced e.m.f in the circuit.

Q.2 State Faraday's law of electromagnetic induction. Explain with experiment how current is induced in a solenoid? Write factors. ***(K.B+A.B+U.B)***

Ans: **FARADAY'S LAW**

Statement:

"The value of induced e.m.f in a circuit is directly proportional to the rate of change of number of magnetic lines of force through it."

Induce Current in Solenoid:

Faraday perform experiments in which a current is induced by moving a magnetic into the solenoid or out of the solenoid.

When the magnet is stationary, no current is induced. When the magnet is moved towards the solenoid, the needle of galvanometer deflects towards right, indicating that current is being induced in the solenoid.

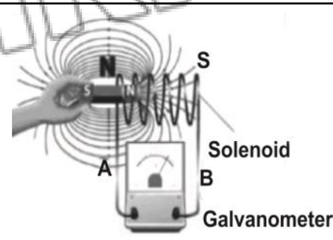


Figure: Magnet Move Towards Stationary Solenoid

When the magnet is pulled away from the solenoid, the galvanometer deflects towards left, indicating that the induced current in the solenoid is in the opposite direction.

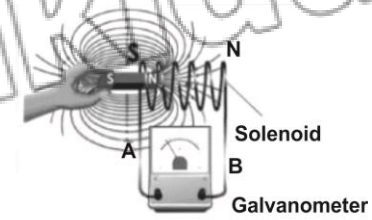


Figure: Magnet Move Away From Stationary Solenoid

Conclusion:

From the experiments it is concluded that an e.m.f in induced in the coil when there is a relative motion between the coil and the magnet.

Electromagnetic Induction:

The phenomenon in which an e.m.f is induced due to the relative motion between the coil and the magnet is called electromagnetic induction.

Factors Affecting Induced e.m.f:

The magnitude of induced e.m.f in a circuit depends on the following factors:

- Speed of relative motion of coil and magnet
- Number of turns of coil.

Q.3 State Lenz's law? Describe the direction of an induced e.m.f in a circuit. How does this phenomenon relate to conservation of energy? *(K.B+U.B+A.B)* (Review Ex. 15.9)

Ans: LENZ'S LAW

Statement:

"The direction of an induced current in a circuit is always such that it opposes the cause that produces it".

Direction of Induced e.m.f:

Lenz devised a rule to find out the direction of a current induced in a circuit.

Experiment:

If we bring a north pole of a bar magnet near a solenoid, an e.m.f will be induced in the solenoid by electromagnetic induction.

The direction of the induced current in the solenoid by the induced e.m.f will be such that it will repel the north pole of the magnet. This is only possible if the left end of the solenoid becomes north pole. Hence according to right hand grip rule the direction of the induced current in the solenoid will the anticlockwise.

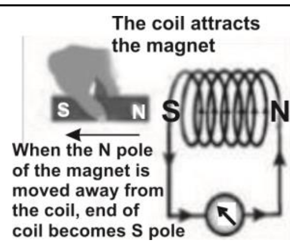


Figure: Direction of Induced Current When Magnet is Moved Toward the Coil

Similarly, when we move the north pole of the magnet away from the solenoid the direction of the induced current will be clockwise. In this case left end of solenoid becomes south pole.

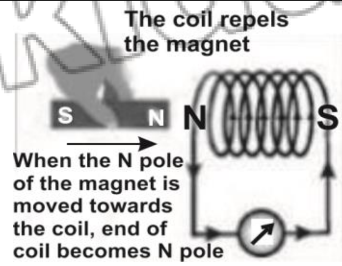


Figure: Direction of Induced Current When Magnet is Moved Away From the Coil

Induce e.m.f and Conservation of Energy:

If we apply the law of conservation of energy to electromagnetic induction, we realize that the electrical energy induce in a conductor comes from the kinetic energy of the moving magnet. We do some work on the magnet to bring it close to the solenoid. This work consequently appears as electrical energy is the conductor. Thus mechanical energy of our hand used to push the magnet towards or away from the coil results into electrical energy. Hence Lenz's law is a manifestation of law of conservation of energy.

Q.4 What is A.C. Generator? How is it constructed? How current is induced in it? ***(K.B+U.B+A.B)***
(LHR 2013, SGD 2016) , (Review Ex. 15.10)

Ans: **A.C GENERATOR**

Definition:

"A device which generates an alternating e.m.f is called A.C. generator".

A generator converts mechanical energy into electrical energy.

Working Principle:

The number of lines of magnetic force passing through the coil will be maximum when the plane of the coil is perpendicular to the lines of magnetic force. The number of lines of magnetic force will be zero when plane of the coil is parallel to the lines of force. Thus, when a coil rotates in a magnetic field, the induced current in it continuously changes from maximum to minimum value and from minimum to maximum value and so on. This is the basic principle on which an A.C generator works.

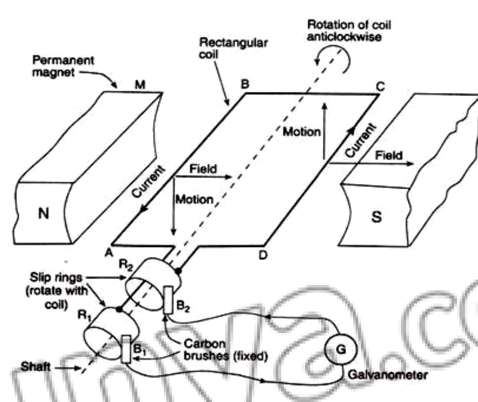


Figure: A.C Generator

Construction and Working:

An A.C generator consists of a rectangular coil and magnet, which is rotated between the poles of a permanent magnet. Both the ends of the coil are soldered to the two slip rings fixed on the arm of the coil as shown in figure.

Two carbon brushes are kept in contact with these slip rings with the help of two springs. Current is drawn from the coil through these brushes.

The armature is arranged so that it can rotate freely in the magnetic field. As the armature turns, the wire loops cut through the magnetic field lines and induces an e.m.f will be produced. The e.m.f. developed by the generator depends on the length of the wire rotating in the field. Increasing the number of loops in the armature increases the wire length, thereby increasing the induced e.m.f.

Current from a Generator:

When a generator is connected in a closed circuit, the induced e.m.f generates an electric current. As the loop rotates the strength and the direction of the current changes.

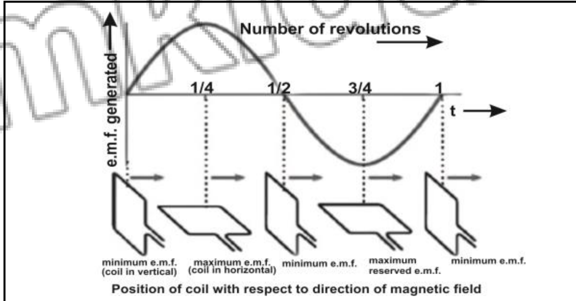


Figure: **e.m.f Vs Time for AC Generator**

When the plane of coil is perpendicular to field, the number of lines of magnetic force passing the trough it is maximum. But the change in the number of line through the coil is minimum. So e.m.f. induced is minimum.

The current is minimum when the plane of the loop is perpendicular to the magnetic field; that is, when the loop is in the vertical position. As the loop rotates from the vertical to the horizontal position, it cuts through large magnetic field lines per unit of time, thus the e.m.f and the current increase. When the loop is horizontal the plane of the loop becomes parallel to the field, the e.m.f and the current reaches its maximum values. As the loop continues to turn, the segment that was moving up begins to move down and reverses the direction of the e.m.f and the current in the loop. This change in direction takes place each time the loop turns through 180^o. Thus, the e.m.f and the current change smoothly from zero to some maximum values and back to zero during each half-turn of the loop.

15.5, 15.6, 15.7 SHORT QUESTION

Q.1 Define electromagnetic induction. ***(K.B)***

(LHR 2016, FSD 2016, SHW 2016, DGK 2016, SGD 2017, RWP 2017)

Ans: **ELECTROMAGNETIC INDUCTION**

Definition:

"The process of generating an induced current in a circuit by changing the number of magnetic lines of force passing through it is called electromagnetic induction."

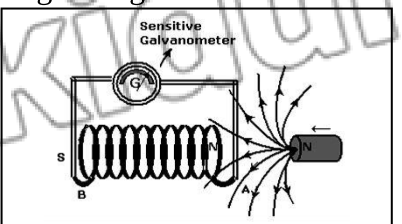


Figure: **Electromagnetic Induction**

Q.2 State Faraday law of Electromagnetic Induction. ***(K.B)*** **(GRW 2013, LHR 2013, SHW 2016)**

Ans: ***Given on Page # 287***

Q.3 Define A.C. Generator. ***(K.B)***

Ans: ***Given on Page # 289***

Q.4 Write down the principle of A.C. generator. ***(U.B)*** **(GRW 2015, LHR 2015)**

Ans: **PRINCIPLE OF A.C. GENERATOR**

Principle:

The number of lines of magnetic force passing through the coil will be maximum when the plane of the coil is perpendicular to the lines of magnetic force. The number of lines of magnetic force will be zero when plane of the coil is parallel to the lines of force. Thus, when a coil rotates in a magnetic field, the induced current in it continuously changes from maximum to minimum value and from minimum to maximum value and so on. This is the basic principle on which an A.C generator works.

Q.5 What is meant by strength of magnetic field? When it is maximum and minimum? ***(K.B)***

Ans: *Given on Page # 286*

Q.6 Is it possible that a constant current flowing in a coil produces an induced current in another coil? ***(K.B)***

Ans: **PRODUCTION OF INCDUCED CURRENT**

No, a constant current flowing in one coil cannot produce induced current in another coil. In order to produce induced current in another coil, the current in first coil must be changing continuously so that magnetic flux may pass through another coil.

Q.7 State Lenz's law? ***(K.B)*** **(LHR 2014, 2017, SGD 2017, RWP 2017, SHW 2016)**

Ans: *Given on Page # 288*

Q.8 Prove that Lenz law is a manifestation of the law of conservation of energy. ***(K.B+U.B)***

OR How does Induce e.m.f relate to conservation of energy?

Ans: **INDUCE E.M.F AND CONSERVATION OF ENERGY**

If we apply the law of conservation of energy to electromagnetic induction, we realize that the electrical energy induce in a conductor appears from the kinetic energy of the moving magnet. We do some work on the magnet to bring it close to the solenoid. This work consequently appears as electrical energy is the conductor. Thus mechanical energy of our hand used to push the magnet towards or away from the coil results into electrical energy. Hence Lenz's law is a manifestation of the law of conservation of energy.

Q.9 What is the contribution of Joseph Henry in electromagnetic induction? ***(K.B)***

Ans: **PHYSICS FACT** **(Text book Info. Pg. # 126)**

It is said, Joseph Henry (1797-1878) had observed an induced current before Faraday, but Faraday published his results first and investigated the subject in more detail.

Q.10 Differentiation between A.C Generator and D.C Generator. ***(Conceptual Base)***

Ans: **DIFFERENTIATION**

A.C Generator	D.C Generator
• A device which produces or generates an alternating emf is called A.C. generator. • Slip rings are used to produce alternating current.	• A device which produces or generates an direct emf is called D.C. generator. • Commutators are used in D.C generator to produce direct current.

Q.11 What was the contribution of Michael Faraday? *(K.B)*

Ans: **MICHAEL FARADAY** **(Text book Info. Pg. # 129)**

Michael Faraday was a British chemist and physicist. He discovered the principle of electromagnetic induction and the laws of electrolysis etc.

Figure: Michael Faraday

Q.12 How electricity is produce by electromagnetic induction? *(K.B)*

Ans: **PRODUCTION OF ELECTRICITY**

If we place a coil in the magnetic field of a bar magnet, some of the magnetic lines of force will pass through it.

When the Coil is Far Away From the Magnet:

If the coil is far away from the magnet, only a few lines of force will pass through the coil.

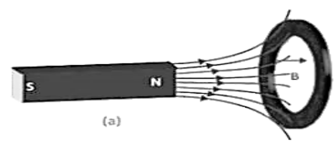


Figure: Less Line of Force

When the Coil is Closed to the Magnet:

If the coil is close to the magnet, a large number of lines of force will pass through it, In this way we can change the number of magnetic lines of force through a coil by moving it in the magnetic field. This change in the number of magnetic field lines will induce and e.m.f in the coil as shown in fig b.

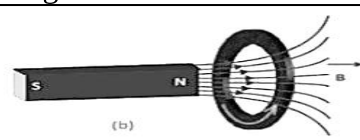


Figure: More Line of Force

Note: This is the basic principle of production of electricity and working of A.C Generator.

Q.13 What factors affect induced emf? *(K.B)* **(RWP 2017,BWP 2016), (Review Ex. 15.8)**

OR What are the factors which affect the magnitude of e.m.f. induced in a circuit by a changing magnetic field?

Ans: **FACTORS AFFECTING INDUCED E.M.F**

The magnitude of induced e.m.f in a circuit depends on the following factors:

- Speed of relative motion of coil and magnet
- Number of turns of coil.
- Strength of magnet

Q.14 Fleming's right-hand rule. *(Conceptual Base)*

Ans: **"**Stretch the thumb, forefinger and the middle finger of the right hand mutually perpendicular to each other. If the forefinger points in the direction of the magnetic field, the second finger in the direction of induced current, then the thumb would indicate the direction of motion of conductor.

Q.15 Define Eddy Currents. ***(Conceptual Base)***

Ans: If the aluminium disc below is set spinning, it may be many seconds before frictional force finally brings it to rest. However, if it spinning between the poles of a magnet, it stops almost immediately. This is because the disc is a good conductor and currents are induced in it as it moves through the magnetic field. These are called eddy currents. They produce a magnetic field which, by Lenz's law, opposes the motion of the disc. Eddy currents occur wherever pieces of metal are in a changing magnetic field – for example, in the core of a transformer.

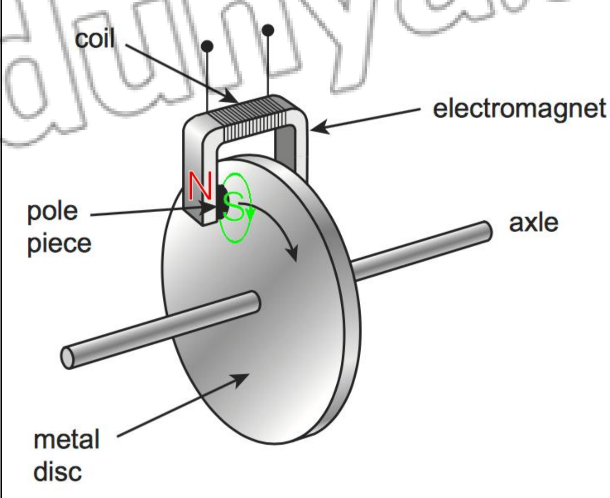


Fig. Metal disc rotating in magnet

Q.16 How metal detector work? ***(Conceptual Base)***

Ans: Metal detector rely on eddy currents. Typically, a pulse of current through a flat coil produces a changing magnetic field. This induces eddy currents in any metal object underneath. The eddy currents give off their own changing field which induces a second pulse in the oil. This is detected electronically.

Fig. Metal Detector

Q.17 Which device convert mechanical energy into electrical energy in hydroelectric dam? ***(K.B)*** **(Do you know Pg. # 129)**

Ans:

GENERATOR

A generator inside a hydroelectric dam uses electromagnetic induction to convert mechanical energy of a spinning turbine into electrical energy.

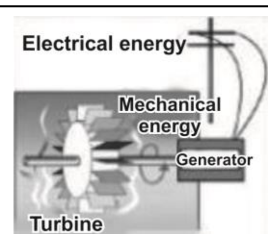


Figure: **Generator Inside Hydroelectric Dam**

15.5, 15.6, 15.7 MULTIPLE CHOICE QUESTIONS

1. Electromagnetic induction was discovered by: *(K.B)* **(GRW 2013)**
(A) Newton (B) Galileo
(C) Einstein (D) Faraday

2. Who found the direction of induced e.m.f first time? *(K.B)*
(A) Faraday (B) Lenz
(C) Henry (D) Bohr

3. The value of induced emf is directly proportional to the rate of change of: *(U.B+A.B)*
(A) Current (B) Resistance
(C) Potential (D) Flux

4. The number of magnetic lines of force passing through any surface: *(K.B)*
(A) emf (B) Current
(C) Flux (D) Resistance

5. The magnitude of induced emf depends upon the speed of: *(K.B)*
(A) Magnet (B) Coil
(C) Current (D) relative Motion

6. A device used to convert mechanical energy into electrical energy: *(K.B)*
(A) Transformer (B) A.C Generator
(C) D.C Motor (D) All of them

7. A generator works on the principle of: *(K.B)*
(A) Electromagnetic induction (B) Electrostatic induction
(C) Both of them (D) None of these

8. When a straight current carrying conductor is placed in a magnetic field at right angle to it, the direction of force acting on conductor is: *(U.B)*
(A) Same as the direction of field (B) Opposite to the direction of the field
(C) Makes an angle of 45^0 with the current (D) At right angle to both the field and current

9. Walk through metal detector are installed at airport and other places for: *(K.B)*
(A) Security purpose (B) Decoration
(C) Useless purpose (D) All of these

10. According to Faraday's law of induced emf is ____proportional to change in flux. *(U.B+A.B)*
(A) Directly (B) Inversely
(C) Equal (D) Opposite

11. Who discovered the phenomenon of electromagnetic induction? *(K.B)* **(GRW 2013)**
(A) Ohm (B) Coulomb
(C) Faraday (D) None of these

12. Micheal Faraday belonged to _______. **(LHR 2015)**
(A) Russia (B) K.S.A
(C) U.S.A (D) British

13. Law of electromagnetic induction and electrolysis were presented by: *(K.B)*(GRW 2015)
(A) Simon ohm (B) Jeorge Coulomb
(C) Newton (D) Michel Faraday

14. Which thing work on the phenomenon of electromagnetic induction in hydroelectric power plant? *(U.B)*
(A) Motor (B) Generator
(C) Galvanic cell (D) Volatic cell

15. Magnetic field of coil Is identical to field of ________ magnet. *(K.B)* **(Do you know Pg. # 131)**
(A) Bar (B) Disk Shaped
(C) Horse shoe (D) none

16. A generator is a ____ with its inputs and outputs reversed. *(K.B)*
(A) Transformer (B) D.C Motor
(C) Relay (D) Capacitor

15.8 MUTUAL INDUCTION
15.9 TRANSFORMER
15.10 HIGH VOLTAGE TRANSMISSION

LONG QUESTIONS

Q.1 What is meant by mutual induction? ***(K.B+U.B+A.B)***
OR What do you understand by the term mutual induction?
(SGD 2016, MTN 2016), (Review Ex. 15.11)

Ans: **MUTUAL INDUCTION**

"The phenomenon of production of induced current in one coil due to change of current in a neighboring coil is called mutual induction".

Explanation:

Suppose a system of two coils A and B placed closed to each other. The coil A is connected to a battery and a switch, while a sensitive galvanometer is connected to the coil B. We observe that as soon as the switch of the coil A is closed, the galvanometer shows a momentary deflection. Similarly when the switch is opened the galvanometer again shows a deflection but this time its direction is opposite to that of the previous case.

Mechanism:

We can explain these observation using Faraday's law of electromagnetic induction. When the switch of coil A is closed, a current begins to flow in the coil due to which magnetic field is developed across the coil. Some of the magnetic lines of forces of this field start passing through the coil B. Since current is changing in the coil A, hence number of magnetic lines of force across the coil B also changes due to which a current is induced in the coil B in accordance with Faraday's law. When current in the coil A becomes steady, number of magnetic lines of force across the coil A also becomes constant. Therefore there is no more change in number of magnetic lines of force through the coil B due to which induced current in coil B reduces to zero.

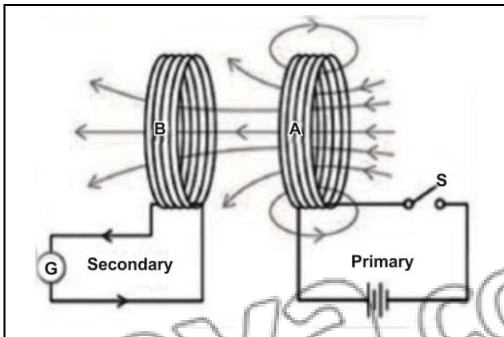


Figure: Mutual Induction

Similarly when the switch of the coil A is opened, the flow of current through it stops and its magnetic field reaches to zero. The number of magnetic lines of force through the coil B decreases to zero due to which current is again induced in it but in opposite direction to that in the previous case.

Q.2 What is transformer? Explain its construction, working principle and types. ***(K.B+U.B+A.B)***
OR What is a transformer? Explain the working of a transformer in connection with mutual induction.
(LHR 2013, SHW 2016, MTN 2016), (Review Ex. 15.12)

Ans: **TRANSFORMER**

"Transformer is an electrical device which is used to increase or decrease the value of A.C voltage".

Construction:

A transformer has two coils, electrically insulated from each other, but wound around the same iron core. One coil is called the primary coil the other coil is called the secondary coil. Number of turns on the primary and the secondary coils are represented by N_P and N_S respectively.

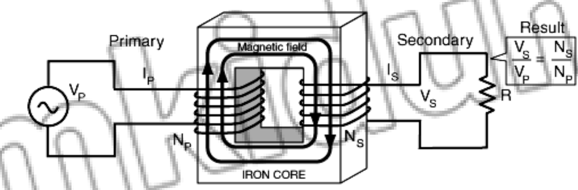


Figure: Transformer

WORKING PRINCIPLE

When the primary coil is connected to a source of A.C, voltage, the changing current creates a changing magnetic field, which is carried through the core to the secondary coil. In the secondary coil, the changing field induces a alternating e.m.f. This effect is called mutual inductance. Hence, mutual inductance is working principle of transformer.

Voltages and Number of Turns of Coil:

The e.m.f induced in the secondary coil, called the secondary voltage V_S is proportional to the primary voltage V_P. The secondary voltage also depends on the ratio of the number of turns on the secondary coil to the number of turns on the primary coil, as shown by the following expressions, $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

Types:

There are two types of transformer

- Step – up transformer
- Step-down transformer

Step – up transformer:

If **Ns>Np**, then secondary voltage is larger than the primary voltage, then the transformer is called a step-up transformer.

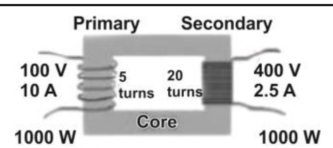


Figure: Step Up Transformer

Step-down transformer:

If **Np > Ns** then the secondary voltage is smaller than the primary voltage, then transformer is called a step-down transformer.

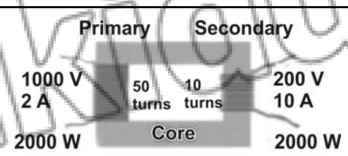


Figure: Step Down Transformer

An Ideal Transformer :

In an ideal transformer, the electric power delivered to the secondary circuit equals the power supplied to the primary circuit. An ideal transformer dissipates no power itself and for such a transformer we can write:

$$P_P = P_S$$

$$V_P I_P = V_S I_S$$

Uses of Transformer:

Transformer are used to increase or decrease AC voltages. Usage of transformers is common because they change voltages with relatively little loss of energy. In fact, many of the devices in our homes, such as game systems, printers and stereos use transformers for their working.

Q.3 How high voltage transmission reach from power station to consumer?*(U.B+A.B)*

OR Why alternating voltage is stepped up at the generating station?

Ans: **HIGH VOLTAGE TRANSMISSION**

Dissipation of Heat in Transmission:

Electric power is usually generated at places which are far from the places where it is consumed. The power is transmitted over long distances at high voltage to minimize the loss of energy in the form of heat during transmission. As heat dissipated in the transmission cable of resistance R is I^2Rt. Hence by reducing the current through the cable, power loss in the form of heat dissipation can also be reduced. So the alternating voltage is stepped up at the generating station.

Stepping Down Voltage:

High voltages are transmitted to the main sub-station. This voltage is stepped down and is transmitted to the switching transformer station or the city sub-station. At the city sub-station it is further stepped down to 20V and supplied to the consumer.

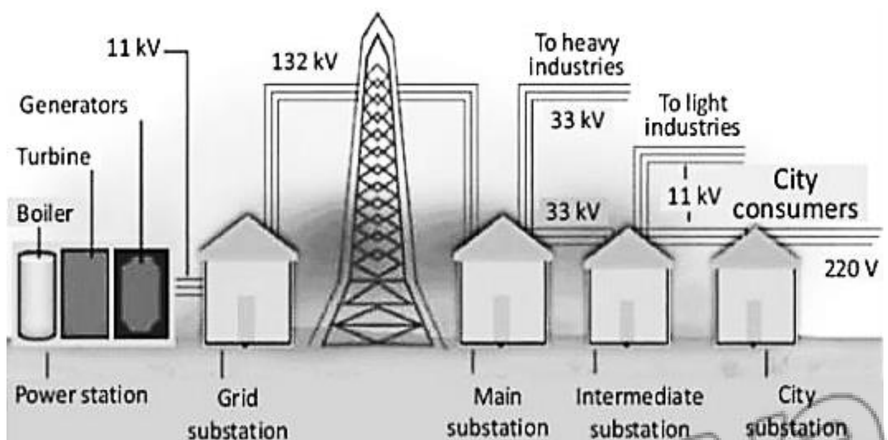


Figure: **High Voltage Transmission**

Main Power is Supplied as Alternating Current:

Transformers play an essential part in power distribution. Transformer work only with AC. This is one reason why mains power is supplied as alternating current.

Q.4 What is an electromagnetic? Explain its uses giving one practical example. ***(A.B)***

Ans: **ELECTROMAGNET**

Definition:

"Magnetic effect of current is called electromagnet".

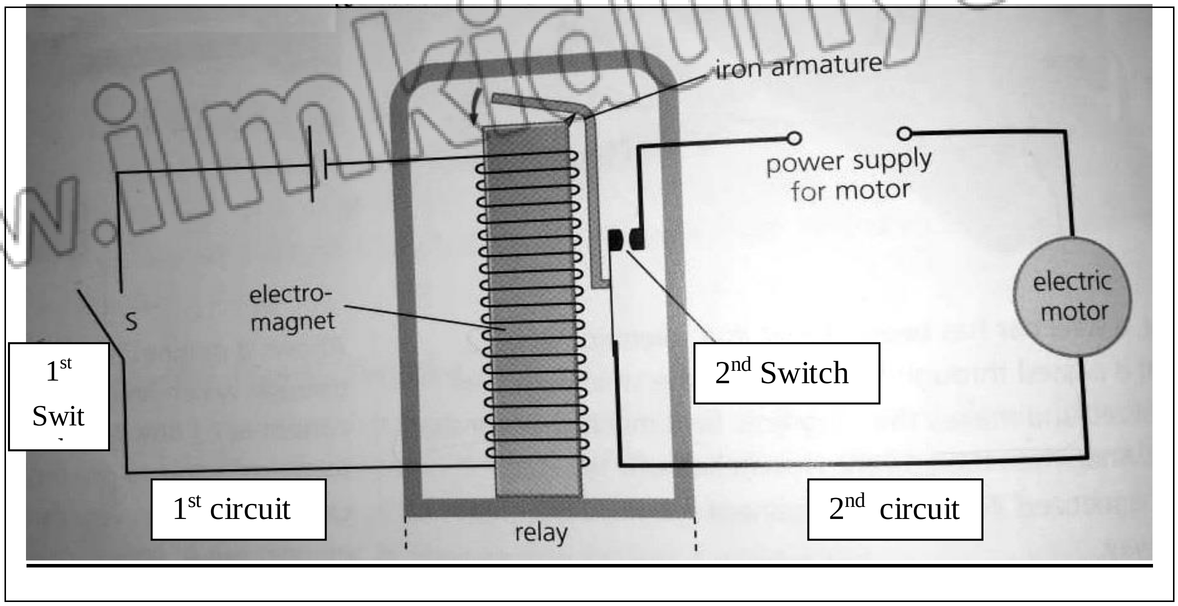
Application / Uses:

This affect is used in many devices like relay, electric bell etc. soft iron can easily magnetized and demagnetized.

Relay Circuit: **(GRW 2013)**

"A relay is an electrical switch that opens and closes under the control of another electrical circuit". The relay is used to control a large current with the help of small current.

Working Principle of Relay Circuit:



The 1st circuit (input circuit) supplies current to the electromagnet. The electromagnet is magnetized and attracts one end of the iron armature. The armature then closes the contacts (2nd switch) and allows current to flow in second circuit when the first switch is opened again, the current to the electromagnet stops. Now electromagnet loses its magnetism and the 2nd switch is opened. Thus the flow of current stops in the 2nd circuit.

Examples of Magnetic Effect of an Electric Current:

- Loud Speaker
- Circuit breaker
- Door latches

15.8, 15.9, 15.10 SHORT QUESTIONS

Q.1 Define mutual induction. ***(K.B)***
(GRW 2013, LHR 2013, FSD 2016, 2017, SGD 2016, 2017, MTN 2016)

Ans: *Given on Page # 295*

Q.2 Define self-Induction. ***(K.B)***

Ans: **SELF INDUCTION**

Definition:

"If the current through a coil or a circuit changes and this change induces an e.m.f in the circuit itself, the phenomenon is known as self-induction".

Q.3 Define transformer. ***(K.B)*** **(GRW 2014)**

Ans: *Given on Page # 295*

Q.4 What do you know about primary coil and secondary coil? ***(K.B)***

OR How many coils are used in transformer? ***(K.B)*** **(LHR 2014, SHW 2017, RWP 2017)**

Ans: *Given on Page # 296*

Q.5 Define step down transformer and step up transformer. ***(K.B)***
(LHR 2015, SDG 2016, 2017, FSD 2017, MTN 2016, BWP 2017)

Ans: *Given on Page # 296*

Q.6 What is the function of core in the transformer? ***(K.B)***

Ans: **FUNCTION OF CORE OF TRANSFORMER**

The functions of core in transformer are:

- The iron core enhances the magnetic flux produced in the primary coil.
- The magnetic flux linked to the secondary coil through iron core.

Q.7 Why alternating voltage is stepped up at the generating station? *(K.B)* **(Review Ex. 15.13)**

OR The voltage chosen for the transmission of electrical power over large distance is electrical power is transmitted at high voltage.

Ans: **REASON OF STEPPING UP**

Electric power is usually generated at places which are far from the places where it is consumed. The power is transmitted over long distances at high voltage to minimize the loss of energy in the form of heat during transmission. As heat dissipated in the transmission cable of resistance R is I^2 Rt. Hence by reducing the current through the cable, power loss in the form of heat dissipation can also be reduced. So the alternating voltage is stepped up at the generating station.

Q.8 How voltages are stepped down? **(Review Ex. 15.14)**

OR Why is the voltage used for the domestic supply much lower than the voltage at which the power is transmitted? *(K.B+A.B)*

Ans: **REASON OF STEPPING DOWN**

High voltages are transmitted to the main sub-station. This voltage is stepped down and is transmitted to the switching transformer station or the city sub-station. At the city sub-station it is further stepped down to 220V and supplied to the consumer.

Q.9 Why mains power is supplied as alternating current? *(K.B)*

Ans: **REASON OF MAINS ALTERNATING VOLTAGE**

Transformers play an essential part in power distribution. Transformer work only with AC. This is only reason why mains power is supplied as alternating current.

Q.10 What is relay circuit? *(K.B)*

Ans: ***Given on Page # 297***

Q.11 Explain working principle of relay circuit. *(K.B+U.B)*

Ans: ***Given on Page # 297***

Q.12 Define ideal transformer. *(K.B)*

Ans: ***Given on Page # 296***

Q.13 What is working principle of transformer? *(K.B)*

Ans: ***Given on Page # 296***

Q.14 Can a transformer work on D.C? *(K.B+U.B)*

As the transformer work on the principle of mutual induction and this phenomena occurs only in the case of A.C. That is why transformer cannot work on D.C.

Q.15 What are uses of transformer? *(A.B)*

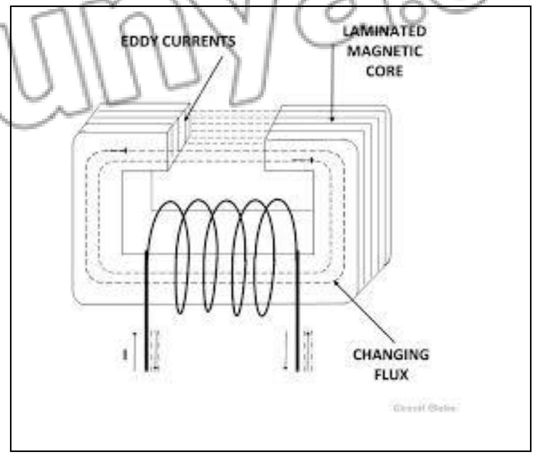
Ans: **USES OF TRANSFORMER**

The uses of transformer are:

- Transformer are used to increase or decrease AC voltages.
- Usage of transformers is common because they change voltages with relatively little loss of energy.
- Many of the devices in our homes, such as game systems, printers and stereos use transformers inside their casings or as part of their connecting cords.

Q.16 Why the core of transformer is laminated (layered)? *(Conceptual Base)*

Ans: The core is itself a conductor, so the changing magnetic field induces currents in it. These circulating eddy currents have a heating effect. To reduce them, the core is laminated (layered): it is made from thin, insulated sheets of iron or Mumetal, rather than a solid block.



15.8, 15.9, 15.10 MULTIPLE CHOICE QUESTIONS

1. If the Current is induced in a circuit due to change of current in an other circuit, this process is known as: *(K.B)*
(A) Electrostatic induction (B) Mutual induction
(C) Self-induction (D) None of them

2. The coil of transformer in which change in current produces induced current in another coil is known as: *(K.B)*
(A) Primary (B) Secondary
(C) Solenoid (D) All of them

3. A coil in which current is induced is known as: *(K.B)*
(A) Primary (B) Secondary
(C) Solenoid (D) All of them

4. If the current through a coil or a circuit changes and this change induces an emf in the circuit itself, this process is known as: *(K.B)*
(A) Electrostatic induction (B) Mutual induction
(C) Self-induction (D) None of them

5. An electrical device which is used to increase or decrease the value of alternating voltage: *(A.B)*
(A) Transformer (B) A.C generator
(C) D.C motor (D) All of them

6. The coil which is connected to the alternating voltage whose value is to be altered is known as: *(K.B)*
(A) Primary coil (B) Secondary coil
(C) Solenoid (D) All of them

7. The Coil of transformer in which alternating voltage is induced is known as: *(K.B)*
(A) Primary coil (B) Secondary coil
(C) Solenoid (D) All of them

8. Transformer works on the principle of: *(K.B)*
(A) Electrostatic induction (B) Mutual induction
(C) Self Induction (D) All of them

9. Type of transformer which is used to increase the value of alternating voltage: *(A.B)*
(A) Step up (B) Step down
(C) Step forward (D) Step back

10. Type of transformer which is used to decrease the value of alternating voltage: *(A.B)*

(A) Step up (B) Step down
(C) Step forward (D) Step back

11. A transformer has 100 turns in primary and 500 turns in the secondary. If 6 Volts D.C is applied across its primary, the voltage induced across its secondary would be: *(A.B)*

(A) 0V (B) 30V
(C) 45V (D) 60V

12. A practical application of mutual induction is: *(A.B)*

(A) Transformer (B) Electrical motor
(C) Generator (D) Diode

13. Number of turns on the primary coil is represented as: *(K.B)*

(A) N_s (B) N_p
(C) N_s (D) N_a

14. Number of turns on secondary coil is: *(K.B)*

(A) N_s (B) N_d
(C) N_a (D) N_p

15. In step-up transformer: *(U.B)*

(A) $V_s > N_s$ (B) $U_p > V_p$
(C) $V_s > V_p$ (D) $V_s > N_s$

16. Transformer is called step-down when: *(U.B)*

(A) $V_s > V_p$ (B) $V_s > N_s$
(C) $V_p < V_s$ (D) $V_s < V_p$

17. Electric power is usually generated at places which are far from the places where it is: *(K.B)*

(A) Consumed (B) Produced
(C) Not needed (D) Developed

18. Voltage of current supplied to consumers is: *(K.B)*

(A) 230 V (B) 240 V
(C) 210 V (D) 220 V

19. Electromagnet is used in device: *(A.B)*

(A) Electric bell (B) Relay
(C) Both A and B (D) Thermometer

20. Which is an electric switch that opens and closes under the control of another electrical circuit? *(K.B)*

(A) Relay (B) Electric bell
(C) Electric circuit (D) A.C Generator

21. Step down transformer: *(K.B)* **(LHR 2016)**

(A) Decreases input current (B) Decreases input voltage
(C) Has more turns in secondary coil (D) Has less turns in primary coil

22. Transformer is used to: *(A.B)* **(GRW 2016)**

(A) Increase voltage (B) Decrease voltage
(C) Both a and b (D) None of these

23. Types of transformer are: *(K.B)* **(GRW 2013)**

(A) 1 (B) 2
(C) 3 (D) 4

24. Transformers are used to: ***(A.B)*** **(LHR 2016)**

(A) Increase voltage (B) Increase resistance
(C) Both a and b (D) None of these

25. Transformer is used to change the value of: ***(A.B)*** **(LHR 2017)**

(A) Voltage (B) Power
(C) Energy (D) Charge

EXAMPLE 15.1 *(U.B+A.B)*

If a transformer is used to supply voltage to a 12V model train which draws a current of 0.8 A. Calculate the current in the primary if the voltage of of the A.C. Source is 240 V.

Given Data

Primary voltage = V_P= 240 V
Secondary voltage = V_s = 12 V
Secondary current = I_s= 0.8 A

To Find:

Primary current = I_p = ?

Formula:

According to law of conservation of energy,

Input Power of the primary = Output power of the secondary

i.e., $I_pV_p = I_sV_s$

Calculation:

$$I_P = \frac{I_S V_S}{V_P}$$

$$I_P = \frac{(12\text{ V})(0.8\text{ A})}{240\text{ V}} = 0.04\text{A}$$

Result:

The primary current to the transformer is 0.04 A.

MCQ'S ANSWER KEY (TOPIC WISE)

15.1 MAGNETIC EFFECTS OF A STEADY CURRENT

15.2 FORCE ON A CURRENT – CARRYING CONDUCTOR PLACED IN MAGNETIC FIELD

1	2	3	4	5	6	7	8	9	10	11	12
C	C	B	B	C	B	A	B	C	A	A	B
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**			
A	B	B	B	C	A	A	B	C			

15.3 TURNING EFFECT ON CURRENT CARRYING COIL IN MAGNETIC FIELD

15.4 D.C MOTOR

1	2	3	4	5
B	C	D	D	A

15.5 ELECTROMAGNETIC INDUCTION

15.6 DIRECTION OF INDUCED E.M.F – LENZ'S LAW

15.7 A.C GENERATOR

1	2	3	4	5	6	7	8	9	10	11	12
A	B	D	C	D	B	A	D	A	A	C	D

13	14	15	16
D	B	B	B

15.8 MUTUAL INDUCTION
15.9 TRANSFORMER
15.10 HIGH VOLTAGE TRANSMISSION

1	2	3	4	5	6	7	8	9	10	11	12
B	A	B	C	A	A	B	B	A	B	B	A
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
B	A	C	D	A	D	C	A	B	C	D	C
25											
A											

TEXT BOOK EXERCISE
MULTIPLE CHOICE QUESTIONS

i. Which statement is true about the magnetic poles? *(K.B)*
(a) opposite poles repel (b) like poles attract
(c) magnetic poles do not effect each other. (d) a single magnetic pole does not exist

ii. What is direction of the magnetic field lines inside a bar magnet? *(K.B)* (LHR 2017)
(a) from the pole of south pole (b) from south pole to north pole
(c) from side to side (d) there are no magnetic field lines

iii. The presence of a magnetic field can be detected by a *(K.B)* (LHR 2015, GRW 2016)
(a) small mass (b) stationary positive charge
(c) stationary negative charge (d) magnetic campus

iv. If the current in a wire which is placed perpendicular to a magnetic field increases, the force on the wire *(K.B)* (LHR 2014)
(a) increase (b) decrease
(c) remain the same (d) be zero

v. A D.C motor converts: *(K.B)*
(a) mechanical energy into electrical energy (b) mechanical energy into chemical energy
(c) electrical energy into mechanical energy (d) electrical energy into chemical energy

vi. Which part of a D.C motor reverses the direction of current through the coil every half cycle? *(A.B)*
(a) the armature (b) the commutator
(c) the brushes (d) the slip rings

vii. The direction of induced e.m.f in a circuit in accordance with conservation of *(K.B)* (LHR, GRW 2017)
(a) mass (b) charge
(c) momentum (d) energy

viii. The step-up transformer: *(K.B)*
(a) increase the input current (b) increases the input voltage
(c) has more turns in the primary (d) has less turns in the secondary

ix. The turn ratios of a transformer is 10. It means: *(U.B)* (GRW 2014, 2015, 2017)
(a) $Is = 101_P$ (b) $N_s = N_p/10$
(c) $N_s = 10N_p$ (d) $V_s = Vp/10$

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
d	b	d	a	c	b	d	b	c

REVIEW QUESTIONS

15.1 Demonstrate by an experiment that a magnetic field is produced around a straight current carrying conductor. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.1 & 15.2, Long Question-1)

15.2 State and explain the rule by which the direction of the lines of force of magnetic field around a current carrying conductor can be determined. ***(K.B)***

Ans: (See Topic 15.1 & 15.2, Short Question-2)

15.3 Your are given an unmarked magnetized steel bar and bar magnet its north and south ends marked N and S respectively. State how would you determine the polarity at each and the unmarked bar? ***(K.B)***

POLARITY OF UNMARKED BAR MAGNET

Ans: When one end of unmarked magnet bring close to end 'N' of marked magnet. If marked magnet attract the unmarked then this show that there is south pole on unmarked and if 'N' pole of marked magnet repel the end of unmarked, this show that there is also north 'N' pole of unmarked magnet.

15.4 When a straight current carrying conductor is placed in a magnetic field, it experiences a force. State the rule by which the direction of this force can be found out. ***(K.B)***

Ans: (See Topic 15.1 & 15.2, Short Question-4)

15.5 State that a current carrying coil in a magnetic field experiences a torque. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.3 & 15.4, Long Question-1)

15.6 What is an electric motor? Explain the working principle of D.C motor? ***(K.B+U.B+A.B)***

Ans: (See Topic 15.3 & 15.4, Long Question-2)

15. 7 Describe a simple experiment to demonstrate that a changing magnetic field can induce e.m.f in a circuit. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-1)

15.8 What are the factors which affect the magnitude of the e.m.f induced in a circuit by a changing magnetic field? ***(K.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Short Question-10)

15.9 Describe the direction of an induced e.m.f in a circuit? How this phenomenon is related to the conservation of energy? ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-3)

15. 10 Draw a labeled diagram to illustrate the structure and working of A.C. generator. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-4)

15.11 What do you understand by the term mutual induction? ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-1)

15.12 What is transformer Explain the working of transformer in connection with mutual induction. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.8, 15.9 & 15.10, Long Question-1)

15.13 The voltage chosen for the transmission of electrical power over large distance is many time greater than the voltage of the domestic supply. State two reasons why electrical power is transmitted at high voltage *(K.B+U.B+A.B)*

Ans: (See Topic 15.8, 15.9 & 15.10, Long Question-2)

15.14 Why is the voltage used for the domestic supply much lower than the voltage at which the power is transmitted. *(K.B+U.B+A.B)*

Ans: (See Topic 15.8, 15.9 & 15.10, Short Question-7)

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 the magnet.

Ans: **IDENTIFICATION OF MAGNET**

Bring an iron strip close to each bar one by one. The iron bar which does not affect the iron strip is not a magnet.

15.2 Suppose you have coil of wire and a bar magnet. Describe how you could use them to generate and electric current.

Ans: **GENERATION OF CURRENT**

By moving a magnet and coil towards each other or away form each other would induce voltage in the coil. This induce voltage will cause current in the coil. You can also induce current in the coil by moving magnet and keeping the coil fixed and vice versa.

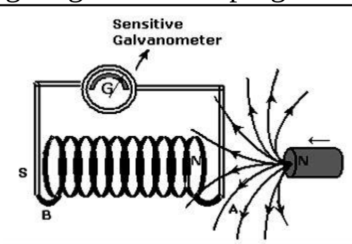


Figure: Electromagnetic Induction

15.3 Which devise is used for converting electrical energy into mechanical energy?

Ans: **DEVICE**

Motor is an electrical device which can be used to convert electrical energy into mechanical energy as in fans.

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?

Ans: **DIRECTION OF SWINGING OF COIL**

The coil will swing opposite to the direction of motion of the magnet according the lenz's law. It is due to the fact that current in the coil is always induced in such a way so as to cancel the cause which induces it.

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?

Ans: **RELATIVE MOTION OF WIRE**

To generate maximum voltage through the conductor, it must be moving perpendicular to the direction of magnetic field in this case maximum magnetic force will act upon the conductor.

15.6 What is the difference between a generator and a motor?

Ans: **DIFFERENTIATION**

The differences between generator and a motor are as follows.

Generator	Motor
Conversion of Energy	
• Generator converts mechanical energy into electrical energy.	• Motor converts electrical energy into mechanical energy.
Mechanism	
• Generator produces current.	• Motor drives current.
Construction	
• Generators have slip rings.	• Motors have split rings.

15.7 What reverses the direction of electric current in the armature coil of D.C. motor?

Ans: **PURPOSE OF CARBON BRUSHES**

To reverse the direction of current the connection to coil is made through an arrangement of brushes and a ring that is split into two halves, called splitting commutator. The split ring is arranged so that each half of the commutator changes the brushes just as the coil reaches the vertical position. Changing brushes reverse the current in the loop.

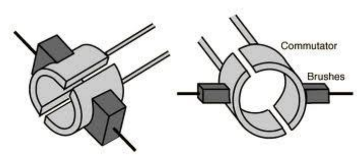
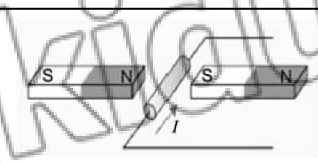


Figure: Electromagnetic Induction

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?

Ans: **DIRECTION OF MOTION OF WIRE**

According to Fleming's left hand rule it will move downward direction.



15.9 Can a transformer operate on direct current?

Ans: **REASON OF A.C IN TRANSFORMER**

No, the cycle doesn't change in D,C. that is why there is not change in magnetic flux in core of transformer, that is why, there is no change of flux in secondary coil and current is not induced.

NUMERICAL PROBLEMS *(U.B+A.B)*

15.1 A transformer is needed to convert a mains 240 V supply into a 12V supply. If there are 2000 turns on the primary coil, then find the number of turns on the secondary coil. **(LHR 2014, 2015, GRW 2015)**

Solution:

Given Data:

Primary Voltage = V_p = 240 V

Secondary Voltage = V_s = 12V

Number of turns in primary = N_p = 2000

To Find:

Number of turns in secondary = N_s = ?

Calculations:

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

$$Ns = \frac{Vs \times Np}{Vp}$$

$$= \frac{12 \times 2000}{240}$$

$$Ns = 100$$

Result:

Hence, Secondary coil of transformer consist of 100 turns.

15.2 A step-up transformer has a turn ratios of 1:100.An alternating supply of 20V is connected across the primary coil. What is secondary voltage? **(LHR 2015)**

Solution:

Given Data:

Turn ratio of step-up transformer $N_p : N_s = 1:100$

Primary Voltage $= V_p = 20V$

To Find:

Secondary Voltage = V_s = ?

Formula:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{N_p}{N_s} = \frac{1}{100}$$

Calculations:

$$Vs = \frac{N_s \times V_p}{N_p} = \frac{100}{1} \times 20$$

$$V_s = 2000 \text{ Volt}$$

Result:

Hence, Secondary voltage obtained from transformer will be 2000 volts.

15.3 A step – down transformer has a turns ratio of 1:100. An ac voltage of amplitude 170V is applied to the primary. If the current in the primary is 1.0 mA, what is the current in the secondary?

Solution:

Given Data:

Turn ratio of step – down transformer

$= N_s : N_p = 1:100$

$= \frac{N_s}{N_p} = \frac{1}{100}$

Primary Voltage $= V_p = 170v$

Primary current $= I_p = ImA = 1 \times 10^{-3}$ A

To Find:

Secondary current $= I_s = ?$

Formula:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$V_s = \frac{N_s}{N_p} \times V_p$$

Calculations:

$$V_s = \frac{1}{100} \times 170 = 1.7V$$

For an ideal transformer

Power of primary = Power of secondary

$P_p = P_s$

$I_p V_p = I_s V_s$

$$\frac{I_p V_p}{V_s} = I_s$$

$$\frac{1 \times 10^{-3} \times 170}{1.7} = I_s$$

0.1 A = I_s $\Rightarrow$ I_s = 0.1A Ans

Result:

Hence, Current of 0.1 A will be obtained from secondary coil.

15.4 A transformer, designed to convert the voltage from 240 V a.c. mains to 12V, has 4000 turns on the primary coil. How may 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 0.4A?

Solution:

Given Data:

Primary Voltage $= V_p = 240V$

Secondary Voltage $= V_s = 12V$

Number of turns in Primary $= N_p = 4000$

To Find:

Number of turns in secondary $= N_s = ?$

Formula:

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

Calculations:

$$Ns = \frac{V_s \times N_p}{v_p} = \frac{12 \times 4000}{240}$$

$N_s = 200$ Ans

$I_p = ?$

$I_s = 0.4A$

$P_p = P_s$

$I_p V_p = I_s V_s$

$$Ip = \frac{I_s V_s}{V_p} = \frac{0.4 \times 12}{240}$$

I_p = 0.02 A

Result:

Hence, Current of 0.2 A will be given to primary coil.

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:

Given Data:

Voltage =V = 250 x 10^3V

Power = P = 500 x 10^6W

To Find:

Current flowing transmission =I = ?

Formula:

P = IV

Calculations:

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

$$\frac{500\times10^6}{250\times10^3} = 1$$

$$2\times10^3 A = 1 \qquad \Rightarrow \quad I = 2KA$$

Ans

Result:

Hence, Current of 2kA will be flown through transmission lines.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. The presence of a magnetic field can be detected by a:

(A) Small mass (B) Stationary positive charge
(C) Stationary negative charge (D) Magnetic campus

2. A step down transformer:

(A) Decreases input current (B) Decreases input voltage
(C) Has more turns in secondary coil (D) Has less turns in primary coil

3. According to Faraday's law, the induced emf and change in flux are:

(A) Directly proportional (B) Inversely proportional
(C) Equal (D) Opposite

4. A device which is used to convert electrical energy into rotational kinetic energy:

(A) Transformer (B) A.C Generator
(C) D.C Motor (D) All of them

5. Weak ionic current that travel along the nerve can produce the:

(A) Electric effect (B) Magnetic effect
(C) Electric and Magnetic field (D) All of these

6. Shape of Magnetic lines of force in straight conductor are:

(A) Straight (B) Elliptical
(C) Circular (D) All of them

Q.2 Give short answers to following questions. **(5×2=10)**

i. Define electromagnetism.
ii. Differentiate between primary and secondary coil.
iii. Which factors increase the force on armature?
iv. State Fleming's left hand rule.
v. State Faraday's law of electromagnetic induction.

Q.3 Answer the following questions in detail. **(4+5=9)**

a) What is an electric motor? Write its construction and working.
b) A transformer is needed to convert a mains 240 V supply into a 12V supply. If there are 2000 turns on the primary coil, then find the number of turns on the secondary coil.

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.

UNIT 16

BASIC ELECTRONICS

16.1 THERMIONIC EMISSION
16.2 INVESTIGATING THE PROPERTIES OF ELECTRONS
16.3 CATHODE-RAY OSCILLOSCOPE (C.R.O)

LONG QUESTION

16.1 Q.1 What is meant by thermionic emission? How thermionic emission is produced? *(K.B)*

(GRW 2017) (Review Ex. 16.5)

Ans: **THERMIONIC EMISSION**

Definition:

"The process of emission of electrons from hot metal surfaces is called thermionic emission".

Production of Thermionic Emission:

Metals contain a large number of free electron. At room temperature, electrons cannot escape the metal surface due to attraction forces of atomic nucleus. If the metal is heated to a high temperature, some of the free electrons may gain sufficient energy to escape the metal surface.

Tungsten Filament:

Thermionic emission can be produced by electrically heating a fine tungsten filament. Typical values of the voltage and current used for this purpose are 6V and 0.3 A respectively.

16.2 Q.1 How electron beam is obtained? Explain the effect of electric and magnetic field on electron beam. *(K.B+U.B+A.B)* **(RWP 2017)**

OR Write a note on electron gun. **(DGK 2017), (Review Ex. 16.5)**

OR Discuses deflection of electrons by electric field. **(SGD 2016, 2017)**

OR Describe, using one simple diagram in each case, what happens when a narrow beam of electrons is passed through (a) a uniform electric field (b) a uniform magnetic field. What do these results indicate about the charge on electron?

(Review Ex. 16.1)

Ans: **PRODUCTION AND PROPERTIES OF ELECTRON**

Electron Beam:

Electrons are produced by the thermionic emission from a tungsten filament heated by 6V supply.

A high positive potential is applied several thousand to a cylindrical anode (+). The electrons are accelerated to a high speed and pass through the hole of the anode in the form of a fine beam of electrons. The whole setup is fitted in an evacuated glass tube.

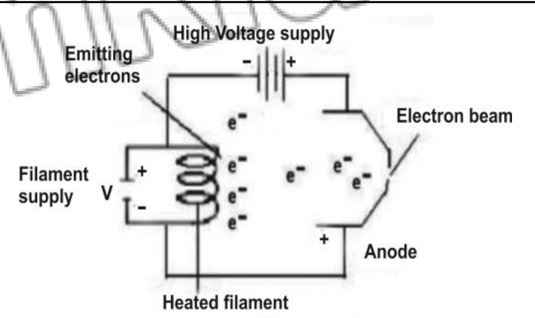


Figure: Electron Gun

Deflection of Electrons by Electric Field:

We can setup electric field by applying a potential difference across two parallel metal plates separated by some distance. When an electron beam passes between two plates, it can be seen that the electrons are deflected toward the positive plate.

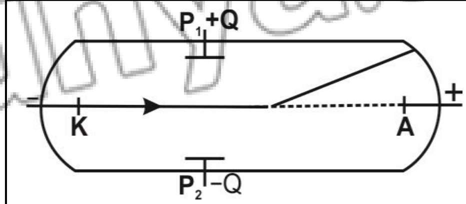


Figure: Deflection of Cathode Rays by an Electric Field

Reason:

The reason for this is that electrons are attracted by positive charges and are repelled by negative charges due to the force

$$\mathbf{F = qE}$$

Where 'q' is the charge of electron and 'E' is the electric field due to plates. The degree of deflection of electrons from their original direction is proportional to the strength of the electric field applied.

Deflection of Electrons by Magnetic Field:

Magnetic field is applied at right angle to the beam of electrons by using horseshoe magnet.

The spot of electron beam will be noticed on the screen due to the deflection of beam from its original (direction). Now change the direction of the horseshoe magnet. We will see the spot on the fluorescent screen is getting deflected in the opposite direction.

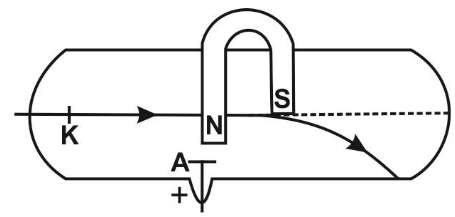


Figure: Deflection of Cathode Rays by a Magnetic Field

16.3 Q.1 What is cathode – rays oscilloscope (C.R.O)? Explain the working of different parts of oscilloscope? *(K.B+U.B+A.B)* **(Review Ex. 16.2)**

(LHR 2014, 2016, 2017, GRW 2015, 2017, SGD 2016, 2017, SHW 2017, FSD 2017, MTN 2017)

Ans: **CATHODE – RAYS OSCILLOSCOPE**

The cathode – ray oscilloscope is an instrument which is used to display the magnitudes of changing electric currents or potentials.

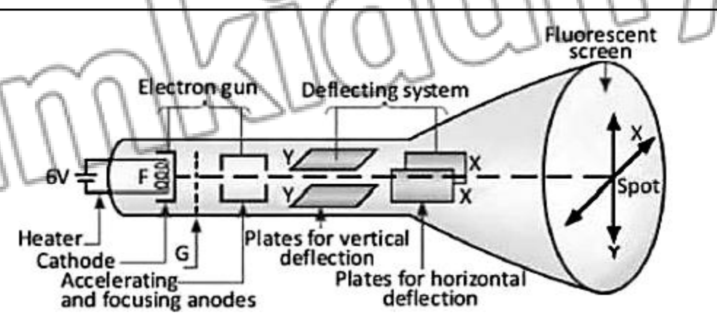


Figure: Cathode Ray Oscilloscope

The information is displayed on the screen of a "cathode ray tube." This screen appears a circular or rectangular window usually with a centimeter graph superimposed on it.

Examples:

- Picture tube in our TV set
- Display terminal of most computers are cathode ray tubes

Construction:

The cathode-ray oscilloscope (C.R.O) consists of the following components:

- The electron gun with control grid
- The deflecting plates
- A fluorescent screen

Working of Electron Gun: **(LHR 2015)**

The electron gun consists of an electron source which is an electrically heated cathode that ejects electrons.

Electron gun also has an electrode called grid G for controlling the flow of electrons in the beam. The grid is connected to a negative potential. The more negative this potential, the more electrons will be repelled form the grid and hence fewer electrons will reach the anode and the screen. The number of the electrons reaching the screen determines. The brightness of the screen. Hence the negative potential of the grid can be used as a brightness control.

The anode is connoted to the positive potential and hence is used to accelerate the electrons. The electrons are focused into a fine beam as they pass through the anode.

The Deflecting Plates:

After leaving electron gun, the electron beam passes between a pair of horizontal plates. A potential difference applied between these plates deflects the beam in a vertical plane. This pair of plates provides the Y-axis or vertical movement of the spot on the screen. A pair of vertical plates provides the X-axis or horizontal movement of the spot on the screen.

The Fluorescent Screen:

The screen of cathode – ray tube consists of a thin layer of phosphor, which is a material that gives light as a result of bombardment by fast moving electrons.

Uses of C.R.O:

The CRO is used in many fields of science, some uses are given below:

- Displaying wave forms
- Measuring voltages
- Range finding (as in radar)
- Echo – sounding (to find the depth of sea – beds)
- To display heart beats

16.1, 16.2, 16.3 SHORT QUESTIONS

Q.1 Define electronics. ***(K.B)*** **(SHW 2017, LHR 2015, 2017, GRW 2017)**

Ans: *Electronics is that branch of applied physics which deals with the controlled motion of electrons using different devices.*

Q.2 What do you understand by thermionic emission? ***(K.B)***
(LHR 2014, 2017, GRW 2016, 2017), BWP 2017, MTN 2017)

Ans: ***Given on Page # 312***

Q.3 What happens when a narrow beam of electrons is passed through a uniform electric field? ***(K.B+U.B)***

Ans: ***Given on Page # 313***

Q.4 What is the function of electromagnet in television? *(K.B)* **(Do you know Pg. # 142)**

Ans: **FUNCTION OF ELECTROMAGNET**

Electromagnets are used to deflect electrons to these desired positions on the screen of a television tube.

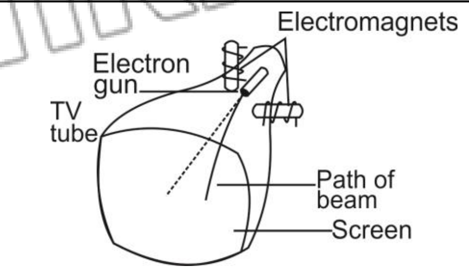


Figure: CRO in Television

Q.5 What happens when a narrow beam of electrons is passed through a uniform magnetic field? *(K.B+U.B)* **(LHR 2015, GRW 2014)**

Ans: ***Given on Page # 313***

Q.6 When and who discovered electrons? *(K.B)*

Ans: **DISCOVERY OF ELECTRONS**

1n the 1850's physicists stared to examine the passage of electricity through vacuum by putting two electrodes in a sealed vacuum tube. They discovered that some kind of rays were emitted from the cathode or the negative electrode, these rays were called cathode rays. J.J Thomson in 1897 observed the deflection of cathode rays by both electric and magnetic field. From these deflection experiments, he concluded that cathode rays must carry a negative charge. These negatively charged particles were given the name of electrons.

Q.7 How thermionic emission is produced? *(K.B)*

Ans: **PRODUCTION OF THERMIONIC EMISSION**

Metals contain a large number of free elections. At room temperature electrons cannot escape the metal surface due to attraction forces of atomic nucleus. If the metal is heated to a high temperature some of the free electrons may gain sufficient energy to escape the metal surface.

Q.8 What is cathode – rays oscilloscope (C.R.O)? *(K.B+A.B)* **(DGK 2017)**

Ans: ***Given on Page # 313***

Q.9 Describe functions of the electron gun. *(K.B+A.B)* **(LHR 2014)**

Ans: ***Given on Page # 314***

Q.10 Write down uses of CRO. *(A.B)* **(SGD 2017)(Review Ex. 16.3)**

Ans: ***Given on Page # 314***

Q.11 What are the components of CRO? *(K.B)* **(SGD 2017, DGK 2017, SHW 2017)**

Ans: ***Given on Page # 314***

Q.12 How glow is produced in the tube? *(K.B)* **(Do you know Pg. # 143)**

Ans: **PRODUCTION OF GLOW IN THE TUBE**

The glow in the tube is due to the circular motion of electrons in the magnetic field. The glow comes from the light emitted from the excitations of the gas atoms in the tube.

Figure: Glow in the Tube

Q.13 What are the functions of deflecting plates in CRO? *(K.B+A.B)* **(LHR 2015)**

Ans: **<u>FUNCTIONS OF DEFLECTING PLATES</u>**

The functions of deflecting plates in CRO are given below:

- After leaving electron gun, the electron beam passes between a pair of horizontal plates.
- A potential difference applied between these plates deflects the beam in a vertical plane.
- This pair of plates provides the Y-axis or vertical movement of the spot on the screen.
- A pair of vertical plates provides the X-axis or horizontal movement of the spot on the screen.

Q.14 What is fluorescent screen? *(K.B)* **(FSD 2017, BWP 2017)**

Ans: ***Given on Page # 314***

Q.15 Why beam of electron is called cathode ray? *(K.B)* **(Do you know Pg. # 143)**

Ans: **<u>CATHODE RAY</u>**

The beam of electrons was called a cathode ray, because the electron had not yet been discovered. The old terminology survives in electronic engineering where a cathode-ray tube is any tube constructed along Thomson's lines whether in a computer, monitor, a television, or an oscilloscope.

Q.16 How we came to know about the cathode rays? *(K.B)* **(For your information Pg. # 140)**

Ans: **<u>EVIDENCE OF CATHODE RAYS</u>**

In a cathode-rays tube, a greenish glow is formed on the inner surface of the glass opposite the cathode, which itself is glowing orange. The shadow cast by the cross at the centre of the tube gives evidence that rays of some kind are passing through the tube.

Q.17 How we can say that cathode rays move in a straight line? *(K.B)* **(Physics Insight Pg. # 140)**

Ans: **<u>STRAIGHT LINE MOTION OF CATHODE RAYS</u>**

When an opaque object like a metal cross is placed in the path of cathode rays in a cathode ray tube, a shadow of the metal cross is formed at the end opposite to the cathode. This is an evidence that rays of some kind are passing straight through the tube.

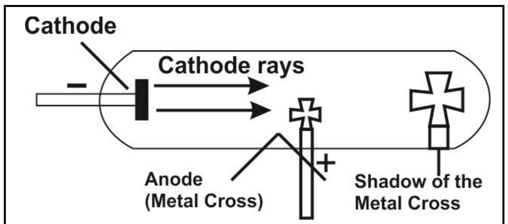


Figure: <u>Straight Line Motion of Cathode Rays</u>

Q.18 In what ways an oscilloscope acts as a voltmeter? ***(K.B+U.B)***

Ans: **OSCILLOSCOPE AS VOLTMETER**

In order to use oscilloscope as a voltmeter, switch OFF the time base and connect the voltage to be measured to the Y-input terminals. In this way the deflection of the spot would be vertically. The deflections is proportional to potential difference, which is to be measured. In this way the input of CRO (i.e. internal resistance between Y-inputs terminals) is very height, typically several million ohms. This makes an oscilloscope very nearly an ideal voltmeter.

Q.19 When a magnet is brought near to the screen of a television tube picture on the screen is distorted. Do you know why? ***(K.B+U.B)*** **(Point to ponder Pg. # 142)**

Ans. **DISTORTION OF TV SCREEN**

Electromagnets are used to deflect electrons to the desired positions of the screen of a television tube to produce clear picture. When a magnet is brought near to the screen of the television tube, the spot of the electrons beam on the screen is distorted.

Q.20 How cathode ray will deflect when it is under the inference of magnetic field. ***(K.B+U.B)***

Ans. **DEFLECTION OF CATHODE RAYS**

A Cathode ray will deflect as shown when it is under the influence of an external magnetic field.

Figure: **Deflection of Cathode Ray in Magnetic Field**

Q.21 Is it possible for us to pass electric current through vacuum? ***(Conceptual Base)***

Ans. Current can flow through vacuum when charge carriers, electrons or ions, are transported across it. A good example are electronic vacuum tubes where electrons are emitted from a heated cathode filament and transported through vacuum by an applied electric field to a positively charged anode. The current is often controlled by applying a voltage to a grid in the path of this electron flow.

Q.22 How the pattern of electric current is produce on the fluorescent screen of CRO? ***(Conceptual Base)***

Ans. The pattern of electric current is produce on the fluorescent screen of CRO when the electron produce from electron gun strike on thin layer of phosphor of fluorescent screen it produce light and draw a pattern of electric current.

Q.23 Why the negative charge on the grid is not keep minimum for a long time? ***(Conceptual Base)***

Ans. The grid in CRO is used to control the brightness of CRO screen. If the negative charge on grid is minimum the number of electron striking on the screen is maximum and the brightness of screen is maximum. So when the brightness of screen is maximum for a long time it will destroy the screen.

16.1,16.2,16.3 MULTIPLE CHOICE QUESTIONS

1. **The branch of applied physics which deals with the behaviour of electrons using different devices for various useful purposes is: *(K.B)***
(A) Light (B) Mechanics
(C) Thermodynamics (D) Electronics

2. **Who observed the deflection of cathode rays by both electric and magnetic fields? *(K.B)***
(A) Newton (B) J.J Thomson
(C) Plank (D) Charles

3. **Cathode rays contain negatively charged particles called: *(K.B)***
(A) Neutrons (B) Protons
(C) Electrons (D) Positrons

4. **The process of emission of electrons from the hot metal surface is called: *(K.B)*(GRW 2014)**
(A) Dynamic emission (B) Electronic emission
(C) Thermionic emission (D) Static emission

5. **Metals contain large number of: *(K.B)***
(A) Free electrons (B) Free protons
(C) Free neutrons (D) Bound electrons

6. **For thermionic emission typical values of voltage and current used are: *(K.B)***
(A) 3v, 0.4A (B) 6V, 0.3A
(C) 5V, 0.3A (D) 6V, 0.1A

7. **Electron gun is used to investigate the properties of: *(K.B)***
(A) Electron beam (B) Nucleus
(C) Neutron (D) Proton

8. **The degree of deflection of electrons from their original direction is proportional to: *(K.B+U.B)***
(A) The speed of electrons (B) The strength of the electric field applied
(C) The amount of current (D) The potential difference

9. **A component of cathode-ray oscilloscope (C.R.O) is: *(K.B)***
(A) The electron gun (B) The deflecting plates
(C) A fluorescent screen (D) All of given

10. **Electron gun has an electrode for controlling the flow of electron in the beam: *(K.B)***
(A) Grid C (B) Grid A
(C) Grid B (D) Grid G

11. **The screen of a cathode-ray tube consists of a thin layer of: *(K.B)***
(A) Aluminium (B) Potassium
(C) Phosphor (D) Sulphur

12. **Cathode-ray oscilloscope (C.R.O) is used in many field of science for: *(A.B)***
(A) Displaying waveforms (B) Measuring voltages
(C) Range-finding (D) All given are true

13. **To find the depth of sea-beds, C.R.O is used as: *(A.B)***
(A) Echo-sounding (B) Displaying waveforms
(C) Measuring voltage (D) Range finding

14. **Deflecting plate is a component of ________. (BWP 2017)**
(A) Computer (B) C.R.O
(C) Radio (D) Fluorescent tube

15. When we heat a metal at high temperature they emit ____. *(K.B)*
(A) Hole (B) Neutron
(C) Proton (D) Electron

16. C.R.O consists of _____ main parts. *(K.B)*
(A) Five (B) Four
(C) Three (D) Two

16.4 ANALOGUE AND DIGITAL ELECTRONICS
16.5 BASIC OPERATIONS OF ELECTRONIC-LOGIC GATES

LONG QUESTION

16.4 Q.1 Write a note on analogue and digital electronics. *(A.B+K.B)* **(LHR 2015, 2017) (Review Ex. 16.6)**

Ans: ANALOGUE AND DIGITAL ELECTRONICS

Analogue quantities:
Those quantities whose values vary continuously are known as analogue quantities.

Example:
The temperature of air varies in a continuous fashion during 24 hours of a day. If we plot a graph between time and temperature recorded at different times, we get a graph.
This graph shows that the temperature varies continuously with time. Therefore temperature is an analogue quantity. Similarly time, pressure, distance etc., are analogue quantities.

Analogue Electronics:
The branch of electronics consisting of circuits which processes analogue quantities is called analogue electronics.

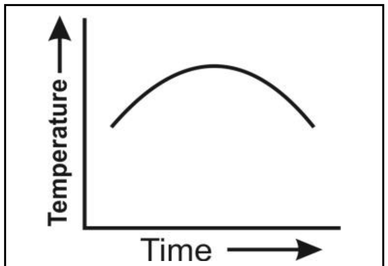


Figure: Temperature Time Graph

Example:
For example the public address system is an analogue system in which the microphone converts sound into a continuously varying electric potential. This potential is an analogue signal which is fed into an amplifier. Amplifier is an analogue circuit which amplifies the signal without changing its shape to such an extent that it can operate a loudspeaker. In this way loud sound is produced by the speaker.
Other examples of analog electronics are:

- Radio
- Television
- Telephone

Digital Quantities:
The quantities whose values vary in discrete steps are called digital quantities.

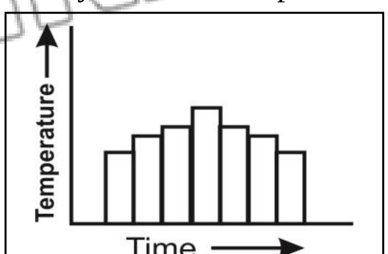


Figure: Temperature Time Graph

Digital quantities are expressed in the form of digits or numbers.

Digital Electronics:

"The branch of electrons which deals with the digital quantities is called digital electronics**"**.

For this purpose digital electronics uses only two digits 0(zero) and 1 (one) and the whole data is provided in binary system due to which processing of data becomes easy.

Examples:

- For quite a long period the use of digital electronics was limited to computers only, but now-a-days its application is very wide spread.
- Modern telephone system
- Radar system
- Naval and other systems of military importance
- Devices to control the operation of industrial machines
- Medical equipments
- Household appliances

Analogue Signal:

A continuously varying signal is called an analogue signal.

Example:

An alternating voltage varying between the maximum value of +5V and the minimum value of -5V is an analogue signal.

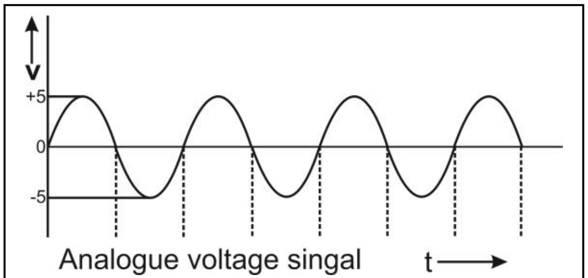


Figure: Analog Signal

Digital Signal:

A signal can have only two discrete values is called a digital signal.

Example:

A voltage with square waveform is a digital signal. This signal has only two values +5V and 0V. The high voltage is +5V and the low voltage is 0V.

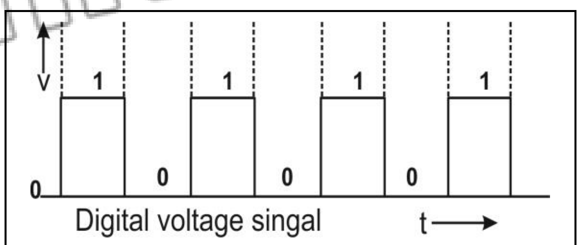


Figure: Digital Signal

Analogue to Digital Converter (ADC):

"A circuit has been designed which converts the analogue signal into a digital one in the form of digits. This circuit is known as analogue to digital converter, i.e., ADC".
When we get an analogue signal in the form of digits, we can process it with digital circuit, the output of which is also in digital form.

Digital to Analogue Converter (DAC):

"A circuit that is designed to convert digital output into analogue form by a circuit known as digital to analogue converter (DAC)".
As the output of DAC is an analogue signal, it can be readily sensed by us. Thus electronic systems used at present consist of both analogue and digital type circuits.

S	Lamp
Open	Off
Closed	On

16.4 Q.2 What is use of ADC and DAC? Briefly explain? *(K.B+A.B+U.B)*

Ans: ADC AND DAC

In our daily life the quantities that we perceive by our senses are usually analogue quantities which cannot be processed by digital circuits. To overcome this problem different circuits has been designed which convert analogue quantities into digital quantities and digital quantities into analogue quantities are per required. There circuits are known as ADC and DAC.

Analogue to Digital Converter (ADC):

"A circuit has been designed which converts the analogue signal into a digital one in the form of digits. This circuit is known as analogue to digital converter, i.e., ADC".
When we get an analogue signal in the form of digits, we can process it with digital circuit, the output of which is also in digital form.

Digital to Analogue Converter (DAC):

"A circuit that is designed to convert digital output into analogue form by a circuit known as digital to analogue converter (DAC)".
As the output of DAC is an analogue signal, it can be readily sensed by us. Thus electronic systems used at present consist of both analogue and digital type circuits.

16.5 Q.1 What is meant by binary (Boolean) variables? Explain with example. *(K.B+U.B+A.B)*

Ans: BOOLEAN VARIABLES

"The variables which have only two possible states are knows as binary variables".

Explanation:

There are many things which have two possible sates e.g.

- A switch could be either open or closed.
- A circuit may be either ON or OFF.
- A statement would be either true or false.
- The answer of a question could be right or wrong.

All three things which have only two possible states are called binary (Boolean) variables.

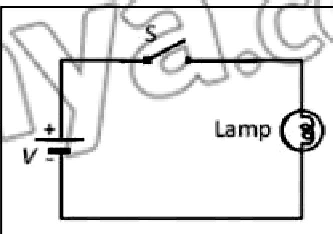


Figure: Circuit Diagram

Representation of Binary Variables:

The state of binary variables are usually represented by the digits '0' and '1'.

Example:

Suppose we form a circuit by connecting a lamp to battery using a switch 'S'. We call the state of switch as input and state of current or lamp as output.

Switch and Lamp are Binary Variables:

When the switch is open no current passes through the circuit and lamp is OFF. In other words when input is zero output is also zero.

When the switch is closed current passes through the circuit and the lamp is ON. Both switch and lamp have value '1'. Hence switch and lamp (Current) both have two possible states Zero (0) and one (1). Therefore, they are considered as binary variables. These states are called logic states and logic variables.

16.5 Q.2 What is meant by Boolean Algebra? Explain its importance. ***(K.B+A.B)***

Ans: **BOOLEAN ALGEBRA**

George Boole invented Boolean Algebra. It is also known as algebra of logics.

Definition:

"It is the branch of mathematics that deals with the relationship of logic variables**''**.

Application:

By using Boolean algebra the values of output variables are determined when the values of input variables of circuit or system are known. Boolean Algebra handles variables that represent two types of logic propositions! 'true and false'.

Importance:

Boolean algebra has become the foundation of digital electronic.

- It operates with two logic states '1' and '0' represented by two distinct voltage levels.
- It interpret the logical operators AND, OR and NOT.
- It develop a systematic complex digital systems.
- Simple logic gates perform the simple mathematical as well as intricate logical operations.
- Logic operations are considered as combination of switches.

16.4, 16.5 SHORT QUESTIONS

Q.1 Define digital and analogue electronics. ***(K.B)***

(MTN 2017, SGD 2017, RWP 2017, FSD 2017, LHR 2015, 2016, GRW 2014)

OR Explain the difference between analogue and digital electronics. **(Review Ex. 16.7)**

Ans: *Given on Page # 319*

Q.2 Name five analogue and five digital devices that are commonly used in everyday life. ***(K.B+A.B)*** **(Review Ex. 16.7)**

Ans: **NAMES OF ANALOGUE AND DIGITAL DEVICES**

The names of analogue and digital devices are as follows:

Analogue Devices:

- Electric iron
- Electric fan
- Radio receiver
- Refrigerator
- Washing machine

Digital Devices:

- Computer
- Calculator
- Digital camera
- Mobile phone
- Security system

Q.3 Write the importance of digital electronics? ***(K.B+A.B)*** **(For your information Pg. # 145)**

Ans: **IMPORTANCE OF DIGITAL ELECTRONICS**

Digital technology has entered every part of our lives. Digital TV gives excellent view and allows us to be interactive. Digital cameras are faster replacing traditional film equipment. We can download an image into a PC and crop, enhance, airbrush and edit the picture. Smart ID cards are being developed. A single card can be a passport, national insurance card and driving license all in one. The card could also hold biometric data like an eye retina scan and voice scan for unique identification and security. All of this data would be held digitally in the tiny chip.

Q.4 What is meant by logic operation? ***(K.B)***

Ans: **LOGIC OPERATION**

Digital circuits perform the binary arithmetic operation with binary digits '1' and '0'. These operations are called logic function or logic operations.

Q.5 What do you meant by logic gate? ***(K.B)***

Ans: **LOGIC GATES**

Logic gate is a switch (digital circuit), its outputs can have only one of the two possible states. Such circuits have been designed which implement the various logic operations. These circuits are known as logic gates.

Q.6 What are basic operations of digital electronics? ***(K.B)*** **(FSD 2017)**

Ans: **BASIC OPERATIONS OF DIGITAL ELECTRONICS**

Basic operations of digital electronics are:

- AND operation
- OR operation
- NOT operation

Q.7 Briefly introduce Boolean algebra. ***(K.B)*** **(Intro. to Boolean algebra Pg. # 146)**

Ans: **INTRODUCTION OF BOOLEAN ALGEBRA**

The algebra used to describe logic operations by symbols is called Boolean Algebra. Like ordinary algebra, English alphabets (A, B, C, etc.) and used to represent the Boolean variables. However, Boolean variable can have only two values; 0 and 1.

Q.8 Why TV and telephone signals has been transformed from analogue to digital? ***(K.B)***

(Do you know Pg. # 146)

Ans: **TRANSFORMATION OF ANALOGUE SIGNALS TO DIGITAL SIGNALS**

TV and telephone signals once travelled as analogue signals. Electric signals in copper wire would interfere with each other and give poor quality of sound and vision. Today, everything is going digital. The big advantage of digital is quality. There is no interference or loss of strength in digital signals travelling in an optical fiber.

Q.9 Show analogue signal of microphone. ***(K.B)*** **(Do you know Pg. # 144)**

Ans: Microphone creates an analogue signal, shown by the voltage versus time graph.

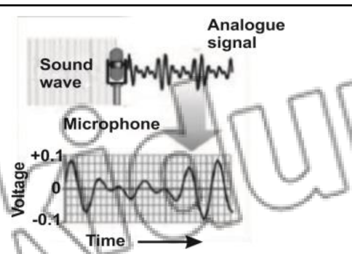


Figure: Analogue Signal by Microphone

16.4, 16.5 MULTIPLE CHOICE QUESTIONS

1. Analogue quantities are: ***(K.B)***

(A) Whose values vary continuously (B) Whose values remain constant
(C) Temperature of air (D) All of given are true

2. Time , pressure, distance are all: ***(K.B)***

(A) Analogue quantities (B) Variable quantiites
(C) Nominal quantities (D) Digital quantities

3. Which is an analogue circuit which amplifies the signals without changing its shape to such an extent that it can operate a loudspeaker? *(K.B)*
(A) Galvanometer (B) Manometer
(C) amplifier (D) Optical fiber

4. The quantities whose value vary in non – continuous manner are called: *(K.B)*
(A) Analogue quantities (B) Digital quantities
(C) Statistic quantities (D) Continuous quantiies

5. Those quantities whose value vary continuously or remain constant: *(K.B)*
(A) Analogue (B) Digital
(C) Hybrid (D) All of them

6. Which of the following is an analogue device? *(K.B)*
(A) Electric fan (B) Electric iron
(C) Radio receiver (D) All of them

7. Electronics which provides the data in the form of maximum and minimum voltage signals: *(K.B)*
(A) Analogue (B) Digital
(C) Hybrid (D) All of them

8. Which of the following are digital devices? *(K.B)*
(A) Computer (B) Mobile phone
(C) Digital camera (D) All of them

9. Circuits which convert the digital signal into analogue signals: *(K.B)*
(A) ADC (B) DAC
(C) CAD (D) None of them

10. Circuits which convert the analogue signal into digital signal: *(K.B)*
(A) ADC (B) DAC
(C) CAD (D) None of them

11. Digital electronics uses two digits. *(K.B)*
(A) 0,2 (B) 0,3
(C) 0,1 (D) 0,4

12. A switch has only possible states. *(K.B)*
(A) Two (B) Three
(C) Four (D) Five

13. The states of binary variables are usually represented by the digits: *(K.B)*
(A) 1,2 (B) 0,2
(C) 0,3 (D) 0,1

14. George Boolean invented a special algebra known as algebra of logics or ________.*(K.B)*
(A) Boolean algebra (B) Geometry
(C) Ratios (D) Trigonometry

15. Boolean algebra operates with two logic states represented by two distinct voltage level. *(K.B)*
(A) 0,2 (B) 0,3
(C) 1,0 (D) 1,1

16. The number of operations of Boolean algebra are: *(K.B)*
(A) 1 (B) 2
(C) 3 (D) 4

17. In Boolean algebra zero represents: *(K.B)*
(A) Zero potential (B) Ground potential
(C) Low potential (D) Both a & b

18. In Boolean algebra 1 represents: *(K.B)*
(A) 5V (B) 1V
(C) Both a & b (D) None of above

16.6 AND OPERATION
16.7 OR OPERATION

LONG QUESTION

16.6 Q.1 What is AND operation? Explain in possible states. Write its symbol, Expression and gate? *(K.B+A.B+U.B)*
(LHR 2015, 2017, GRW 2014, 2016, DGK 2017, MTN 2017, SHW 2017)(Review Ex. 16.10)

Ans: **AND OPERATION**

"AND operation is such a logic operation that its output is 1 only when all the values of its inputs are 1".

Explanation:
In order to understand the logic AND operation, we consider a circuit in which a lamp is connected to a battery using two switches S_1 an S_2 connected in series. These switches are considered as inputs and lamp is an output, this circuit is given as.

Possible States:
There are four possible states of two switches are given as

(i) When S_1 and S_2 are both open, the lamp is OFF.
(ii) When S_1 is open and S_2 is closed, the lamp is OFF.
(iii) When S_1 is closed and S_2 is open, the lamp is ON.
(iv) When both S_1 and S_2 are closed, the lamp is OFF.

These states of switches and lamp are shown in table. It is clear from table that when either of the switches (S_1 and S_2) or both are open, the lamp is OFF. When both switches are closed, the lamp is ON.

S_1	S_2	Lamp
Open	Open	OFF
Open	Closed	OFF
Closed	Open	OFF
Closed	Closed	ON

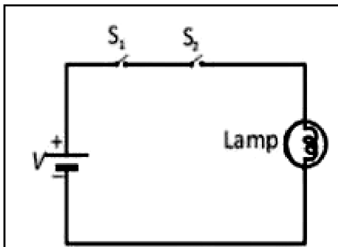


Figure: Circuit Diagram of AND Operation

Symbol and AND Operation:
Symbol for AND operation is dot (.)

Expression:
Boolean expression of AND operation is
X = A.B
This expression is read as
"X equals to A AND B

Truth Table:
"Set of inputs and outputs in binary from is called truth table".

In binary language, when either of the inputs or both the inputs are low (0,, the output is slow (0). When both the inputs are high (1), the output is high (1).

These relationship are shown in table. Where 'X' represent the output. Hence AND operation may be represented by switches concede in series and each switch represents an input.

A	B	X = A.B
0	0	0
0	1	0
1	0	0
1	1	1

Important Results:

- When two switches are close i.e. the inputs of the AND operation are at logic '1', The output and AND operation will be at logic '1'.
- When two switches are open i.e. the inputs of AND operation are at logic '0', the output of AND operation will be at logic '0'.

AND Gate:

"The circuit which implements the AND operation is known as AND gate".

Symbol and AND Gate:

Symbol of AND operation is given as:

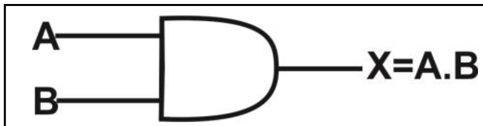


Figure: Symbol of AND Operation

AND gate has two or more than two inputs and only one output. The value of output of AND gate is always in accordance with the truth table of AND operation. It means output of AND gate will be '1' only when all are of its input at logic '1'and for all other situations output of AND gate will be '0'.

16.7 Q.1 What is OR operation? Explain its possible states. Write its symbol, expression and gate? *(K.B+A.B+U.B)*

(GRW 2014, 2016, 2017, FSD 2017, BWP 2017)(Review Question 16.10)

Ans: **OR OPERATION**

"The logical operation in which the value of output variable is equal to 1 when any one of the both input variables have value equal to 1".

Explanation:

In order to under the logic OR operation we consider a circuit in which a lamp is connected to a battery using two switches, $S_1$and S_2 connected in parallel considered as two inputs.

Possible States:

There are four possible states which are given as:

(i) When S_1 and S_2 are open the lamp is OFF.
(ii) When S_1 is open and S_2 closed the lamp is ON.
(iii) When S_1 is closed and S_2 open the lamp is ON.
(iv) When both S_1 and S_2 are closed the lamp ON.

S_1	S_2	Lamp
Open	Open	OFF
Open	Closed	ON
Closed	Open	ON
Closed	Closed	ON

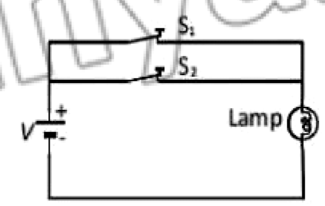


Figure: <u>Circuit Diagram of OR Operation</u>

All possible states of the lamp and switches are shown on the table given below.
It is clear from table that the lamp will glow if at least one of the switch i.e. S_1 and S_2 is closed (at logic '1')

Symbol of OR Operation:
OR operation is represented by the symbol of plus (+).

Expression:
Boolean expression for OR operation is given as:

$$X = A + B$$

This expression is read as:
"X equals to A OR B"

Truth Table:
"Set of inputs and outputs in binary form is called truth table".
Truth table of OR operation is shown as:

A	B	X=A+B
0	0	0
0	1	1
1	0	1
1	1	1

Hence OR operation may be represented by switches connected in parallel, since only one of these parallel switches need to turn on in order to flow current in the circuit.

OR Gate:
The electronic circuits which implements the OR operation is known as OR gate".

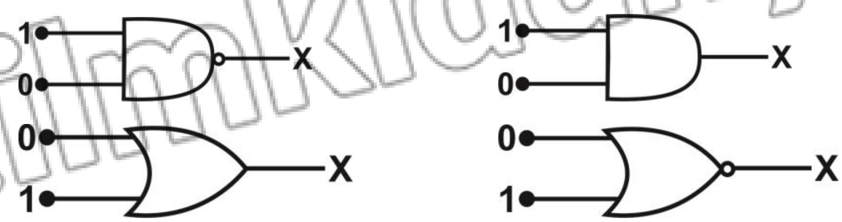
Symbol of OR Gate:
Symbol of 'OR' gate is given below.

Figure: <u>Symbol of OR Gate</u>

OR gate has two or more than two inputs and has only one output. The values of output of OR gate are always in accordance with the truth table of OR operation. It means value of output of OR gate will be '1' when anyone of its inputs is at '1' the value of output will be '0'. when both inputs are at '0'.

16.6, 16.7 SHORT QUESTIONS

Q.1 Which of the following gates would have 1 as output. *(K.B+U.B)*



Ans: a and d gates would have 1 as output.

Q.2 Define OR operation. *(K.B)* **(LHR 2017, MTN 2017)**

Ans: ***Given on Page # 326***

Q.3 Write down Truth table of OR gate *(K.B+U.B)*

Ans: **TRUTH TABLE OF OR OPERATION**

The truth table of OR gate is given below:

A	B	X = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Q.4 Define AND operation. *(K.B)* **(RWP 2017)**

Ans: ***Given on Page # 325***

Q.5 Write down Truth table of AND gate. *(K.B+U.B)* **(LHR 2017, GRW 2016)**

Ans: **TRUTH TABLE OF AND OPERATION**

Truth table shows all the values of the input variables and the value of output for each set of the values of the inputs.

A	B	X = A.B
0	0	0
0	1	0
1	0	0
1	1	1

Q.6 Define Truth table. *(K.B)*

Ans: **TRUTH TABLE**

Definition:

"Set of inputs and outputs in binary form is called truth table".

16.6, 16.7 MULTIPLE CHOICE QUESTIONS

1. **The logical operation, whose output will only be one if its all inputs are 1: *(K.B)***
   (A) AND (B) OR
   (C) NOT (D) All of above
2. **The logical operation, whose output will only be zero if its all inputs are zero: *(K.B)***
   (A) AND (B) OR
   (C) NOT (D) All of above
3. **AND operation is just like _________ combinations of resistors. *(K.B)***
   (A) Series (B) Parallel
   (C) Both (D) None of above

4. **AND operations is represented by: *(K.B)***
(A) Dot (•) (B) Multiplication sign
(C) Any sign (D) Both a & b

5. **OR operation is just like _________ combinations of resistors. *(K.B)***
(A) Serial (B) Parallel
(C) Both (D) None of above

6. **OR operations is represented by: *(K.B)***
(A) Dot (•) (B) Multiplication sign
(C) '+' sign (D) Both a & b

7. **The various operations of Boolean variables are also called: *(K.B)***
(A) Boolean constants (B) Algebraic operations
(C) Logic operations (D) Both b & c

8. **The circuit which implements the AND operation is called: *(K.B)***
(A) AND gate (B) AND circuit
(C) OR gate (D) Both a & b

9. **The circuit which implements the OR operation is called: *(K.B)***
(A) AND gate (B) OR circuit
(C) OR gate (D) Both b & c

10. **In case of OR operation the lamp is Off when: *(K.B)***
(A) S_1 and S_2 are open (B) S_1 is open and S_2 is closed
(C) S_1 is closed and S_2 is open (D) S_1 and S_2 are closed

11. **OR operation is represented by the symbol of (+) and Boolean expression for OR is: *(K.B)***
(A) $x = A + B$ (B) $x = A - B$
(C) $x + A = A$ (D) $X = \overline{A+B}$

12. **The output of OR operation is 0 when: *(K.B)***
(A) A = 0, B = 0 (B) A = 1, B = 1
(C) A = 0, B = 1 (D) A = 1, B = 0

16.8 NOT OPERATION
16.9 NAND GATE

LONG QUESTIONS

16.8 Q.1 What is meant by NOT operation? Explain its possible states, write its symbol, Expression and gate. *(K.B+U.B+A.B)* **(LHR 2015)(Review Question 16.10)**

Ans: **NOT OPERATION**

"A logical operation which changes the state of binary (Boolean) variable".

OR

"Not operation inverts the value of Boolean variable".

Explanation:

In order to understand NOT operation, we consider a circuit in which a lamp is connected to a battery with a switch 'S in parallel way.

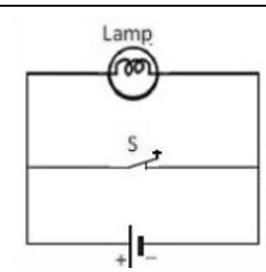


Figure: Circuit Diagram of NOT Gate

Possible States:

NOT operation has only one input and only one output. There are two possible sates.

- When the switch "S' is open , the current will pass through the lamp and it will glow.
- When the switch is closed, no current will pass through the lamp due to large resistance of its filament and it will not glow.

S	LAMP
OFF	ON
ON	OFF

Symbol of NOT operation:

NOT operation is represented by a line or bar over the symbol i.e . $X = \overline{A}$.

Expression:

Boolean expression for NOT operation is given as:

$$X = \overline{A}$$

This is read as: "X equals A NOT".

Truth Table:

"A set of inputs and outputs in binary form is called truth table". If the value of Boolean variable is 1, then after NOT operation it values would change to 0. Similarly, if it values before NOT operation, then after NOT operation it would change to '1'.

A	$X = \overline{A}$
0	1
1	0

"Thus NOT operation inverts the state of Boolean variable".

NOT Gate:

The electronic circuit which implements NOT operation is known as NOT gate.

Symbol of NOT Gate:

The symbol of NOT gate is given as NOT gate has only one input and one output terminal NOT gate works in such a way that if its input is '0' is output would be '1'. It its input is '1' the nits output would be '0'. Not gate performs the basic logical function called inversion of complementation. Not gate is also called inverter.

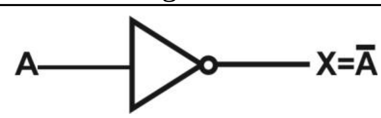


Figure: Symbol of NOT Gate

Purpose of Gate:

The purpose of this gate is to convert one logic to opposite logic level into the opposite logic level. When a high level is applied to an inverter, a low level appears on its output in vice versa.

16.9 Q.1 What is NAND gate? Explain its symbol. Express and Truth table? *(K.B+U.B+A.B)*

(LHR 2017, GRW 2014)

Ans: **NAND GATE**

NAND operation is simply AND operation followed by a NOT operation. "the NAND gate is obtained by coupling a NOT gate with the output terminal of the AND gate".

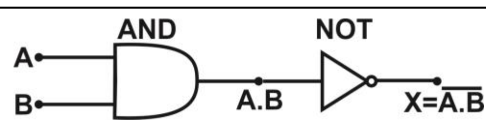


Figure: Symbol of NAND Gate

Symbol of NAND Gate:
Symbol of NAND gate is given as:
The NOT gate inverts the output of the AND gate.
Short Symbol of NAND Gate:
In this symbol the NOT gate has been replaced with a small circle. this small Circle attached to a the output of NAND gate shows NOT operation.

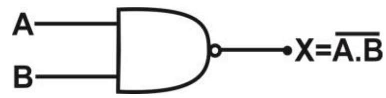


Figure: Short Symbol of NAND Gate

Expression:
Boolean expression for NAND operation is described as:
The output of the NAND gate equals A.B and is written as:

$$X = \overline{A.B}$$

It is read as

"X equals A AND B NOT".

Truth Table:

B	A	$X = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

Hence it is clear form table that inverts the output of the NAND gate.

16.8, 16.9 SHORT QUESTIONS

Q.1 Which gate perform logic complementations? *(K.B)* **(SHW 2017)**
OR Define NOT Gate. **(RWP 2017)**
Ans: **NOT GATE**
Definition:
"An operation after which the Boolean variable changes its state and acquires the second possible state is known as NOT operation**"**.
NOT gate performs logic complementation.

Q.2 Write down Truth table of NOT gate. *(U.B+K.B)*
Ans: ***Given on Page # 330***

Q.3 Define NAND Gate. *(K.B)* **(BWP 2017)**
Ans: ***Given on Page # 330***

Q.4 Write down Truth table of NAND gate. *(U.B+K.B)* **(BWP 2017)**
Ans: ***Given on Page # 331***

Q.5 Write down the purpose of NOT Gate? *(K.B+A.B)*
Ans: **PURPOSE OF NOT GATE**
The purpose of NOT gate is as follows:
The purpose of this gate is to convert one logic to opposite logic level into the opposite logic level. And a high level is applied to an inverter, a low level appears on its output in vice versa.

16.8, 16.9 MULTIPLE CHOICE QUESTIONS

1. **NOT operation is represented by: *(K.B)***
(A) line (B) bar over the symbol
(C) both A & B (D) (.) dot

2. **Value of a Boolean variable 1 after NOT operation is: *(K.B+U.B)***
(A) 0 (B) +1
(C) -1 (D) -2

3. **After NOT operation the value of Boolean variable 0 is: *(K.B+U.B)***
(A) 0 (B) +1
(C) -1 (D) 1

4. **NOT gate is also called: *(K.B)***
(A) converter (B) inverter
(C) adder (D) subs tractor

5. **NAND operation is simply an AND operation followed by a: *(K.B)***
(A) NOR operation (B) OR operation
(C) NOT operation (D) AND operation

6. **NOT operation is also known as: *(K.B)***
(A) Gate (B) Inverter
(C) Converse (D) All of above

7. **Number of input(s) of NOT operation are: *(K.B)***
(A) 1 (B) 2
(C) 3 (D) 4

8. **The circuit which is used to implement NOT operation: *(K.B)***
(A) AND gate (B) NOT gate
(C) OR gate (D) Both a & b

9. **NAND gate is the combination of: *(K.B)***
(A) AND & OR (B) AND & NOT
(C) NOT & OR (D) None of them

10. **A and B are two inputs of NAND gate. Its output would be zero when: *(K.B)***
(A) A=0, B=0 (B) A=1, B=0
(C) A=0, B=1 (D) A=1, B=1

11. **The equation of NOT operation is ________.*(K.B)*** **(GRW 2016)**
(A) X = A. B (B) X = A + B
(C) X = A – B (D) $X = \overline{A}$

12. **The output of NAND gate is 0 when _______ . *(K.B)*** **(RWP 2017)**
(A) A=0, B=0 (B) A=1, B=1
(C) A=0, B=1 (D) A=1, B=0

16.10 NOR GATE
16.11 USES OF LOGIC GATES

LONG QUESTIONS

16.10 Q.1 What is NOR gate? Explain its symbol, expression and truth table? *(K.B+A.B+U.B)*

(LHR 2014, GRW 2014)

Ans: **<u>NOR GATE</u>**

The NOR operation is simply an OR operation followed by a Not operation. " The NOR gate is obtained by coupling the output of the OR gate with NOT gate".

<u>Symbol of NOR Gate</u>:

The symbol of NOR gate is given as: For the same combination of inputs, the output of a NOR gate will be opposite to that of an OR gate.

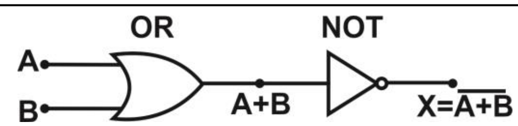


Figure: <u>Symbol of NOR Gate</u>

<u>Short Symbol of NOR Gate</u>:

In this symbol the NOT gate has been replaced with a small circle. In the symbol lf NOR gate, this small circle attached at the output of OR gate shows NOT operation, its fig is given as.

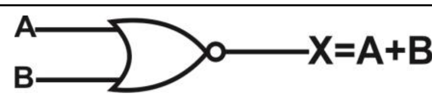


Figure: <u>Short Symbol of NOR Gate</u>

<u>Expression</u>: **(BWP 2017)**

Boolean expression for NOR operation is describes as:

$$X = \overline{A + B}$$

It is read as: "X equals A OR B NOT".

<u>Truth Table</u>:

B	A	$X = \overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

" A set of inputs and outputs in binary form is called truth table".

16.11 Q.1 What is the use of logic gates? Explain with one example. *(K.B+U.B+A.B)*
(GRW 2014)

Ans: **<u>USES OF LOGIC GATES</u>**

We can use logic gates in electronic circuits to do useful tasks. These circuits usually use light depending resistors (LDRs) to keep inputs LOW. An LDR can act as a switch that is closed when illuminated by light and open in the dark.

House Safety Alarm:

We can use single NAND gate to make burglar alarm. This can be done by using NAND gate, an LDR, a push – button switch S and an alarm. Connect LDR between NAND gate input B and the positive terminal of the battery. the LDR will cause a HIGH level input '1' at B when in light because of its low resistance. The LDR will cause a LOW level input '0' at B when light is interrupted and causes high resistance in LDR. A LOW level signal is also caused at A when burglar steps on switch S. So this burglar alarm sounds when either burglar interrupts light falling on LDR or steps on switch S.

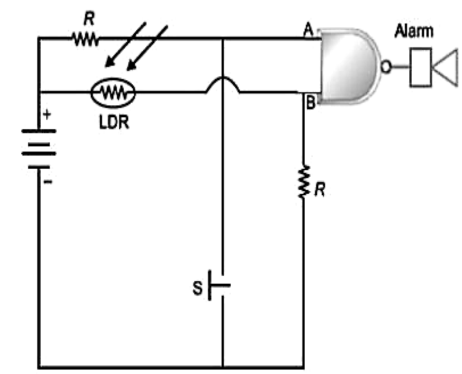


Figure: **Burglar Alarm Schematic Circuit**

16.10, 16.11 SHORT QUESTIONS

Q.1 Define NOR Gate. ***(K.B)***

Ans: ***Given on Page # 333***

Q.2 Write down Truth table of NOR gate. ***(K.B+U.B)*** **(LHR 2014, 2015)**

Ans: ***Given on Page # 333***

Q.3 What is bit and byte? ***(K.B)*** **(For your information Pg. # 151)**

Ans: **BIT AND BYTE**

A bit represents data using 1' and 0's.

Eight bits is equal to 1 byte.

Q.4 What is digitization? ***(K.B)*** **(For your information Pg. # 151)**

Ans: **DIGITIZATION**

Digitization is the process of transforming information into 1's and 0's.

Q.5 Assume you have an OR gate with two inputs, A and B. Determine the output C, for the following cases: ***(U.B)*** **(Quick Quiz Pg. # 151)**

(a) A = 1, B = 0 (b) A = 0, B = 1

If either input is one, what is the output?

Ans. The value of the output of OR gate will '1' when either of its inputs is '1'. Thus, in this case, the output C will be '1'.

$$X = \overline{\overline{A}} = A$$

$$X = \overline{\overline{A+B}} = A+B$$

$$X = \overline{\overline{A.B}} = A.B$$

Here double line indicates double NOT operation.

Q.6 How we can obtain NOT gate from NAND or NOR gate explain with the help of truth table? *(K.B+U.B)* **(For your information Pg. # 150)**

Ans:

<u>FORMATION OF NOT GATE</u>

Formation of NOT gate from NAND and NOR gates with the resultant truth table.

A	Output	A	Output
0	1	0	1
1	0	1	0

Figure: **<u>Formation of NOT gate from NAND and NOR gates with the resultant truth tables</u>**

16.10, 16.11 MULTIPLE CHOICE QUESTIONS

1. The NOR operation is simply an OR operation followed by a: *(K.B)*

(A) NOT operation (B) AND operation

(C) NAND operation (D) OR operation

2. The Boolean expression for NOR operation is: *(K.B)*

(A) $X = \overline{A+B}$ (B) $X = A - B$

(C) $X = A + B$ (D) $X = \overline{A.B}$

3. To make burglar alarm, we use: *(A.B)*

(A) NAND gate (B) OR gate

(C) NOT gate (D) NOR gate

4. NOR gate is the combination of: *(K.B)*

(A) AND & OR (B) AND & NOT

(C) NOT & OR (D) None of them

5. A and B are the two input of NOR gate. Its output would be 1 when: *(U.B)*

(A) A=0, B=0 (B) A=1, B=0

(C) A=0, B=1 (D) A=1, B=1

MCQ'S ANSWER KEY (TOPIC WISE)

16.1 THERMIONIC EMISSION

16.2 INESTIGATING THE PROPERTIES OF ELECTRONS

16.3 CATHODE RAY OSCILLOSCOPE (C.R.O)

1	2	3	4	5	6	7	8	9	10	11	12
D	B	C	C	A	B	A	B	D	D	C	B
13	**14**	**15**	**16**								
A	B	D	C								

16.4 ANALOGUE AND DIGITAL ELECTRONICS

16.5 BASIC OPERATIONS OF ELECTRONIC-LOGIC GATES

1	2	3	4	5	6	7	8	9	10	11	12
D	A	C	B	A	D	B	D	B	A	C	A
13	**14**	**15**	**16**	**17**	**18**						
D	A	C	B	D	A						

16.6 AND OPERATION

16.7 OR OPERATION

1	2	3	4	5	6	7	8	9	10	11	12
A	B	A	A	B	C	C	A	A	A	A	A

16.8 NOT OPERATION

16.9 NAND GATE

1	2	3	4	5	6	7	8	9	10	11	12
B	A	B	B	C	B	B	B	B	D	D	B

16.10 NOR GATE

16.11 USES OF LOGIC GATES

1	2	3	4	5
A	A	C	C	A

TEXT BOOK EXERCISE

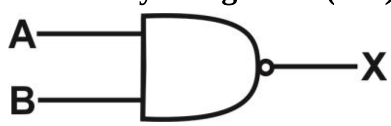
MULTIPLE CHOICE QUESTIONS

Choose the correct answer from the following choices:

i. The process by which electrons are emitted by a hot metal surface is known as: *(K.B)* (LHR 2015)
(a) boiling (b) evaporation
(c) conduction (d) thermionic emission

ii. The particles emitted from a hot cathode surface are *(K.B)* (GRW 2014, 2015, LHR 2017)
(a) positive ions (b) negative ions
(c) protons (d) electrons

iii. The logical operation performed by this gate is: *(K.B)*



(a) AND (b) NOR
(c) NAND (d) OR

iv. AND gate can be formed by using two: *(K.B)* (GRW 2015, SGD 2017)
(a) NOT gates (b) OR gates
(c) NOR gates (d) NAND gates

v. The output of a two-input NOR gate is 1 when: *(K.B)*
(a) A is 1 and B is 0 (b) A is 0 and B is
(c) both A and B are 0 (d) both A and B are 1

vi. If X = A. B, then X is 1 when: *(K.B+U.B)* (GRW 2014, 2016, LHR 2016)
(a) A and B are 1 (b) A or B is 0
(c) A is 0 and B is 1 (d) A is 1 and B is 0

vii. The output of a NAND gate is 0 when: *(K.B+U.B)*
(a) both of its inputs are 0 (b) both of its inputs are 1
(c) any of its inputs is 0 (d) any of its inputs is 1

ANSWER KEY

i	ii	iii	iv	v	vi	vii
D	D	C	D	C	A	B

REVIEW QUESTIONS

16.1 Describe, using one simple diagram in each case, what happens when a narrow beam of electrons is passed through (a) a uniform electric field)b a uniform magnetic field. What do these results indicate about the charge on electron? *(K.B+U.B)*

Ans. (See Topic 16.1, 16.2 & 16.3, Long Question-2)

16.2 Explain the working of different parts of oscilloscope. *(K.B+U.B+A.B)*

Ans: (See Topic 16.1, 16.2 & 16.3, Long Question-3)

16.3 Name some uses of oscilloscope. ***(A.B)***

Ans: **USES OF CRO**

The CRO is used in many fields of science, some uses are given below:

- Displaying wave forms
- Measuring voltages
- Range finding (as in radar)
- Echo – sounding (to find the depth of sea – beds)
- To display heart beats

16.4 Considering an oscilloscope explain.

(i) How the filament is heated? ***(K.B)***

Ans: Filament is heated electrically by a battery (6V Supply).

(ii) Why the filament is heated? ***(K.B)***

Ans: By heating filament a fine beam of electrons is obtained.

(iii) Why the anode potential is positive with respect to the cathode potential. ***(K.B)***

Ans: To accelerate the electrons emitted form heated filament positive potential of anode is used. In this way the electrons are focused into a fine beam as they pass through the anode.

(iv) Why a large potential is applied between anode and cathode. ***(K.B+U.B)***

Ans: After leaving the electron gun, electron beam passes between pair of horizontal. A large potential difference is applied between anode and cathode, due to this potential electrons are directed in specific direction. Higher voltage in short time produced and excellent displaying wave forms height voltage supply also heat the filament quickly and increased the rate of thermo ionic emission.

(v) Why the tube evacuated? ***(K.B)***

Ans: Ionization of gases present in tube occur due to height voltage applied across tube, so it must be evacuated. Due to ionization of gases a fine beam of electrons cold not be produced and accelerate in specific direction.

16.5 What is electron gun? Describe the process of the thermionic emission. ***(K.B+A.B+U.B)***

Ans. (See Topic 16.1,16.2 & 16.3 Long Question-1 & 2)

16.6 What do you understand by digital and analog quantities? ***(K.B)***

Ans. (See Topic 16.4, Long Question-1)

16.7 Differentiate between analog electronics and digital electrons. Write down names of five analogue and five digital devices that are commonly used in every day. ***(K.B+A.B)***

Ans: **DIFFERENTIATION**

The differences between analogue and digital electronics are given below:

Analogue Electronics	Digital Electronics
Definition	
• The branch of electronics consisting of such circuits which process the analogue quantities (continuously vary) is called analogue electronics.	• The branch of electronics which deal with the digital quantities is called digital electronics.

Examples	
• Amplifier • Electric iron • Refrigerator	• Computer • Digital camera • Mobile phone

NAMES OF ANALOGUE AND DIGITAL DEVICES

The names of analogue and digital devices are as follows:

Analogue Devices:
- Electric iron
- Electric fan
- Radio receiver
- Refrigerator
- Washing machine

Digital Devices:
- Computer
- Calculator
- Digital camera
- Mobile phone
- Security system

16.8 State and explain for each case whether the information given by the following devices is in analogue or a digital form. ***(K.B+U.B)***

(a) A moving coil voltmeter measuring the e.m.f of a cell

Ans: A moving coil voltmeter measuring the e.m.f of a cell provide information in the form of analogue form.

(b) A microphone generating an electric current.

A microphone generating an electric voltage is also in the form of analogue form.

(c) A central heating thermostat controlling the water pump.

Central heating thermostats controlling the water pump in the form of analogue signal.

(d) Automatic traffic lights controlling the flow of traffic.

Automatic traffic lights also work on the basis of analogue quantities.

16.9 Write down some benefits of using digital electronics over analogue electronics. ***(A.B)*** **(BWP 2017)**

Ans: **ADVANTAGES OF DIGITAL ELECTRONICS**

The benefits of using digital electronics over analogue electronics is given below:

- The big advantage of digital electronics is quality.
- There is no interference or loss of strength in digit signal traveling in an optical fibre.
- Digital technology in TV gives excellent view and alloy you to be interactive.
- Smart ID cards are being developed. A single card can be passport, national insurance card and driving license all in one. The card could also hold biometric data like an eye retina scene and voice scene for unique identification and security.
- All of this data would be held digitally in the tiny chip.
- Now, today everything is going digital like digital cameras are fast replacing traditional film equipment.
- You can download an image into a PC and edit the picture.

16.10 What are the three universal Logic Gates? Give their symbols and truth tables. ***(K.B+U.B+A.B)***

Ans. (See Topic 16.6 & 16.7, Long Question-1 & 2)
(See Topic 16.8 & 16.9, Long Question-1)

CONCEPTUAL QUESTIONS

16.1 Name two factors which can enhance thermionic emission.

Ans: **FACTORS ENHANCING THERMIONIC EMISSION**

The factors which enhance thermionic emission are as follows:

- Rate of thermionic emission depends upon the nature of the metal used, temperature and surface area of the metal.
- By increasing the temperature and surface area of the cathode, rate of thermionic emission can be increased.

16.2 Give three reasons to support the evidence that cathode rays are negatively charged electrons.

Ans: **NEGATIVE CHARGE ON ELECTRONS**

IN the beginning, no one was sure about the nature of cathode-rays. It was J.J. Thomson who carried out many experiments and concluded that cathode-rays are negatively charged electrons. The three reasons to support this evidence are as follows.

- They are attracted towards positively charged plate.
- They are deflected in magnetic field opposite to the direction of positive charge.
- Their charge to mass ratio (e/m) is equal to e/m of electrons.

16.3 When electrons pass through two parallel plates having opposite charges they are deflected towards the positively charged plate. What important characteristics of the electron can be inferred form this?

Ans: **PROPERTY OF ELECTRON**

From the deflection of electrons towards the positively charged plate, we can easily conclude that electrons carry 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.

Ans: **FACTORS ENHANCING ELECTRON DEFLECTION**

The factors which enhance electron deflection are as follows:

- Strength of magnetic field
- Speed of electron.

16.5 How can you compare the logic operation X = A.B with usual operation of multiplication?

Ans: **COMPARISON**

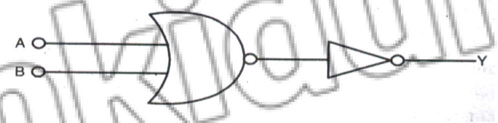
From the truth table of AND operation it is clear that behave as multiplicative inverse. Each time result is zero when is multiplied with any Boolean variable. Hence logic operation X = A.B behave as operation of multiplication.

16.6 NAND gate is the reciprocal of AND gate. Discuss.

Ans: **REFCIPROCAL OF AND GATE**

In NAND gate the value of AND gate is inverted by NOT gate. From the sets of inputs and output given in truth table of NAND gate, its is clear that it is the reciprocal of AND gate i.e. every time the value of output of AND gate is

16.7 Show that the circuit given as below acts as OR gate.

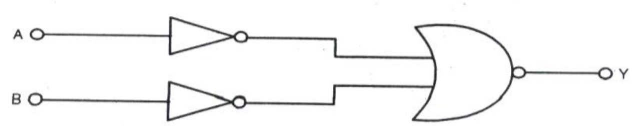


Ans: **<u>OR GATE</u>**

The electronic circuit which implements the OR operation is known as OR gate. It has two or more than two inputs and has only one output. The values of output of OR gate are always in accordance with the truth table of OR operation.. It means, the value of output of OR gate will be 'l' when one of its inputs is at 'l'. The output will be '0', when both inputs are at '0'.

A	B	X = A + B	$X = \overline{A+B}$	$X = \overline{\overline{A+B}}$
0	0	0	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	0	1

16.8 Show that the circuit given as below acts as AND gate.



Ans: **<u>AND GATE</u>**

The circuit which implements the AND operation is known as AND gate. AND gate has two or more than two inputs and only one output. The value of output of NAND gate is always in accordance with the truth table of AND operation. It means output of AND gate will be 'l' only when both of its inputs are at logic 'l', for all other situations output of AND gate will be '0'.

A	B	$\overline{A}$	$\overline{B}$	$\overline{A}.\overline{B}$	$\overline{\overline{A}.\overline{B}}$
0	0	1	1	1	0
0	1	1	0	1	0
1	0	0	1	1	0
1	1	0	0	0	1

16.9 What is LDR?

Ans. The light-dependent resistor or photoresistor is a passive component that decreases resistance with respect to receiving luminosity (light) on the component's sensitive surface. The resistance of a photoresistor decreases with increase in incident intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light sensitive detector circuits and light activated and dark-activated switching circuits acting as a resistance semiconductor.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. NAND operation is simply an AND operation followed by a:

(A) NOR operation (B) OR operation
(C) NOT operation (D) AND operation

2. A and B are two inputs of NAND gate. Its output would be zero when:

(A) A= 0, B = 0 (B) A = 1, B = 0
(C) A= 0, B = 1 (D) A = 1, B = 1

3. The various operations of Boolean variables are also called:

(A) Boolean constants (B) Algebraic operations
(C) Logic operations (D) Both b & c

4. Digital electronics uses two digits.

(A) '0' and '2' (B) '0' and '3'
(C) '0' and '1' (D) '0' and '4'

5. The main components of C.R.O are:

(A) Five (B) Four
(C) Three (D) Two

6. Typical value of the voltage and current used for thermionic emission are:

(A) 3v and 0.4A (B) 6V and 0.3A
(C) 5V and 0.3A (D) 6V and 0.1A

Q.2 Give short answers to following questions. **(5×2=10)**

i. Define thermionic emission.
ii. Differentiate between digital and analogue quantities.
iii. What are the uses of C.R.O?
iv. Define AND operation. Also draw its circuit diagram.
v. What are the uses of logic gates?

Q.3 Answer the following questions in detail. **(4+5=9)**

a) Write a note on C.R.O.
b) What is OR operation? Draw its circuit diagram and truth table.

<u>Note</u>:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.

UNIT 17
INFORMATION AND COMMUNICATION TECHNOLOGY

17.1 INFORMATION AND COMMUNICATION TECHNOLOGY
17.2 CBIS

LONG QUESTIONS

Q.1 What are the components of information technology? Clearly indicate the function of each component. ***(K.B+U.B+A.B)*** **(Review Question 17.3)**

OR Explain CBIS?

Ans:

CBIS

Introduction:

CBIS stands for Computer Base Information System. Every system being used for processing and transferring data in which computers are involved is called Computer Based Information System.

Components of CBIS:

There are five parts that must come together in order to produce a Computer-Based Information System (CBIS).

Hardware	Software	Data	Procedures	People

Figure: Components of CBIS

Hardware:

The term hardware refers to machinery. This includes the central processing unit (CPU), and all of its support equipment. Among the support equipment are input and output devices, storage devices and communication devices.

Software:

The term software refers to computer programs and the manuals that support them. Computer programs are machine-readable instructions that direct the circuitry within the hardware parts of the CBIS to produce useful information from data. Programs are generally stored on some input output medium, often a disk or tape.

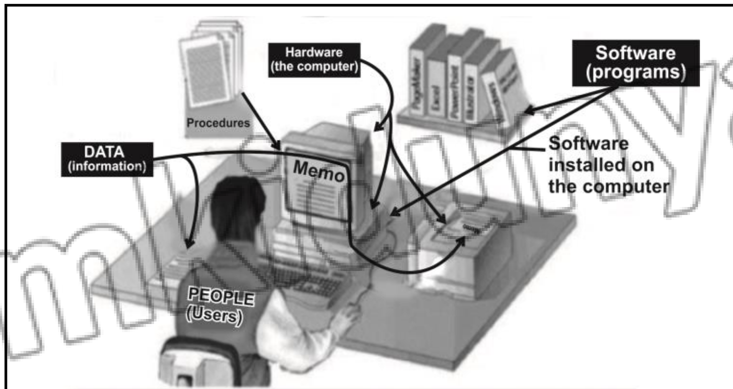


Figure: Components of CBIS

Data:

Data are facts and figures that are used by programs to produce useful information. It may be in the form of text, graphic or figure that can be recorded and that have specific meaning. Like programs, data are generally stored in machine-readable form on disk or tape until the computer needs them.

Procedures:

These are set of instructions and rules to design and use information system. These are written in manuals and documents for use. These rules or methods may change from time to time. The Information System must be flexible to incorporate these changes.

People (User):

Every CBIS needs people if it is to be useful, who influence the success or failure of information systems. People design and operate the software, they feed input data, build the hardware for the smooth running of any CBIS. People write the procedures and it is ultimately people who determine the success or failure of a CBIS.

17.1, 17.2 SHORT QUESTIONS

Q.1 Write some sources of communications being used now-a- days. ***(A.B)***

Ans: **SOURCES OF COMMUNICATIONS**

We are living in the age of information and communication technology. It is not long ago when the telephone was the only device of communication within the country or abroad. Now-a-days, in addition to telephone, mobile phone, fax machine, computer and internet are the main sources of contact. These sources have shortened the distances and have brought in contact the whole world.

Q.2 Differentiate data and information. ***(K.B)*** **(LHR 2017)**

OR What is difference between data and information? **(Review Question 17.1)**

Ans: **DIFFERENTIATION**

Data and Information can be differentiated as:

Data	Information
Definition	
• Data are facts and figures that are used by programs to produce useful information. It may be in the form of text, graphic or figure that can be recorded and that have specific meaning.	• In computer technology, processed data is called information. Computer processes the data and converts it into useful information. This information is transmitted to distant places in the form of sound, picture and computerized data.
Input/output	
• Data is always an input for a computer system.	• Information is output of data.
Meanings	
• Data does not carry a meaning.	• Information must carry a logical meaning.
Format	
• Data is always in machine readable form.	• Information is always user's readable form.
Example	
• 1,2,+,=3 values are data	• 1+2=3 is an information

Q.3 What do you understand by information and communication technology (ICT)? *(K.B)*

(LHR 2015)(Review Question 17.2)

Ans: **ICT**

Definition:

"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 equipment".

Explanation:

Information and Communication Technology (ICT) is basically an electronic based system of information transmission, reception, processing and retrieval. ICT is a blend of two fields: information technology and telecommunication. The two terms are defined as follows:

- The scientific method used to store information, to arrange it for proper use and to communicate it to others is called information technology.
- The method that is used to communicate information to far off places instantly is called telecommunication.

Q.4 Define the terms. *(K.B)* **(LHR 2014, 2015, 2017, GRW 2017)**

(i) Information technology

(ii) Telecommunication

Ans: **INFORMATION TECHNOLOGY**

Definition:

"The scientific method used to store information, to arrange it for proper use and to communicate it to others is called information technology".

TELECOMMUNICATION

Definition:

"The method that is used to communicate information to far off places instantly is called telecommunication".

Q.5 Differentiate between hardware and software. *(K.B)* **(GRW 2014, 2015, 2017)**

OR What is the difference between hardware and software? Name different software.

(Review Question 17.9)

Ans: **DIFFERENTIATION**

Hardware and software can be differentiated as:

Hardware	Software
Definition	
• The term hardware refers to machinery that can be physically touched.	• The term software refers to computer programs and the manuals that support them.
Nature	
• Hardware is physical in nature.	• Software is logical in nature.
Durability	
• Hardware wears out over time	• Software does not wear out over time. However, bugs are discovered in software as time passes.
Types	

• Input, storage, processing, control, and output devices are different types of hardware	• System software, Programming software, and application software are different types of software
Examples	
• CPU • Keyboard • Monitor • Mouse	• Word processing program • Power point • Operating system

Q.6 Define computer programs. *(K.B)*

Ans:

COMPUTER PROGRAMS

Definition:

Computer programs are machine-readable instructions that direct the circuitry within the hardware parts of the CBIS to produce useful information from data. Programs are generally stored on some input output medium, often a disk or tape.

Q.7 What are the uses of modern electromagnetic radiation?*(K.B)* (For your information Pg. # 156)

Ans:

USES OF MODERN TELECOMMUNICATION

All modern telecommunications use some form of electromagnetic radiation. Radiowaves carry information to local radio and T.V. Microwaves are used for mobile phones, radar and transmission to satellite in space.

17.1, 17.2 MULTIPLE CHOICE QUESTIONS

1. **The computer-based information system (CBIS) is formed by components: *(K.B)***
   (A) 2 (B) 3
   (C) 4 (D) 5
2. **Which is the most suitable means of reliable continuous communication between the orbiting satellites and earth: *(K.B)* (For your information Pg. # 156)**
   (A) Micro waves (B) Radiowaves
   (C) Sound waves (D) Light waves
3. **In computer terminology the term machinery refers to: *(K.B)***
   (A) Software (B) Hardware
   (C) Data (D) Procedures
4. **Set of instructions and rules are called: *(K.B)***
   (A) Software (B) Hardware
   (C) Data (D) Procedures
5. **Who determines the success and failure of CBIS? *(K.B)***
   (A) Data (B) Information
   (C) Procedures (D) People
6. **Microwaves are used for: *(A.B)* (For your information Pg. # 156)**
   (A) Mobile phones (B) Radar
   (C) Satellites (D) All of these
7. **Which source has shortened the distances and has brought in contact the whole world? *(K.B)***
   (A) Telephone (B) Mobile phone
   (C) Fax machine (D) All of these

8. Which is basically an electronic based system of information transmission reception, processing and retrieval? *(K.B)*

(A) ICT (B) IDT or OR
(C) CRO (D) ADC or DAC

9. The method used to communicate information to far off places instantly is called: *(A.B)*

(A) Telecommunication (B) Information
(C) Transfer of data (D) Production

10. Who design and operate the software and feed input data, build the hardware for the smooth running of any CBIS? *(K.B)*

(A) Software (B) Hardware
(C) People (D) Data

17.3 FLOW OF INFORMATION
17.4 TRANSMISSION OF ELECTRICAL SIGNAL THROUGH WIRES

LONG QUESTIONS

Q.1 What is flow of information? Write its elements. *(K.B+U.B+A.B)*

Ans: **FLOW OF INFORMATION**

Definition:

"Flow of information means the transfer of information from one place to another through different electronic and optical equipment".

Means of Communication System:

Following are important means of communication system:

- In telephone, information is sent through wires in the form of electrical signals.
- In radio, television and cell phone information is sent either through space in the form of electromagnet waves, or through optical fibres in the form of light.
- Radiowaves are continuously refracted by different layers in the Earth's atmosphere. This leads to weaken the signal, making it difficult to be received over long distances. Unlike radiowaves, microwaves are not refracted. Microwaves are used for satellite communications.

Elements of Communication System:

There are three essential parts of any communication system:

- Transmitter
- Transmission channel
- Receiver

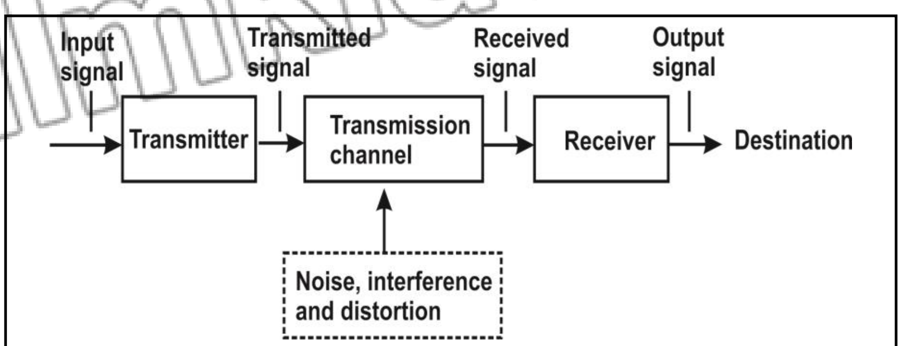


Figure: Elements of Communication System

Explanation:

The transmitter processes the input signal. The transmission channel is the medium which sends the signal from source to destination. It may be a pair of wires, a coaxial cable, a radio wave or optical fibre cable. So, the signal power progressively decreases with increasing distance. The receiver takes the output signal from the transmission channel and delivers it to the transducer after processing it. The receiver may amplify the input signal to compensate for transmission loss.

Figure: **A Telephone**

Q.2 Explain transmission of electrical signals through wires. ***(K.B+U.B+A.B)***

Ans:

TRANSMISSION THROUGH WIRES

Introduction:

Alexander Graham Bell in 1876 made a simple telephone model to send voice in the form of electrical signal from one place to another.

Construction of Telephone:

It consists of a metal reed, an electric coil, and a vibrating diaphragm. Modern telephone also uses diaphragms to turn voices into electrical signal that are transmitted over phone lines. Telephone system has two parts:

- Mouthpiece
- Earpiece

Working:

There are two steps for the working of this system:

- 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.
- This process is reversed at the other end of the line by the receiver. 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.

17.3, 17.4 SHORT QUESTIONS

Q.1 Define coaxial cable. ***(K.B+A.B)*** **(For your information Pg. # 158)**

Ans:

COAXIAL CABLE

Definition:

"Coaxial cable wires are used to transmit electric signals such as cable TV to your home. To prevent electric and magnetic interference from outside, a covering of conducting material surrounds the coaxial wires".

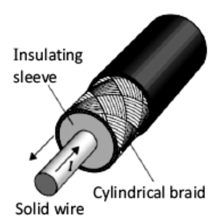


Figure: Coaxial Cable

Q.2 Define flow of information. ***(K.B)***

Ans: **FLOW OF INFORMATION**

Definition:

"Flow of information means the transfer of information from one place to another through different electronic and optical equipment".

Means of Communication System:

Following are important means of communication system:

- In telephone, information is sent through wires in the form of electrical signals.
- In radio, television and cell phone information is sent either through space in the form of electromagnet waves, or through optical fibres in the form of light.

Q.3 Why satellite communication system is based on microwaves instead of radiowaves? ***(K.B)***

Ans: **SATELLITE COMMUNICATION**

Radiowaves are continuously refracted by different layers in the Earth's atmosphere. This leads to weaken the signal, making it difficult to be received over long distances. Unlike Radiowaves, microwaves are not refracted that is why microwaves are used for satellite communications.

Q.4 Write essential parts of communication system. ***(K.B+U.B)***

Ans: **COMMUNICATION SYSTEM**

There are three essential parts of any communication system:

- Transmitter
- Transmission channel
- Receiver

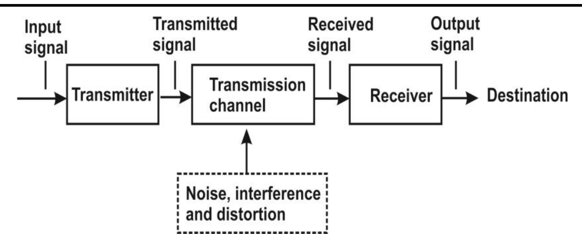


Figure: **Elements of Communication System**

Q.5 Define transmission channel. ***(K.B)***

Ans: **TRANSMISSION CHANNEL**

Definition:

The transmission channel is the medium which send the signal from source to destination. It may be a pair of wires, a coaxial cable, a radiowaves or optical fibre cable.

17.3, 17.4 MULTIPLE CHOICE QUESTIONS

1. **How many essential parts are there in any communication system?** ***(K.B)***
   (A) 2 (B) 3
   (C) 4 (D) 5
2. **Noise, interference and distortion can occur in:** ***(K.B)***
   (A) Transmitter (B) Receiver
   (C) Transmission channel (D) None
3. **Telephone was first invented in:** ***(K.B)***
   (A) 1676 (B) 1876
   (C) 1776 (D) 1976

4. Telephone was first invented by: *(K.B)*
(A) Marconi (B) Newton
(C) Graham Bell (D) Edison

5. In telephone the mouth piece and receiver contain: *(K.B)*
(A) Carbon granules (B) Metal diaphragm
(C) Antenna (D) Both (A) & (B)

6. The transfer of information from one place to another through different electronic and optical equipment is: *(K.B)*
(A) Flow of information (B) Information storage
(C) Information collection (D) Cheque information

7. In telephone, information is sent in form of signals through: *(K.B)*
(A) Wires (B) Plastic
(C) Spring (D) Threads

8. The essential part of any communication system is: *(K.B)*
(A) Transmitter (B) Transmission channel
(C) Receiver (D) All given

9. Alexander Graham Bell in 1876 made a: *(K.B)*
(A) Machine (B) Computer
(C) Telephone (D) Cell

10. Telephones send voice in form of: *(K.B)*
(A) Waves (B) Elect4rical signals
(C) Mechanical signals (D) Magnetic signals

17.5 TRANSMISSION OF RADIOWAVES THROUGH SPACE
17.6 TRANSMISSION OF LIGHT SIGNALS THROUGH OPTICAL FIBRES

LONG QUESTIONS

Q.1 Explain the transmission of radiowaves through space. *(K.B+U.B+A.B)*
(LHR 2016)(Review Question 17.6)

Ans: **TRANSMISSION OF RADIOWAVES**

Introduction:
Electrical signals representing information from a microphone, a TV camera, or a computer can be sent from one place to another place using either cables or radiowaves. Information in the form of audio frequency (AF) signals may be transmitted directly by cable. However, in order to send information over a long distance it has to be superimposed on electromagnetic waves.

Components Used for Transmission:
There are two main components used for transmission of radiowaves through space
- Transmitter
- Receiver

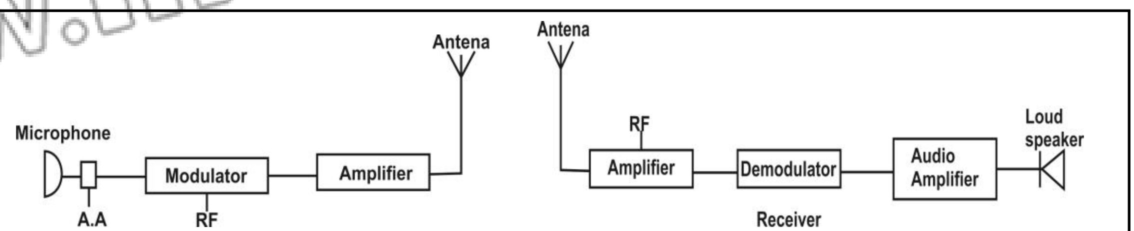


Figure: Radio Transmission and Receiving System

Working:

There are two steps for the working of this system:

- Sound waves produced at the radio station are changed into electrical signals through microphone. These electric signals are then fed into the transmission antenna which consists of two metal rods. Signals falling on the transmission antenna oscillate the charges which then emit these electrical signals in the form of electromagnetic radiowaves.
- At the receiving end, the receiver selects and amplifies the modulated signal. The demodulator then extracts the information signal and delivers it to the receptor.

Q.2 What is Cell Phone Technology? Write its working. ***(K.B+U.B+A.B)***

Ans: **CELL PHONE**

Introduction:

Radio technology is applied in mobile phone. It is a type of radio having two-way communications. A cell phone carries a radio transmitter and a receiver inside it. It sends and receives the message in the form of radiowaves.

Construction:

Cell phone network system consists of:

- Cells
- Base Stations (BSs)
- Mobile Switching Centre (MSC)

Cell:

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.

Cluster:

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.

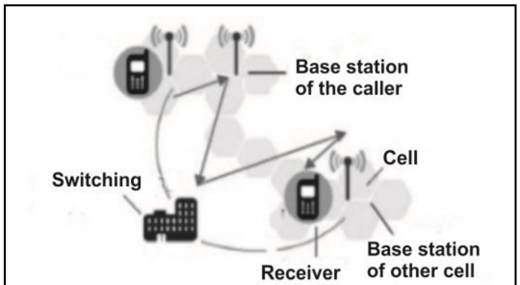


Figure: Cell Phone Network

Working:

When a caller calls another cell phone, sound waves of the caller are converted into radiowaves 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 radiowaves into sound.

Q.3 What is an optical fibre? Write its construction and working. ***(K.B+U.B+A.B)***

OR Describe the transmission of light signals through optical fibres.

OR How are light signals sent through optical fibre? **(GRW 2016)(Review Question 17.7)**

Ans: **OPTICAL FIBRE**

Introduction:

Waves of visible light have a much higher frequency than that of radiowaves. This means, rate of sending information with light beams is larger than that with radiowaves or microwaves. An optical fibre has been used as transmission channel for this purpose.

Construction:

An optical fibre with a coating of lower refractive index is a thin strand of high-quality glass that absorbs very little light. An optical fibre cable is a bundle of glass fibres with thickness of a human hair.

Working:

Light that enters the core at one end of the optical fibre goes straight and hits the inner wall (the cladding) of fibre optics. If the angle of incidence with cladding is less than the critical angle, some of the light will escape the fibre optics and will be lost. However, if the angle of incidence is greater than the critical angle, light is totally reflected into the fibre optics. Then the totally reflected beam of light travels in a straight line until it hits the inner wall again, and so on.

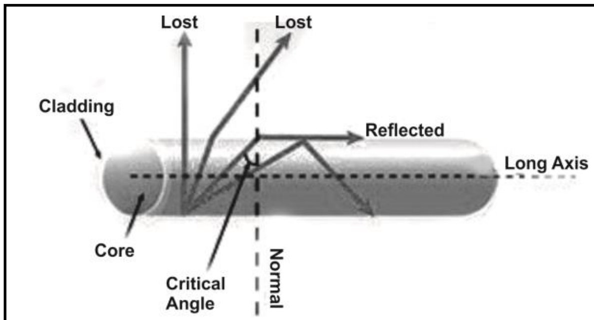


Figure: Light Entering a Glass Rod at Greater the Critical Angle is Trapped inside the Glass

Advantages:

The advantage of optical fibre is that it can be used for sending very high data rates over long distances. This feature of fibre optics distinguishes it from wires. When electrical signals are transmitted through wires, the signal lost increases with increasing data rate. This decreases the range of the signal.

Multi-Mode Cables:

Each optical fibre in a multi-mode cable is about 10 times thicker than fibre optics used in a single-mode cable. This means light beams can travel through the core by following different paths, hence the name multiple-mode. Multi-mode cables can send information only over relatively short distances and are used to link computer networks together.

Conclusion:

Most of the data transmitted across the internet is also carried by light. A network of fibre-optic cables across the country carrying data from one computer to another.

Q.4 What is computer? What is the role of computer in every day of life? ***(K.B+U.B+A.B)***

(LHR 2017)(Review Question 17.8)

Ans: **COMPUTER**

Introduction:

Computer is an electronic computing machine used for adding, subtracting or multiplying and to perform various logic operations .Computer can be programmed to accept data process it and to convert it into Information and to store it for further use.

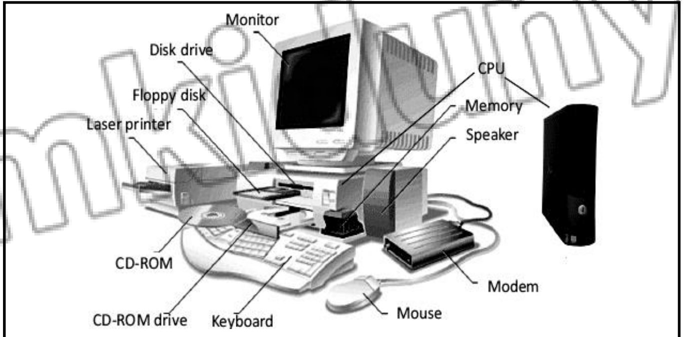


Figure: **Parts of Computer**

Working:

Computers work through an interaction of hardware and software.

Hardware:

Hardware refers to the parts of a computer that you can see and touch. These include CPU, monitor, keyboard, mouse, printer etc.

CPU:

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 we can use to write letters on our computer is a type of software.

The Operating System:

The operating system (OS) is software that manages our computer and the devices connected to it.

Example:

- Windows
- Linux operating system

Role of Computers: **(LHR 2014)**

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.
- 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.

Conclusion:

Now usual desktop computers have been replaced by laptops to a great extent. Laptops are more compact and hence are portable. The most powerful and swift computer which can send an information in one thousand billionth part of a second is called super computer. It contains many processors. They have increased our speed, accuracy and efficiency.

17.5, 17.6 SHORT QUESTIONS

Q.1 Who transmitted first radio signal in space? *(K.B)* **(Do you know Pg. # 159)**

Ans: **FIRST RADIO SIGNAL**

Radiowaves are electromagnetic waves and they travel with the speed of light. Marconi has the distinction that he transmitted the first radio signal through the air.

Figure: A Fax Machine

Q.2 Why are sound waves converted into electromagnetic waves? *(K.B)*

(Interesting Information Pg. # 159)

Ans: **CONVERSION OF SOUND WAVES**

The speed of sound in air is just 1246 km per hour and it cannot go far away from its source. Therefore, it is converted into electromagnetic wave so that they can be sent to far off areas with the speed of light.

Figure: A Photo Phone

Q.3 Write working of radio tuning circuit. *(K.B+U.B)* **(For your Information Pg. # 160)**

Ans: **RADIO TUNING CIRCUIT**

Radio tuning circuit consists of coils of fine wire wounded on a rod which is connected to the antenna. The coils are connected to variable capacitors. The tuned circuit selects signals of only particular frequency. It does not amplify the signals from transmitters with slightly lower or higher frequencies. The voltage rises and falls as the frequency of the received signal increases or decreases relative to the constant frequency of the oscillator.

Figure: A Radio

Q.4 What is a fax machine? Write its working. *(K.B+U.B)* **(GRW 2014, LHR 2015)**

Ans: **FAX MACHINE**

Introduction:

Fax machine is also known as 'Telefacsimile's'. Fax machine is used to send the copy of documents from on place to another place.

Working:

A fax machine basically scans a page to convert its text and graphic into electronics signals and transmits it to another fax machine through telephone line. The receiving machine converts the signal and uses a printer (usually built in) to create the copy of the message that was sent.

Q.5 What is photo phone? *(K.B)* **(LHR 2014, GRW 2014)**

Ans: **PHOTO PHONE**

Modern version of photo phone or video phone is contrary to a common telephone, users can see the pictures of each other. By using the photo and phone numbers of our friends or family members on this telephone, we can call them by pressing the pad with their photos. Thus, we can communicate with our relatives or friends on photo phone with the physical appearance of each other. A mobile phone sends text messages and takes and transmits images. The new 3G and 4G technologies have made video phones common place.

Q.6 What do you know about microwaves? *(K.B)* **(For your information Pg. # 162)**

Ans: **MICROWAVES**

Microwaves are modern means of communication. Microwave, digital and optical fibre technologies are combined to give us today's telecommunications systems. Microwaves travel in straight lines through the space and give a very strong signal. We can connect to the other side of the world in milliseconds.

Uses:

Micro waves are used for mobile phones, radar and transmission to satellites in space.

Q.7 What do you know about INTELSAT and SATCOM? *(K.B)* **(For your information Pg. # 162)**

Ans: **INTELSAT AND SATCOM**

INTELSAT and SATCOM are communication satellites. They are geostationary satellites that stay over the same position above the Earth surface and receive and transmit digital signals across the world.

Q.8 What are super computers? *(K.B)* **(Interesting Information Pg. # 164)**

Ans: **SUPER COMPUTERS**

The most powerful and swift computer which can send an information in one thousand billionth part of a second is called super computer. It contains many processors.

Q.9 Define bit and byte. *(K.B)* **(For your Information Pg. # 164)**

Ans: **BIT AND BYTE**

Definition:

Computers use data in binary from i.e. in the form of 0's and 1's. A bit is a single numeric value, either '1' or '0', that encodes a single unit of digital information. A byte is equal to eight bits. Larger units of digital data are kilobytes (kB), megabyte (MB) and gigabyte (GB). These are defined as below:

1 Kb =1024 bytes
1MB = 1024 kilobytes
1GB = 1024 megabytes

Q.10 What is operating system? *(K.B)* **(LHR 2016)**

Ans: **OPERATING SYSTEM**

Definition:

The operating system (OS) is software that manages our computer and the devices connected to it.

Example:

- Windows
- Linux operating system

17.5, 17.6 MULTIPLE CHOICE QUESTIONS

1. The speed of sound in air is: *(K.B)* **(LHR 2014, GRW 2014)**
(A) 1246 kmh^{-1} (B) 346 ms^{-1}
(C) 300000000 ms^{-1} (D) Both (A) & (B)

2. Radiowaves are: *(K.B)*
(A) Electromagnetic (B) Mechanical
(C) Magnetic (D) Microwaves

3. The speed of radiowaves is equal to: *(K.B)*
(A) Speed of sound (B) Speed of light
(C) Speed of air (D) Speed of electrical signals

4. RF Modulator stands for: *(K.B)*
(A) Radio Force Modulator (B) Removal of Force Modulator
(C) Radio Frequency Modulator (D) Random Frequency Modulator

5. Wireless communication station set up at a particular geographical location is called: *(K.B)*
(A) Cell (B) Cluster
(C) Base station (D) MSC

6. The technology used in cell phone or Mobile phone is: *(K.B)*
(A) Computer (B) Radar
(C) Radio (D) Satellite

7. Information in the form of audio frequency (AF) signals may be transmitted directly by: *(K.B)*
(A) Wire (B) Computer
(C) Cable (D) TV

8. For sending information over a long distance it has to be superimposed on: *(K.B)*
(A) Mechanical waves (B) Electromagnetic waves
(C) Sound waves (D) Kinetic waves

9. At the radio station, sound waves produced are changed into electrical signals through: *(K.B)*
(A) Microphone (B) Modem
(C) Speaker (D) Head phone

10. Which device basically scans a page to convert its text and graphic into electronics signal and transmit it? *(K.B)*
(A) Cell phone (B) Photophone
(C) Fax machine (D) Text machine

11. Cell phone is a type of ____________having two way communications. *(K.B)*
(A) T.V (B) Computer
(C) Radio (D) Microwave oven

12. Cell phone sends and receives the message in the form of : *(K.B)*
(A) Electronic wave (B) Radiowaves
(C) Mechanical waves (D) Magnetic waves

13. Cell phone network system consists of: *(K.B)*
(A) Base stations (B) Mobile switching center
(C) Cells (D) All given

14. Carries more than enough data to support television, telephone and computer data: *(K.B)*
(A) Single copper wire (B) Single fibreoptic cable
(C) Single coaxial cable (D) PTCL line

15. **1kB =?*(U.B)*** **(LHR 2015)**
(A) 1000 bytes (B) 1024 bytes
(C) 100 bytes (D) 1024 kilobytes

16. **1MB =?*(K.B)*** **(LHR 2014, 2016, 2017, GRW 2016)**
(A) 1000 bytes (B) 1024 bytes
(C) 100 bytes (D) 1024 kilobytes

17. **1GB =?*(K.B)***
(A) 1000 bytes (B) 1024 megabytes
(C) 100 bytes (D) 1024 kilobytes

18. **One Byte is to: *(K.B)*** **(GRW 2015)**
(A) 2 bits (B) 4 bits
(C) 6 bits (D) 8 bits

19. **The most powerful and swift computer is: *(K.B)***
(A) Mainframe (B) Desktop
(C) Supercomputer (D) P4

20. **Which refers to computer programs and the manuals that support them? *(K.B)***
(A) Software (B) Hardware
(C) Data (D) Information

21. **Which are facts that are used by programs produce useful information? *(A.B)***
(A) Data (B) Software
(C) Hardware (D) Programs

22. **Which is an electronic computing machine used for adding, subtracting and multiplying? *(A.B)***
(A) Mobile (B) Compute
(C) Cell phone (D) Photophone

23. **The most important piece of hardware is: *(K.B)***
(A) Monitor (B) Keyboard
(C) Printer (D) CPU

24. **Microprocessor is tiny rectangular chip present in: *(A.B)***
(A) CPU (B) Monitor
(C) Printer (D) Keyboard

25. **Which refers to the instructions or programs? *(K.B)***
(A) Hardware (B) Software
(C) Monitor (D) Keyboard

26. **Which are more compact and portable? *(K.B)***
(A) Desktop (B) Computers
(C) Laptops (D) All of these

17.7 INFORMATION STORAGE DEVICES

LONG QUESTIONS

Q.1 What are information storage devices? Write their types. ***(K.B+A.B+U.B)***

Ans: **INFORMATION STORAGE DEVICES**

Introduction:

A storage device is a device designed to store information in computer. Storage devices work on different principles using electronics, magnetism and laser technology.

Types:

In computer technology there are two types of storage devices.

- Primary storage devices
- Secondary storage devices

Primary Storage Devices:

Primary storage devices constitute primary memory

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.
- Random access memory (RAM), which is used by computer as temporary memory. RAM vanishes when the computer is switched off.

Secondary Storage Devices:

The data storage devices are generally the secondary memory of the computer. 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.

Examples:

- Audio-video cassettes
- Hard disk

Q.2 Name different information storage devices and write a note on audio and video cassettes and magnetic disk. ***(K.B+U.B+A.B)***

Or Name different informations storage devices and describe their uses. **(Review Question 17.5)**

Ans: **INFORMATION STORAGE DEVICES**

The devices which are used to store any important data or information are called information storing devices.

Examples:

- Audio video cassettes
- Magnetic disks
- Hard disks
- Compact disk
- Flash drive

The storage devices work on different principles using electronics, magnetism and laser technology.

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.

Working:

Recording of sound on audiotape involves following steps:

- 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.

To produce the sound again following procedure is followed:

- 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.

Figure: Video Cassettes

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.

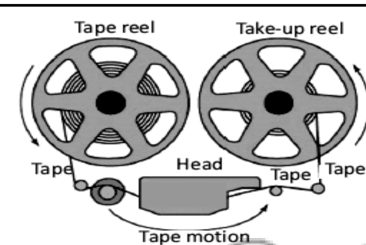


Figure: Magnetic Tape Storage Mechanism

Floppy Disk: **(GRW 2015)**

A floppy disc is a small magnetically sensitive, flexible plastic wafer housed in a plastic case. It is coated with a magnetic oxide similar to the material used to coat cassettes and video tapes. Most personal computers include at least one disk drive that allows the computer to write it and read from floppy disk.

Figure: Floppy Disk

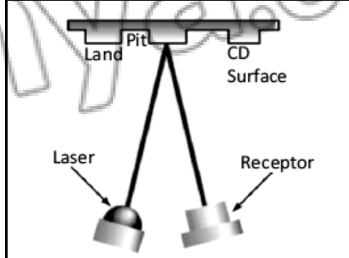


Figure: Laser Beam Scanning

Advantages of Floppy Disks:

Following are advantages of Floppy disks:

- Floppies are inexpensive
- Convenient to use
- Floppies are reliable

Disadvantages of Floppy Disks:

Following are disadvantages of Floppy disks:

- They lack the storage capacity and drive speed for many large jobs.
- Data stored on floppy disks is also subject to loss as a result of stray magnetic fields.
- As far as floppy disks are concerned, they are reliable only for short-term storage and cannot be used longer and no attempts should be made to save the data for a longer period.
- As the magnetic fields weaken the data will also be lost.

Figure: A Flash Drive

Q.3 Write a note on compact disk and flash drive.
(K.B+U.B+A.B)

Ans: **COMPACT DISK (CDs)**

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
- Lands are the areas between pits

Working:

A fine laser beam scans the surface of the rotating disk 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'
- 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 **(LHR 2016)**

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.
- They are slightly larger than a stick of gum, yet many of these devices can carry all of our homework for an entire year.
- We can keep one on a key chain, carry it around our neck, or attach it to our book bag.

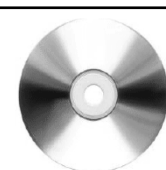


Figure: Compact Disk

Advantages:

A flash drive has following advantages:

- It is easy to carry data from one place to another place.

- 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 can make a backup of our created paper or project on our flash drive and we can save it separate from our computer.
- A flash drive will also enables us to print out homework at school. We can write a paper at home, save it to our flash drive, and then we can plug the drive into a USB port on a school computer for taking prints.

Q.4 Differentiate between primary memory and secondary memory. ***(K.B)***
(Review Question 17.4)

Ans: **DIFFERENTIATION**

Primary and Secondary memory can be differentiated as

Primary Memory	Secondary Memory
Type	
• Primary memory is also known as main memory or internal memory	• Secondary memory is also known as external memory or auxiliary memory
Access of Data	
• In primary memory, data is directly accessed by the processing unit.	• In secondary memory, data is first transferred to main memory and then routed to processing unit.
Storage Devices	
• Semi-conductor chips are used to store information in primary memory.	• Magnetic disk, optical disks are used to store information in secondary memory.
Durability	
• Information stored is temporary and it can be lost when there is a sudden power cut.	• Information stored is permanent unless one deletes it intentionally.
Expense	
• Primary memory devices are more expensive than secondary storage devices.	• Secondary memory devices are less expensive when compare to primary memory devices.
Volatility	
• Primary memory varies nature: • RAM- volatile in nature • ROM- non-volatile	• It's always non-volatile in nature.
Speed	
• It is very fast in interacting with micro processor.	• It is little slow in interacting with micro processor.

Storage Capacity	
• Primary memory has limited storage capacity.	• Secondary memory can store bulk amounts of data in a single unit.
Examples	
• RAM • ROM • Cache memory • PROM • EPROM • Registers	• Magnetic Tapes • Optical Disc • Floppy Disks • Flash memory (USB drives) • Paper Tape • Punched cards

17.7 SHORT QUESTIONS

Q.1 Differentiate between RAM and ROM. ***(K.B)***

Ans: **DIFFERENTIATION**

RAM and ROM can be differentiated as:

RAM	ROM
Function	
• RAM stands for Random Access Memory. It is a part of main memory that is used in the normal operations of a computer once the operating system has been loaded.	• ROM Stands for Read Only Memory. . It is a part of main memory that is used primarily in the startup process of a computer.
Writing Speed	
• Writing data to a RAM chip is a faster process	• Writing data to a ROM chip is a much slower process
Volatility	
• A RAM chip is volatile, which means it loses any information it is holding when the power is turned off.	• A ROM chip is a non-volatile storage medium, which means it does not require a constant source of power to retain the information stored on it.
Storage Type	
• RAM is for temporary storage.	• ROM is meant for permanent storage

Q.2 What are pits and lands? *(K.B)*

Ans:

PITS AND LANDS

Compact Disk is a molded plastic disc on which digital data is stored in the form of microscopic reflecting and nonreflecting spots which are called **"pits"** and **"lands"** respectively.

- Pits are the spiral tracks encoded on the top surface of CD
- Lands are the areas between pits

A fine laser beam scans the surface of the rotating disk 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'
- Absence of pit indicates '0'

Q.3 What do you know about hard disk? *(K.B)* **(LHR 2015, 2016)**

Ans:

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.

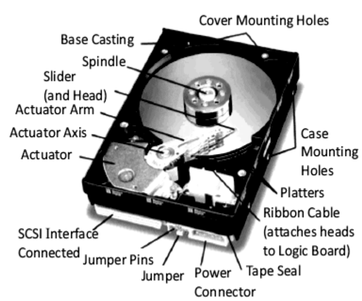


Figure: Hard Disk

In computer hard drive, each platter has a magnetizable coating on each side. The spindle motor turns the platters at several thousand resolution per minute (rpm). There is one read-write head on each surface of each platter.

17.7 MULTIPLE CHOICE QUESTIONS

1. Which statement is incorrect for primary memory? *(K.B)*
(A) It consists of integrated circuit
(B) It vanishes when computer is switched off
(C) Read only memory
(D) Random access memory

2. Which statement is correct about secondary memory? *(K.B)*
(A) Data storage devices are secondary memory
(B) Store data permanently in computer
(C) Audio-video cassettes are secondary storage devices
(D) All given are true

3. Which is small magnetically sensitive, flexible, plastic wafer housed in plastic case? *(K.B)*
(A) Floppy (B) Cassete
(C) Video-disk (D) Audio disk

4. Floppy is coated with: *(K.B)*
(A) Magnetic oxide (B) Sulphuric oxide
(C) Potassium oxide (D) Silver oxide

5. Which is rigid, magnetically sensitive disk that spins rapidly and continuously inside the computer chassis? *(K.B)*
(A) Floppy (B) Hard disk
(C) Cassete (D) Compact disk

6. A CD can store computer data: *(K.B)*
(A) 680 megabyte (B) 660 megabyte
(C) 620 megabyte (D) 610 megabyte

7. A DVD can store computer data up to: *(K.B)*
(A) 17 gigabytes (B) 15 gigabytes
(C) 14 gigabytes (D) 12 gigabytes

8. Which is small storage device that can be used to transport files from one computer to another? *(K.B)*
(A) Compact disk (B) Hard disk
(C) Flash drive (D) Floppy disk

17.8 APPLICATIONS OF COMPUTER

LONG QUESTIONS

Q.1 What do you understand by the term word processing and data managing?
(K.B+U.B+A.B) **(LHR 2015)(Review Question 17.10)**

WORD PROCESSING

Definition:
Word processing is such a use of computer through which we can write a letter, article, and book or prepare a report. Word processing is a computer program.

Features:
Using this program:

- We can develop any document; see it on the screen after typing.
- We can edit the document, add some new text or delete the previous text or make amendments in it.
- We can move text from one page to another, even from one document to another.
- Document can be stored in memory and its print can also be taken.
- By means of modern word processing, we can write it in different styles and in different colors. We can also use graphics.

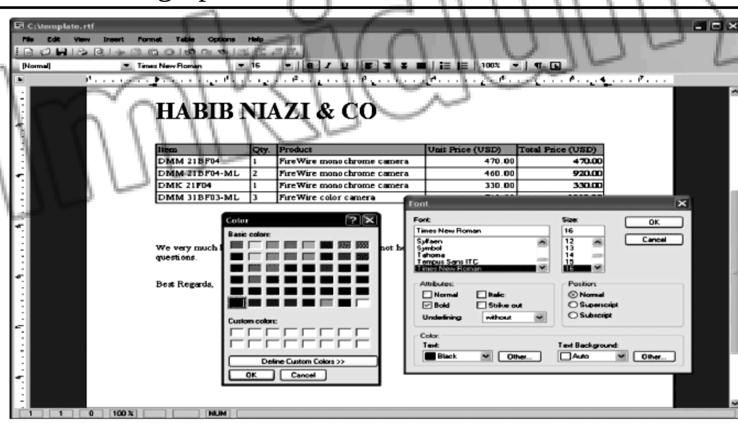


Figure: Features of Word Processing

DATA MANAGEMENT

Definition:

“To collect all information regarding a subject for any purpose and to store them in the computer in more than one inter linked files which may help when needed, is called data managing**”**.

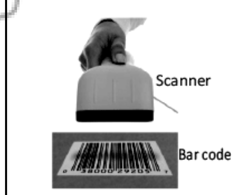


Figure: **Bar Code Scanning**

Uses:

Data management is a need of time. Some of its uses are given below:

- The educational institutions, libraries, hospitals and industries store the concerned information by data management. Additions and deletions are made in the data according to the requirement, which help in the improvement of the management of the institutions.
- In big departmental stores and super markets, optical scanners are used to read, with the help of a Laser Beam, the barcodes of a product which indicate the number at which this product is recorded in the register .In this way, the detail about its price is obtained. The central computer monitors the bills and the related record of the sold goods. It also helps placing the order of goods being sold in a large quantity and to decide about less selling goods.

17.8 SHORT QUESTIONS

Q.1 Define word processing and data management. *(K.B)*

WORD PROCESSING

Definition:

“Word processing is such a use of computer through which we can write a letter, article, and book or prepare a report. Word processing is a computer program**”**.

DATA MANAGEMENT

Definition:

“To collect all information regarding a subject for any purpose and to store them in the computer in more than one inter linked files which may help when needed, is called data management**”**.

17.8 MULTIPLE CHOICE QUESTIONS

1. The process to draw and required line of pictures on a computer screen using, mouse or key board is called : *(K.B)*

(A) Graphic designing (B) Line designing
(C) Data designing (D) Picture designing

2. To collect information for a special purpose and to store it in the computer in more than one interlinked is called: *(A.B)*

(A) Data base (B) Data Storing
(C) Data managing (D) Data processing

3. Data management technique is used by: *(A.B)*

(A) Educational Institute (B) Hospitals
(C) Libraries (D) All of the above

4. If CD is made of metal or glass then it is called as: *(K.B)* **(Do you know Pg. # 167)**

(A) Hard Disk (B) Floppy Disk
(C) CD ROM (D) Flash Drive

5. If CD is made of soft elastic material then it is called as: *(K.B)* **(Do you know Pg. # 167)**

(A) Hard Disk (B) Floppy Disk
(C) CD ROM (D) Flash Drive

17.9 INTERNET
17.10 RISKS OF ICT TO SOCIETY AND THE ENVIRONMENT

LONG QUESTIONS

Q.1 What is internet? Internet is a useful source of knowledge and information. Discuss. *(K.B+A.B+U.B)*

(LHR 2016)(Review Question 17.11)

Ans: **INTERNET**

Introduction:

When many computer networks of the world were connected together, with the objective of communicating with each other, Internet was formed. In other words, we can say that Internet is a network of networks, which spreads all across the globe.

Size of Internet:

Initially the size of internet was small. Soon, people became aware of its utility and advantages and within short span of time, numerous computers and networks got themselves connected to Internet. Its size has increased multi folds within few years. Today Internet comprises of several million computers. There is hardly any country of the world and important city of the country, where Internet is not available.

Working Principle:

Internet is basically a large computers network, which extends all across the globe. In Internet, millions of computers remain connected together through well-laid communication system. We know that telephone communication system is well-defined, time proven system. Internet makes use of this system and many other systems to connect all the computers. 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.

Conceptual Diagram:

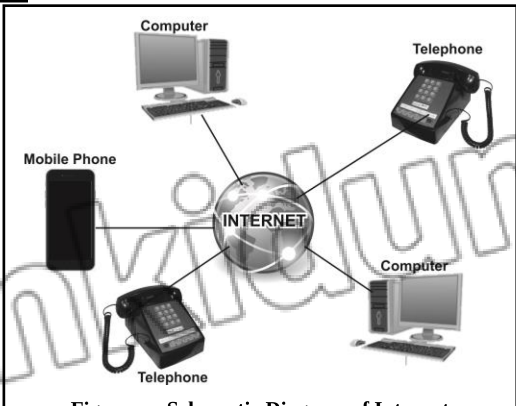


Figure: Schematic Diagram of Internet

Internet services: **(LHR 2017, GRW 2017)**

The main services used on the internet include:

- Web browsing - this function allows users to view web pages using a web browser.
- E-mail - Allows people to send and receive text messages.

Uses of Internet:

Internet has proved to be very beneficial to us. Here is the list of use of internet.

Big Source of Information:

Access of internet to people is increasing day by day. Internet is a useful source of information and knowledge. It provides us online research papers, lectures, notes and many other things of information. We can know about multinational companies and different government departments just by clicking their sites. We can know about vacancies and job through internet. We can share out personal information to the globe as well.

E-Learning:

Getting knowledge from internet is called E-Learning. Millions of students are doing online degrees being offered by different universities. With the help of internet we can watch online lectures. In Pakistan Virtual University is a best step in this regard.

Faster Communication:

Internet is a wonder of the computer science. The world has become global village. Contact can be made at any time during the day or night on internet. With broadband we can download information in seconds. E-mail transmits and receives our messages almost instantaneously. . We can talk to our friends and relatives across the continents with less cost. A web cam enables us to hear and see the person we are speaking to.

Source of Entertainment:

Internet is a global web of more than several million nets in which more than 50 million computers are operating and several million people participate through the world. The number is increasing day by day. Contact can be made at any time during the day or night on internet. We can watch online matches, news and we can also play online games for entertainment.

Access to Social Media

Internet has provided us social media like Facebook, Twitter, Whatsapp and Instagram etc. that have made the world a global family.

Access to Online Services:

Internet has given us the opportunity to gain access to online services provided by different companies and Governments e.g. online renewal of passport, online booking of airline tickets, online shopping etc.

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. For instance, Amazon.com has been selling books, music and video successfully for years. As time passes on, supermarkets and trading companies will be selling more of their goods on line.

Home Banking

Now-a-days, home banking is operating on telephones. We can find our bank balance from the bank on phone, can pay all kinds of bills and transfer our funds by pressing a key of our personal identification number. The bank computer, after our identification, sends us all required information. With the help of ATM machines (Automatic Teller Machine), we can draw money at any time we want.

Q.2 What is E-mail? Write its advantages. *(K.B+U.B+A.B)* **(LHR 2015)**

Ans: **E-MAIL**

One of the most widely used application of internet is electronic mail (or e-mail), which provides very fast delivery of messages to any enabled site on the Internet. Communication through e-mail is more quick and reliable. Through our e-mail, we can communicate with our friends and institution with more ease and pace.

Advantages of E-Mail: **(LHR 2014)**

Some advantages of E-mail are as follows:

Fast Communication:

We can send messages anywhere in the world instantly.

Cost Free Service:

If we have an internet access, 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:

E-mail is a versatile source of communication it means we can not only send text messages through email but we can also send pictures or other files through e-mail in the form of attachments.

Q.3 What are browsers? Write names of different browsers. ***(K.B+A.B+U.B)***

Ans:

BROWSERS

Definition:

"A browser is an application which provides a window to the Web. All browsers are designed to display the pages of information located at Websites around the world".

Examples:

- Internet Explorer
- The World
- Opera
- Safari
- Mozilla Firefox
- Chrome

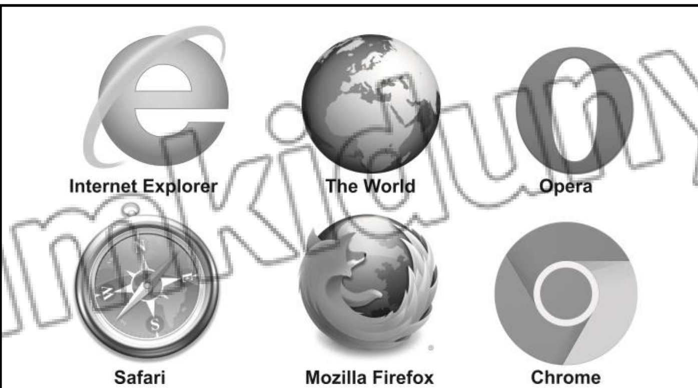


Figure: **Icons of Different Web Browsers**

Browsing:

Searching something on internet and viewing webpages is called browsing. Browsing is great service provided by internet. For browsing we use different browsers like Google Chrome, Internet Explorer, Mozilla Firfox, etc.

Q.4 What are risk of ICT to society and environment? How can we minimize them? *(K.B+A.B)*

(LHR 2015)

Ans: **RISK OF ICT TO SOCIETY AND ENVIRONMENT**

In the modern age we are expected to rely upon information technology. But blind faith in modern technology may be dangerous in many cases.

Health Problems:

Over use of computer is dangerous for our health. Long exposure to computer screen badly effects our eyesight and puts stress to our nerves

Computer Crimes:

Computer crimes are also very common these days. Computer crime is defined as any crime accomplished through knowledge or use of computer technology.

Types:

Computer crimes are of different types:

Theft:

There is also a word theft. Theft is the most common form of crime. Computers are used to steal money, goods, information and computer resources.

Piracy:

Piracy is another issue of importance which is common on computer. It is the illegal duplication of copyright material like books, papers and software etc.

Hacking:

Hacking is still another illegal activity which is committed on computers. It is an unauthorized access to computer systems of other persons. Computers hackers can damage some organizations by stealing their credit cards and valuable information.

Precautions:

One way to reduce the risk of security breaches is to make sure that only authorized person have access to computer equipment. We may be granted access to computer based on some passwords.

We can use a key, an ID card with photo, an ID number, a lock combination, our voice print or finger print as password to secure our computer.

17.9, 17.10 SHORT QUESTIONS

Q.1 Write any two risks of ICT in society and environment. *(K.B)*

RISKS OF ICT

The risks of ICT in society and environment are as follows:

Health Problems:

Over use of computer is dangerous for our health. Long exposure to computer screen badly effects our eyesight and puts stress to our nerves

Hacking:

Hacking is still another illegal activity which is committed on computers. It is an unauthorized access to computer systems of other persons. Computers hackers can damage some organizations by stealing their credit cards and valuable information.

Q.2 Enlist uses of internet. ***(A.B)***

USES OF INTERNET

The uses of internet are as follows:

- Faster communication
- Big source of information
- Source of entertainment
- Access to social media
- Access to online services
- E-commerce
- E-learning

Q.3 Write advantages of E-mail. ***(A.B)***

ADVANTAGES OF E-MAIL

Some advantages of E-mail are as follows:

Fast Communication:

We can send messages anywhere in the world instantly.

Cost Free Service:

If we have an internet access, 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:

E-mail is a versatile source of communication it means we can not only send text messages through email but we can also send pictures or other files through e-mail in the form of attachments.

17.9, 17.10 MULTIPLE CHOICE QUESTIONS

1. Which one is not risk of ICT? ***(K.B)***

(A) Piracy (B) Hacking
(C) Theft (D) E-commerce

2. Which one is not a browser? ***(K.B)***

(A) Opera (B) Safari
(C) Linux (D) Chrome

3. Allows user to view web pages: ***(K.B)***

(A) Data (B) E-mail
(C) Browsing (D) MS. Word

4. The most common form of crime in computer technology is: ***(K.B)***

(A) Piracy (B) Hacking
(C) Theft (D) E-commerce

5. Also called Global web: ***(K.B)*** **(Interesting Information Pg. # 169)**

(A) Computer (B) Mobile phone
(C) Internet (D) Satellite

MCQ'S ANSWER KEY (TOPIC WISE)

17.1 INFORMATION AND COMMUNICATION TECHNOLOGY

17.2 CBIS

1	2	3	4	5	6	7	8	9	10
D	B	D	D	D	A	D	A	A	C

17.3 FLOW OF INFORMAITON

17.4 TRANSMISSION OF EELECTRICAL SIGNAL THROUGH WIRES

1	2	3	4	5	6	7	8	9	10
B	C	B	C	D	A	A	D	C	B

17.5 TRANSMISSION OF RADIOWAVES THROUGH SPACE

17.6 TRANSMISSION OF LIGHT SIGNALS TROUGH OPTICAL FIBRES

1	2	3	4	5	6	7	8	9	10	11	12
D	A	D	C	A	C	C	B	A	C	C	B
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
D	C	B	D	B	D	C	B	B	B	D	A
25	**26**										
B	C										

17.7 INFORMATION STROAGE DEVICES

1	2	3	4	5	6	7	8
B	D	A	A	B	A	A	C

17.8 APPLICATIONS OF COMPUTER

1	2	3	4	5
A	C	D	A	B

17.9 INTERNET

17.10 RISKS OF ICT TO SOCIETY AND THE ENVIRONMENT

1	2	3	4	5
D	C	C	B	C

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

Choose the correct answer from the following choices:

i. In computer terminology information means: *(K.B)* **(LHR 2015, GRW 2017)**

(a) any data (b) raw data
(c) processed data (d) large data

ii. Which is the most suitable means of reliable continuous communication between an orbiting satellite and Earth? *(K.B)*

(a) microwaved (b) radio wave
(c) sound waves (d) any light waves

iii. The basic operations performed by a computer are: *(K.B)*

(a) arithmetic operations (b) non-arithmetic operations
(c) logical operations (d) both A and C

iv. The brain of any computer system is: *(K.B)* **(LHR 2017)**

(a) monitor (b) memory
(c) cPU (d) control memory

v. Which of the following is not processing? *(U.B)* **(GRW 2015)**

(a) arranging (b) manipulating
(c) calculating (d) gathering

vi. From which of the following you can get information almost about everything. *(K.B)*

(a) book (b) teacher
(c) computer (d) internet

vii. What does the term e-mail stands for? *(K.B)* **(LHR 2016, GRW 2016, 2017)**

(a) emergency mail (b) electronic mail
(c) extra mail (d) external mail

ANSWER KEY

i	ii	iii	iv	v	vi	vii
a	b	d	c	b	d	b

REVIEW QUESTIONS

17.1 What is difference between data and information?
Ans: (See Topic 17.1 & 17.2, Short Question-2)
17.2 What do you understand by Information and Communication Technology (ICT)?
Ans: (See Topic 17.1 & 17.2, Short Question-3)
17.3 What are the components of information technology? Clearly indicate the function of each component.
Ans: (See Topic 17.1 & 17.2, Long Question-1)
17.4 Differentiate between the primary memory and the secondary memory.
Ans: (See Topic 17.7, Long Question-4)
17.5 Name different information storage devices and describe their uses.
Ans: (See Topic 17.7, Long Question-2)

17.6 Explain briefly the transmission of Radiowaves through space.
Ans: (See Topic 17.5 & 17.6, Long Question-1)
17.7 How light signals are sent through optical fibre?
Ans: (See Topic 17.5 & 17.6, Long Question-3)
17.8 What is computer? What is the role of computer in everyday life?
Ans: (See Topic 17.5 & 17.6, Long Question-4)
17.9 What is the difference between hardware and software? Name different softwares.
Ans: (See Topic 17.1 & 17.2, Short Question-5)
17.10 What do you understand by the term word processing and data managing?
Ans: (See Topic 17.8, Long Question-1)
17.11 What is Internet? Internet is a useful source of knowledge and information. Discuss.
Ans: (See Topic 17.9, Long Question-1)
17.12 Discuss the role of information technology in school education.
Ans: **ROLE OF INFORMATION TECHNOLOGY**

Information and communication technologies ICT are extremely influencing every discipline under the sun including Education. Impact of ICT and its potential for the education field is manifold. It positively affects all the stakeholders of the education field as:

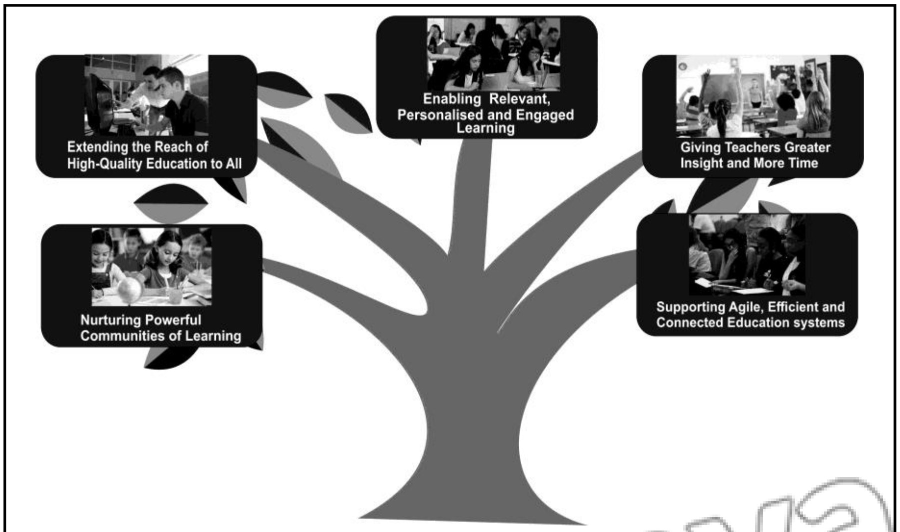


Figure: **Role of Information Technology in School Education**

- It is affecting every aspect of education from teaching-learning to assessment and evaluation.
- It improves the effectiveness of education. It aids literacy movements.
- It enhances scope of education by facilitating mobile learning and inclusive education.
- It facilitates research and scholarly communication.
- Information technology is extending the reach of high quality education to all by e-learning and online courses.
- Information technology is nurturing powerful communities of learning even via social media.

Conclusion:

Information technology is supporting agile, efficient and connected education system throughout the world.

CONCEPTUAL QUESTIONS

17.1 Why optical fibre is more useful tool for the communication process?

Ans: **OPTICAL FIBRE**

The advantage of optical fibre is that it can be used for sending very high data rates over long distances. This feature of fibre optics distinguishes it from wires and makes it more useful tool for the communication process. When electrical signals are transmitted through wires, the signal lost increases with increasing data rate. This decreases the range of the signal. While optical fibres work on the principle of Total internal reflection that minimizes signal loss.

17.2 Which is more reliable floppy disk or a hard disk?

Ans: **MORE RELIABLE**

Floppies are inexpensive, convenient but are not much reliable as they lack the storage capacity and drive speed form many large jobs. There is also a risk of data loss stored on floppy. We do not face such problems in the care of hard disk which is, therefore, more reliable than a floppy.

17.3 What is the difference between RAM and ROM memories?

Ans: **DIFFERENTIATION**

RAM and ROM can be differentiated as:

RAM	ROM
Function	
• RAM stands for Random Access Memory. It is a part of main memory that is used in the normal operations of a computer once the operating system has been loaded.	• ROM Stands for Read Only Memory. . It is a part of main memory that is used primarily in the startup process of a computer.
Writing Speed	
• Writing data to a RAM chip is a faster process	• Writing data to a ROM chip is a much slower process
Volatility	
• A RAM chip is volatile, which means it loses any information it is holding when the power is turned off.	• A ROM chip is a non-volatile storage medium, which means it does not require a constant source of power to retain the information stored on it.
Storage Type	
RAM is for temporary storage.	ROM is meant for permanent storage

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. The speed of sound in air is:

(A) 1246 kmh^{-1} (B) 346 ms^{-1}
(C) 300000000 ms^{-1} (D) Both A & B

2. 1 MB = ?

(A) 1000 bytes (B) 1024 bytes
(C) 100 bytes (D) 1024 kilobytes

3. Floppy is coated with:

(A) Magnetic oxide (B) Potassium oxide
(C) Silver oxide (D) Sulphuric oxide

4. A CD can store over computer data of:

(A) 680 megabyte (B) 660 megabyte
(C) 620 megabyte (D) 610 megabyte

5. Which of the following is not processing?

(A) Arranging (B) Manipulating
(C) Calculating (D) Gathering

6. Which is more compact and portable?

(A) Desktop (B) Laptop
(C) Computer (D) All of these

Q.2 Give short answers to following questions. **(5×2=10)**

i. Differentiate between data and information.
ii. Write a note on working of radio tuning circuit.
iii. Define bit and byte.
iv. Write uses of internet.
v. What do you understand by the term 'Flow of Information'?

Q.3 Answer the following questions in detail. **(4+5=9)**

a) What is computer? Also describe the role of computer in every day of life.
b) Write the advantages and disadvantages of floppy disks.

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.

UNIT 18

ATOMIC AND NUCLEAR PHYSICS

18.1 ATOM AND ATOMIC NUCLEUS
18.2 NATURAL RADIOACTIVITY
18.3 BACKGROUND RADIATIONS

LONG QUESTIONS

Q.1 What is meant by natural radioactivity? Explain how it is discovered and how radiations are identified? *(K.B+A.B+U.B)* **(GRW 2013, DGK 2017)**

Ans: **NATURAL RADIOACTIVITY**

Definition:

"The spontaneous emission of radiation by unstable nuclei is called natural radioactivity. And the elements which emit such radiations are called radioactive elements".

Discovery of Becquerel:

In 1896, Becquerel accidentally discovered that uranium salt crystals emit an invisible radiation that can darken a photographic plate. He also observed that the radiation had the ability to ionize a gas. Subsequent experiments by other scientists showed that other substances also emitted radiations.

Contribution of Marie Curie:

The most significant investigations of this type were conducted by Marie Curie and her husband Pierre. They discovered two new elements which emitted radiations. These were named polonium and radium. This process of emission of radiations by some elements was called natural radioactivity by Marie Curie.

Subsequent experiments performed by Henri Becquerel suggested that radioactivity was the result of the decay or disintegration of unstable nuclei.

International symbol that indicates an area where radioactive material is being handled or produced.

Forms of Radiations:

There are three types of radiations usually emitted by a radioactive substance. These are:

- Alpha (α) particle
- Beta (β) particles
- Gamma (γ) rays

Identification of Radiations:

If the radioactive source is placed inside the magnetic field. The radiation emitted from the source splits into three components: α and β-radiations bend in opposite direction in the magnetic field while Gamma γ-radiation does not change its direction.

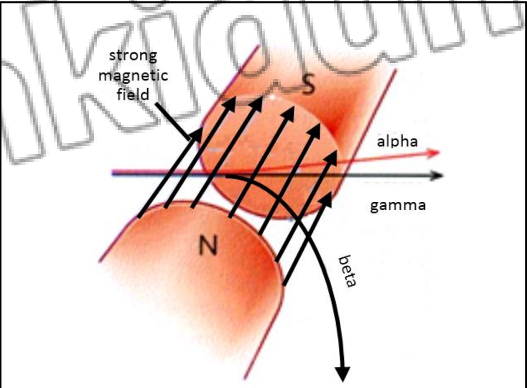


Figure: Schematic Diagram of Types of Radiations

18.1, 18.2, 18.3 SHORT QUESTIONS

Q.1 What do you know about atom? *(K.B)* **(For your information Pg. # 175)**

Ans: **ATOM**

The word atom is derived from the Greek word "atomos", meaning "Indivisible". At one time, atoms were thought to be the smallest particles of matter but currently we define atom as composite systems and contain even smaller particles: protons, neutrons and electrons.

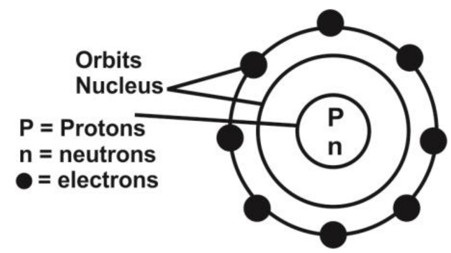


Figure: **Structure of Atom**

Q.2 What do know about discovery of an atom? *(K.B)*

Ans: **DISCOVERY OF AN ATOM**

Scientists were always interested to know the smallest particle of matter. Greek Philosopher Democritus in 585 BC postulated that matter is built from small particles called atoms. The atom means indivisible in Greek language.

Q.3 What do you know about the placement of atomic particles in an atom? *(K.B)*

Ans: **NUCLEUS**

Rutherford in 1911, discovered that atom had a central part called the nucleus.

He also discovered that the positive charge in an atom was concentrated in a small region called nucleus. The nucleus contains protons and neutrons which are collectively called nucleons. Atom also contains electrons which revolve in nearly circular orbits about the positively charged nucleus.

Q.4 What are nucleons? *(K.B)*

Ans: **NUCLEONS**

Definition:

"The nucleus contains protons and neutrons which are collectively called nucleons".

Example:

Nuclide of carbon atom has 6 protons and 6 neutrons.

The number of nucleons is 6 + 6 = 12

Q.5 What is atomic number? *(K.B)*

Ans: **ATOMIC NUMBER**

Definition:

"The atomic number Z is equal to the number of protons in the nucleus".

Example:

Nuclide of carbon atom has 6 protons.

Atomic number of carbon $Z = 6$

Representation:

It is represented by Z.

Q.6 What is neutron number? *(K.B)*

Ans: **NEUTRON NUMBER**

Definition:

"The neutron number N is equal to the number of neutrons in the nucleus**"**.

Example:

Nuclide of Carbon atom has 6 neutrons.
Neutron number of Carbon $N = 6$

Representation:

It is represented by N.

Q.7 What is atomic mass number? *(K.B)*

Ans: **ATOMIC MASS NUMBER**

Definition:

"The atomic mass number is equal to the number of nucleons (protons + neutrons) in the nucleus**"**.

Formula:

$A = Z + N$.

Example:

Nuclide of carbon atom has 6 protons and 6 neutrons.
Atomic number of carbon $Z = 6$
Neutron number of carbon $N = 6$
Atomic Mass number of carbon $A = Z + N$
Atomic Mass number of carbon $A = 6 + 6$
Atomic Mass number of carbon $A = 12$

Representation:

It is represented by A.

Q.8 How an atom is represented? *(K.B)*

Ans: **REPRESENTATION**

Generally an atom is represented by the symbol ${}_{Z}^{A}X$.

Example:

Nuclide of hydrogen atom having only one proton is ${}_{1}^{1}H$.

Q.9 Compare the mass of different atomic particles with atom. *(K.B)*

Ans: **COMPARISON**

The mass of neutron is nearly equal to that of proton. But proton is about 1836 times heavier than an electron. So the mass of an atom is nearly equal to the sum of masses of protons and neutrons.

Q.10 What is the difference between atomic number and atomic mass number? Give a symbolical representation of a nuclide. *(K.B)* **(Review Question 18.1)**

Ans: **DIFFERENTIATION**

The differences between atomic number and atomic mass number is:

Atomic number	Atomic Mass number
Definition	
• The atomic number is equal to the number of protons in the nucleus.	• The atomic mass number is equal to the number of nucleons (protons + neutrons) in the nucleus.
Representation	
• It is denoted by Z.	• It is denoted by A.
Formula	
• $Z = A - N$	• $A = Z + N$

Q.11 Define isotopes with an example. ***(K.B)*** **(MTN 2017, RWP 2017, FSD 2017)**

Ans: **ISOTOPES**

Definition:

"Isotopes are atoms of an element which have same number of protons but different number of neutrons in their nuclei**"**.

Example:

There are three isotopes of hydrogen.

Protium ($^{1}_{1}H$):

Protium contains one proton in the nucleus and one electron that revolves around the nucleus.

Deuterium ($^{2}_{1}H$):

Deuterium contains one proton, one neutron and one electron.

Tritium ($^{3}_{1}H$):

Tritium contains one proton, two neutrons and one electron.

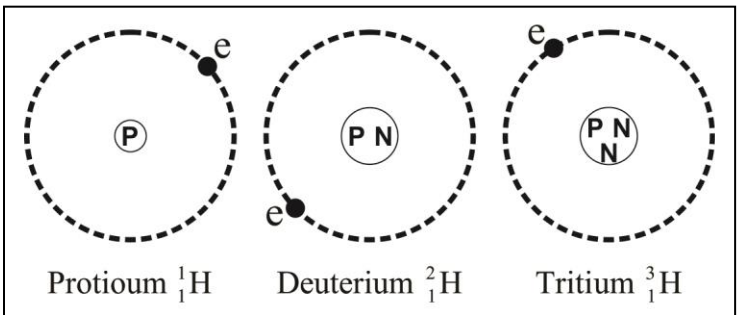


Figure: Isotopes of Hydrogen

Q.12 Define natural radioactivity? ***(K.B)*** **(RWP 2016, SHW 2016, 2017)**

Ans: ***Given on Page # 378***

Q.13 What is the contribution of Marie Curie and Pierre? ***(K.B)***

Ans: ***Given on Page # 378***

Q.14 How many types of radiations are emitted by radioactive substance? Name them. ***(K.B)***

Ans: ***Given on Page # 378***

Q.15 Why positively charged proton in nucleus doesn't fly a part in response of huge electrical force of repulsion between them? ***(K.B)*** **(Do you know Pg. #176)**

Ans: **STRONG NUCLEAR FORCE**

The positively charged protons in a nucleus have huge electrical forces of repulsion between them. There is an attractive force between the nucleons called the strong force which holds them together. This force acts over only a very short distance. Without this strong nuclear force, there would be no atoms beyond hydrogen.

Q.16 What is meant by background radiations? ***(K.B)*** **(SGD 2017, MTN 2017, FSD 2016)**

OR What is meant by background radiations? Enlist some sources of background radiations. **(Review Question 18.9)**

Ans: **BACKGROUND RADIATIONS**

Definition:

"Radiations present in atmosphere due to different radioactive substances are called background radiations**"**.

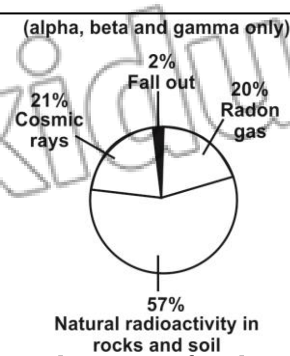


Figure: **The Sources of Background Radiations for Environment**

Everywhere in rocks, soil, water, and air of our planet are traces of radioactive elements. This natural radiation is called the background radiation. It is as much part of our environment as sunshine and rain.

Q.17 What are cosmic radiation? *(K.B)* **(SHW 2016, RWP 2017)**

Ans: **COSMIC RADIATION**

The Earth, and all living things on it also receive radiation from outer space. This radiation is called cosmic radiation which primarily consists of:

- Protons
- Ions
- Alpha particles and larger nuclei.

Q.18 What a secondary radiations? *(K.B)*

Ans: **SECONDARY RADIATIONS**

The cosmic radiation Interacts with atoms in the atmosphere to create a shower of secondary radiation. These include:

- X –Rays
- Muons
- Protons
- Alpha particles
- Electrons
- Neutrons

18.1, 18.2, 18.3 MULTIPLE CHOICE QUESTIONS

1. Matter is built from small particles called: *(K.B)*

(A) Atoms (B) Ions
(C) Radicals (D) Molecules

2. Central part of atom is: *(K.B)*

(A) Nucleus (B) Proton
(C) Electron (D) Neutron

3. Which statement is correct about isotopes? *(K.B)*

(A) Atoms of an element have same number of protons.
(B) Atoms of an element have different number of neutrons in their nuclei
(C) Protium, deuterium and tritium are isotopes of hydrogen
(D) All of above

4. The mass of the proton and neutron is nearly equal to: *(K.B)*

(A) 1.67×10^{-27} kg (B) 1.67×10^{-31} kg
(C) 1.67×10^{-19} kg (D) 1.67×10^{-21} kg

5. A nucleon is _________ times heavier than electron. *(K.B)*
(A) 1827 (B) 1836
(C) 1841 (D) 1832

6. The total number of nucleons in a nucleus is: *(K.B)*
(A) Atomic number (B) Atomic mass number
(C) Isotope number (D) None of these

7. The total number of protons in a nucleus or total number of electrons in the orbits is: *(K.B)*
(A) Atomic number (B) Atomic mass number
(C) Isotope number (D) None of these

8. The atomic number is represented by: *(K.B)*
(A) A (B) Z
(C) N (D) None of them

9. The number of neutrons in a nucleus is represented by: *(K.B)*
(A) A (B) Z
(C) N (D) None of them

10. The number of protons and neutrons in a nucleus or atomic mass is represented by: *(K.B)*
(A) A (B) Z
(C) N (D) None of them

11. Atoms of the element which have same number of protons but different number of neutrons are: *(K.B)*
(A) Isotopes (B) Nuclide
(C) Both a & b (D) None

12. Rutherford discovered that the positive charge in an atom was concentrated in a small region called: *(K.B)*
(A) Atom (B) Nucleus
(C) Molecule (D) Shell

13. ___________ are collectively called nucleons. *(K.B)*
(A) Protons in nucleus (B) Electrons in shell
(C) Protons and neutrons in nucleus (D) Neutrons in nucleus

14. In which simplest atom, nucleus has only one proton? *(K.B)*
(A) Helium (B) Carbon
(C) Nitrogen (D) Hydrogen

15. Generally an atom is represented by the symbol: *(K.B)*
(A) ${}^{A}_{B}X$ (B) ${}^{A}_{Z}X$
(C) ${}^{Z}_{A}X$ (D) ${}^{A}_{0}X$

16. In nuclide ${}^{13}_{6}X$ the number of protons are: *(K.B)*
(A) 3 (B) 10
(C) 8 (D) 6

17. Isotopes of an element have the same: *(K.B)*
(A) Chemical properties (B) Atomic number
(C) Atomic mass number (D) Colures

18. Tritium contains one proton, while protium and deuterium contains: *(K.B)*
(A) Two protons (B) Three protons
(C) One proton (D) No proton

19. Size of electron is: *(K.B)* **(For your information Pg. # 176)**
(A) < 10^{-18}m (B) 10^{-15}m
(C) 10^{-14}m (D) 10^{-10}m

20. Size of atom is: *(K.B)* **(For your information Pg. # 176)**
(A) < 10^{-18}m (B) 10^{-15}m
(C) 10^{-14}m (D) 10^{-10}m

21. Size of nucleus is: *(K.B)* **(For your information Pg. # 176)**
(A) < 10^{-18}m (B) 10^{-15}m
(C) 10^{-14}m (D) 10^{-10}m

22. Who accidentally discovered that uranium salt crystals emit an invisible radiation that can darken a photographic plate? *(K.B)*
(A) Becquerel (B) Marie Curie
(C) Pierre (D) Rutherford

23. How many types of radiation are emitted by radioactive substance? *(K.B)*
(A) 1 (B) 2
(C) 3 (D) 5

24. Which radiation does not change its direction? *(K.B)*
(A) α-radiation (B) β-radiation
(C) γ-radiation (D) None of them

25. The Earth and all living things receive radiation from outer space: *(K.B)*
(A) X- rays (B) Cosmic rays
(C) Radon gas (D) None of these

26. Radiation present in atmosphere due to different radioactive substances: *(K.B)*
(A) Background radiation (B) α - radiation
(C) β- radiation (D) γ - radiation

EXAMPLE 18.1

Find the number of protons and neutrons in the nuclide defined by $^{13}_{6}X$ (BWP 2016) *(U.B+A.B)*

Solution:

Given data:

Atomic number = Z = 6

Atomic mass = A = 13

To Find:

Number of proton = ?

Number of neutron = ?

Calculation:

Atomic number = Number of proton

Atomic Mass = No. of Proton + No. of Neutron

$13 = 6 + \text{Number of neutron}$

$\text{Number of neutron} = 13 - 6 \Rightarrow 7$

Result:

Hence, number of neutrons are 7 and number of protons are 6.

18.4 NUCLEAR TRANSMUTATIONS

LONG QUESTIONS

Q.1 Define nuclear transmutation? Explain the radioactive decay of nuclide. *(K.B+U.B+A.B)*

OR Discuss alpha (α) – decay. Give its general equation and example. **(SHW 2016, SGD 2017)**

OR Discuss beta (β) – decay. Give its general equation and example. **(RWP 2017)**

OR What are the three basic radioactive decay processes and how do they differ from each other? **(Review Question 18.4)**

Ans: **NUCLEAR TRANSMUTATIONS**

Definition:

"The spontaneous process in which a parent unstable nuclide changes into a more stable daughter nuclide with the emission of radiations is called nuclear transmutation**"**.

Introduction:

During natural radioactivity an unstable nucleus of radioactive element disintegrates to become more stable.

Representation:

Radioactive decay by means of a nuclear equation in which an unstable parent nuclide *X* changes into a daughter nuclide *Y* with the emission of an alpha particle, beta particle or gamma particle are given as under.

Alpha (α) –decay:

$${}^{A}_{Z}X_{N} \longrightarrow {}^{A-4}_{Z-2}Y_{N-2} + {}^{4}_{2}He_{2} + \text{Energy}$$

parent nuclide → daughter nuclide + α – particle

Example:

$${}^{226}_{88}Ra_{138} \longrightarrow {}^{222}_{86}Rn_{136} + {}^{4}_{2}He_{2} + \text{Energy}$$

radium → radon + α – particle

It means in alpha decay, the proton number or atomic number *Z* of the parent nuclide reduces by 2 and its mass number or nucleon number A decreases by 4.

Beta (β) –decay:

$${}^{A}_{Z}Z_{N} \longrightarrow {}^{A}_{Z+1}Y_{N-1} + {}^{0}_{-1}e_{+1} + \text{Energy}$$

parent nuclide → daughter nuclide + β – particle

Example:

$${}^{14}_{6}C_{8} \longrightarrow {}^{14}_{7}N_{7} + {}^{0}_{-1}e_{+1} + \text{Energy}$$

carbon → nitrogen + β – particle

In beta (β)-decay, the parent nuclide has its proton number *Z* increased by 1 but its mass number or nucleon number *A* remains unchanged.

Gamma (γ) –decay:

$${}^{A}_{Z}X^{\star} \longrightarrow {}^{A}_{Z}X + \gamma$$

parent nuclide → daughter nuclide + gamma rays

Example:

$${}^{60}_{27}Co^{\star} \longrightarrow {}^{60}_{27}Co + {}^{0}_{0}\gamma + \text{Energy}$$

cobalt → cobalt + γ – rays

Gamma rays are usually emitted alongwith either an alpha or a beta particle.

18.4 SHORT QUESTIONS

Q.1 Define nuclear transmutation? *(K.B)* **(MTN 2017, BWP 2016, FSD 2016)**

Ans: *Given on Page # 385*

Q.2 How a helium atom is formed? *(K.B)* **(Physics Insight Pg. # 178)**

Ans: **FORMATION OF HELUUM ATOM**

When alpha and beta particle are slowed down by collisions, they becomes harmless. In fact, they combine to form neutral helium atoms.

Q.3 Define ionization? *(K.B)* **(MTN 2016)**

Ans: **IONIZATION**

Definition:

"The phenomenon by which radiations split matter into positive and negative ions is called Ionization".

All three kinds of radiations i.e. alpha, beta and gamma can ionize the matter.

Alpha Particles:

Alpha particles have the greatest power of ionization as compared to beta particles and gamma rays. It is due to large positive charge and large mass of alpha particles.

Beta Particles:

Beta particles ionize a gas much less than alpha particles do.

Gamma Rays:

The Ionization power of gamma rays is even less than that of beta particles. Ionization of three radiations in gas.

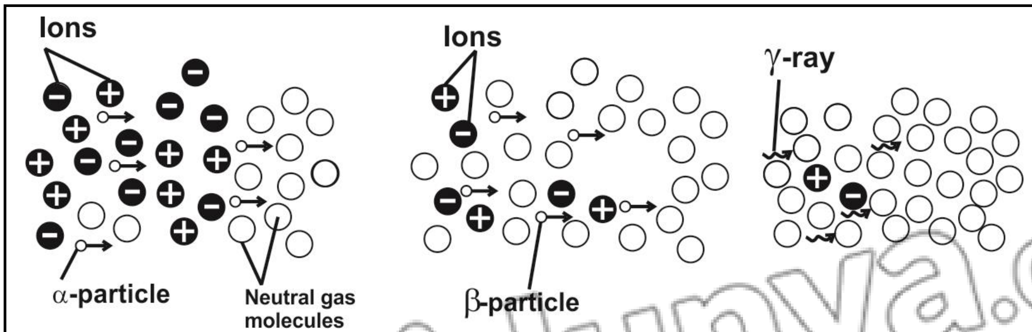


Figure: Ionizing Effect of Radiations

Q.4 What is meant by penetrating ability? *(K.B)* **(FSD 2016, BWP 2017, DGK 2017, RWP 2016)**

Ans: **PENETRATING ABILITY**

The strength of radiations to penetrate a certain material is called penetrating power.

Alpha (α) Particles:

The alpha particles have the shortest range because of its strong interacting or ionizing power.

Beta (β) Particles:

The beta particles have more penetration power than alpha particles and they have less ionizing power than alpha particles.

Gamma (γ) Rays:

The gamma rays can penetrate a considerable thickness of concrete. It is due to their large speed and neutral nature.

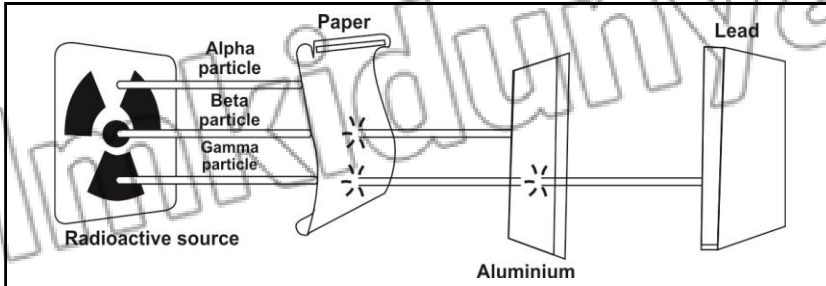


Figure: Penetrating Power of Radiations

Q.5 Why alpha decay occurs in element having atomic number greater than 82? *(C.B)*

Ans: Alpha decay generally occurs in element having greater number of proton and neutron means which has high atomic mass and atomic number. The proton and neutron repel themselves by electromagnetic force and they live together in nucleus due to strong force. Both these forces balance each other and responsible for stability of element but when atomic mass of element increase it means that its electromagnetic forces becomes stronger and strong force become weak. Due to this effect alpha decay happens and the atomic mass of element decrease.

Q.6 Why only Helium-4 nucleus emit during alpha decay but not the isotopes of hydrogen or other element? *(C.B)*

Ans: In alpha decay helium-4 nucleus has two neutron and two proton so its binding energy is maximum because it has magic number 2 Proton and 2 Neutron. But isotopes of hydrogen and other element do not have high binding energy that is why when element having high atomic number and atomic mass decay it emit alpha particle (helium-4).

Q.7 Write any two properties of alpha particles. *(K.B)* **(SGD 2016)**

Ans: **PROPERTIES OF ALPHA PARTICLES**

The properties of alpha particles are as follows:

- Positively charged particles (helium nuclei), ejected at high speed with a range of only a few centimeters in air.
- They can be stopped by an ordinary sheet of thin aluminum foil.

Q.8 Write any two properties of beta particles. *(K.B)* **(MTN 2016)**

Ans: **PROPERTIES OF BETA PARTICLES**

The properties of beta particles are as follows:

- Streams of high – energy electrons, ejected at various speed as high as close to the speed of light.
- Beta particles may be able to penetrate several millimeters of aluminum.

Q.9 What is beta decay? *(C.B)*

Ans: Beta decay in nuclear transmission is decay in which a neutron change into proton, an electron, and an uncharged particle, almost massless relative of the electron called an antineutrino and a proton change into neutron and positron and a neutrino. There are two types of beta decay, **positive beta decay and negative beta decay.** ***(C.B +A.B)***

Q.10 Define positive beta decay?

Ans: The beta decay in which a proton change into neutron and formed a positron and a neutrino particle. Due to positive beta decay the atomic number of element decrease by one but atomic mass remains same because neutron increase by one. .

$$ {}_{Z}^{A}X_{N} \rightarrow {}_{Z-1}^{A}X_{N+1} + e^{+} + \nu_{e}(\text{neutrino}) $$

$$ p \rightarrow n + e^{+} + \nu_{e} $$

Q.11 Define negative beta decay? *(C.B)*

Ans: The decay in which a neutron change into proton and formed a electron and an antineutrino particle. Due to negative beta decay the atomic number of element increase by one but atomic mass remains same because neutron decease by one.

$$ {}^{A}_{Z}X_{N} \rightarrow {}^{A}_{Z+1}X_{N-1} + e^{-} + \bar{\nu}_e \text{(Antineutrino)} $$

$$ n \rightarrow p + e^{-} + \bar{\nu}_e $$

Q.12 Write any two properties of gamma rays. *(K.B)* **(BWP 2016, DGK 2016, FSD 2016)**

Ans: **PROPERTIES OF GAMMA RAYS**

The properties of gamma rays are as follows:

- Electromagnetic radiations of very short wavelength.
- High – energy gamma rays can penetrate at least 30 cm of lead or 2 km of air.

Q.13 Write the ranges of radiations in air. *(K.B)*

Ans: **RANGE OF RADIATIONS**

Alpha (α) Particles:

Alpha particle has a range of only a few centimeters in air.

Beta (β) Particles:

Beta particles have range of several meters in air.

Gamma (γ) Rays:

Gamma rays have a range of several hundred meters in air.

Q.14 What is the commonly used unit of radioactivity? *(K.B)* **(For your information Pg. # 178)**

Ans: **UNIT OF RADIOACTIVITY**

The SI unit of radioactivity is the Becquerel, Bq. In SI bass units, 1 Bq = 1 disintegration per second (dps). This is a very small unit.

Example:

1.0 g of radium has an activity of 3.73×10^{10} Bq. Therefore, the kilo Becquerel (kBq) and the mega Becquerel (MBq) are commonly used. The activity of 1.0 g of radium is 3.73×10^{4} MBq.

Q.15 Write a note on nature of radiations. *(K.B)*

Ans. **NATURE OF RADIATIONS**

Alpha (α) Particles:

Alpha particle is a helium nucleus comprising of two protons and two neutrons with a charge of 2e.

An unstable nucleus with large protons and neutrons may decay by emitting alpha radiations.

Beta (β) Particles:

Beta radiation is a stream of high-energy electrons. An unstable nuclei with excess of neutrons may eject beta radiations.

Gamma (γ) Rays:

Gamma radiations are high energy light protons. They are electromagnetic radiations of very high frequency (short wavelength) emitted by the unstable excited nuclie.

Q.16 Draw table to show the properties of radiations briefly. *(K.B)*

Ans: **PROPERTIES OF RADIATIONS**

The following table show the properties of radiations.

Three Types of Radiations		
Alpha Particle	**Beta Particle**	**Gamma Ray**
Charge		
Charge +2	Charge –1	No Charge
Penetrating power		
Least penetration	Moderate penetration	Highest penetration
Nuclear Transmutation		
Transmutes nucleus: $A \to A-4$ $Z \to Z-2$ $N \to N-2$	Transmutes nucleus: $A \to A$ $Z \to Z+1$ $N \to N-1$	Transmutes nucleus: $A \to A$ $Z \to Z$ $N \to N$

Q.17 Why the beam of radiation only directed to cancerous cells? *(A.B)*

(Radiation treatment Pg.# 181)

Ans: **RADIATION TREAMENT**

Gamma radiations destroy both cancerous cells and healthy cells. Therefore, the beam of radiation must be directed only at cancerous cells.

Example:

During brain radiotherapy, patient is carefully positioned in the helmet to ensure that the gamma rays converge at the desired point in the brain. A lead apron protects the body from exposure to radiation.

18.4 MULTIPLE CHOICE QUESTIONS

1. **Transmutation is: *(K.B)***
(A) Unstable nuclei changes into more stable nuclei
(B) Spontaneous process
(C) Both A and B
(D) Non spontaneous process

2. **Complete the equation $^{226}_{85}\text{Ra} \to ^{222}_{86}\text{Rn} + ?$ + energy: *(U.B)***
(A) $^{0}_{-1}e$ (B) $^{14}_{17}\text{N}$
(C) $^{4}_{2}\text{H}_{e}$ (D) $^{A}_{z}\text{Y}$

3. **$^{14}_{6}\text{C} \to ? + ^{0}_{-1}\text{e} +$ Energy: *(U.B)***
(A) $^{0}_{-1}\text{e}$ (B) $^{4}_{2}\text{He}$
(C) $^{14}_{6}\text{e}$ (D) $^{14}_{7}\text{N}$

4. **$^{60}_{27}\text{Co} \to ^{60}_{27}\text{CO} + ^{0}_{0}\gamma$ + Energy this equation shows emission of: *(U.B)***
(A) β-particles (B) Alpha particles
(C) Gamma particles (D) None of these

5. **SI unit for radioactivity is: *(K.B)***
(A) Becquerel (B) Candela
(C) Mole (D) Ampere

6. **1 Bq = ? *(K.B)***
(A) 1 disintegration per second (dps) (B) ms^{-1}
(C) ms^{-2} (D) All of them

7. **Charge on alpha particles is: *(K.B)***
(A) 2e (B) 3e
(C) 4e (D) 5e

8. **Stream of high energy electrons: *(K.B)***
(A) β-particles (B) α-particles
(C) γ-particles (D) Σ-particles

9. **Gamma rays are also called: *(K.B)***
(A) Photons (B) Electrons
(C) Protons (D) Positrons

10. **Which have the greatest power of ionization as compared to others? *(K.B)***
(A) β-particles (B) α-particles
(C) γ-particles (D) x-rays

11. **Penetrating power of γ rays as compared to α rays and β rays is: *(K.B)***
(A) Greater (B) Smaller
(C) Equal (D) All of these

12. **The phenomenon by which radiations split matter into positive and negative ions is called: *(K.B)***
(A) Ionization (B) Penetration
(C) Sublimation (D) Deflection

13. **Which particle has shortest penetrating range? *(K.B)***
(A) α- particle (B) β-particle
(C) γ- particle (D) None of these

18.5 HALF LIFE AND ITS MEASUREMENT

LONG QUESTIONS

Q.1 What do you understand by the half-life of a radioactive elements? Explain with one example. *(K.B+U.B+A.B)*
(LHR 2013, DGK 2016, BWP 2016, MTN 2016, SGD 2016)(Review Question 18.7)

Ans: HALF-LIFE AND ITS MEASUREMENT

Definition:

"The **time** during which half of the **unstable radioactive nuclei disintegrate** is called the half-life of the sample of radioactive element**".**

Every radioactive element has its own characteristic half-life.

Explanation:

Process of radioactivity is random and the rate of radioactive decay is proportional to the number of unstable nuclei present. In the process, a constant fraction of large number of unstable radioactive nuclei decays in a certain time. So the life time of the unstable nuclei is unlimited and is difficult to measure. We can get the idea about decay rate by the term half-life.

Example:

Radium–226 has a half-life of **1620 years**, which means that half of a radium-226 sample will be converted to other elements by the end of 1620 years. In the next 1620 years, half of the remaining radium will decay, leaving only one-fourth the original amount of radium, and so on.

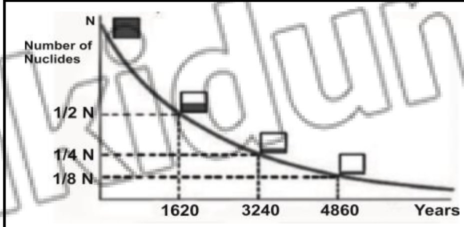


Figure: **Radioactivity of Radium**

Calculation of Half-Life:

If the half-life of the radioactive element is $\mathbf{T_{1/2}}$, then at the end of this time the number of atoms in the sample will become half i.e., 1/2. After a time $\mathbf{2T_{1/2}}$, i.e., after second half-life period, the number of remaining atoms will become $\frac{1}{2}\cdot\frac{1}{2} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$, after a time **3** $\mathbf{T_{1/2}}$, the number of remaining atoms left will be $\frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$, and at the end of '$\mathbf{t\,T_{1/2}}$' number of atoms that remain will be $\left(\frac{1}{2}\right)^t$.

Calculation of Amount of Sample:

If $\mathbf{N_0}$ is the original number of atoms in the sample of radioactive element, then after '**t**' half-lives number of atoms left in the sample can be determined by using the relation,

$$\text{Remaining atoms} = \text{Original atoms}\ \left(\frac{1}{2}\right)^t$$

Or

$$\mathbf{N = N_0 \times \left(\frac{1}{2}\right)^t}$$

Dependence:

The process of radioactivity does not depend upon the chemical combinations or reactions. It is also not affected by any change in physical conditions like temperature, pressure, electric or magnetic fields.

18.5 SHORT QUESTIONS

Q.1 Define half-life. With an example. *(K.B)* **(FSD 2016, SGD 2017)**

Ans: *Given on Page # 392*

Q.2 What is the unit of nuclear radiation? *(K.B)* **(For your information Pg. # 180)**

Ans: **UNIT OF NATURAL RADIATION**

Nuclear radiations is measured in units of roentgen equivalent man (rem), a unit of equivalent dose.

Q.3 What is the safe limit of X-rays for a patient? *(K.B)* **(For your information Pg. # 180)**

Ans: **SAFE LIMIT OF X – RAYS**

Patient should be exposed to X – rays with the limit of 0.1 to 1.0 rem.

Q.4 What is the safe limit of radiations per year? *(K.B)* **(For your information Pg. # 180)**

Ans: **SAFE LIMIT OF RADIATIONS PER YEAR**

The safe limit of radiations exposure is 5.0 rem per year.

Q.5 How long will take for complete decay of pure element? *(K.B)*

(Physics Insight Pg. # 180)(MTN 2017)

Ans: **COMPLETE DECAY OF PURE ELEMENT**

A half – life is the time a radioactive element takes for half of a given number of nuclei to decay. During a second half – life, half of the remaining nuclei decay, so in two half – lives, three quarters of the original material has decayed, not all of it.

Q.6 Enlist half-lives of some isotopes? (K.B)
OR Write half – life of Hydrogen, Lead, Uranium, Carbon. **(BWP 2017)**
Ans: Half-lives of some isotopes are:

Element	Isotope	Half-Life	Radiation Produced
Hydrogen	$^{1}_{0}H$	12.3 years	β
Carbon	$^{14}_{6}C$	5730 years	β
Cobalt	$^{14}_{6}C$	30 years	β,γ
Iodine	$^{131}_{53}I$	8.07 days	β,γ
Lead	$^{212}_{82}Pb$	10.6 hours	β
Polonium	$^{194}_{84}Po$	0.7 seconds	α
Polonium	$^{210}_{84}Po$	138 days	α,γ
Uranium	$^{235}_{92}U$	7.1×10^{8} years	α,γ
Uranium	$^{238}_{92}U$	4.51×10^{9} years	α,γ
Plutonium	$^{236}_{94}Pu$	2.85 years	α
Plutonium	$^{242}_{94}Pu$	3.79×10^{5} years	α,γ

18.5 MULTIPLE CHOICE QUESTIONS

1. **Radium-226 has a half-life of: *(K.B)***
(A) 1820 years (B) 1920 years
(C) 1620 years (D) 1600 years

2. **The rate of radioactive decay is proportional to the number of: *(U.B)***
(A) Stable nuclei present (B) Unstable nuclei present
(C) Electrons present (D) Protons present

3. **High energy gamma rays can penetrate at least _________ of air. *(K.B)***
(Characteristic of radiation Pg. #180)
(A) 1 km (B) 2 km
(C) 3 km (D) 4 km

4. **Nuclear radiation is measured in: *(K.B)*** **(For your information Pg. #180)**
(A) rem (B) dps
(C) As (D) Pa

EXAMPLE 18.2

The activity of a sample of a radioactive bismuth decreases to one – eight of its original activity in 15 days. Calculate the half – life of the sample. *(U.B+A.B)*

Solution:

Let $T_{1/2}$ is the half – life and A_0 is the original activity of the sample. After time $T_{1/2}$ activity will be $A_0/2$. After $2T_{1/2}$ activity will become ½. $A_0/2 = A_0/4$. While after time $3T_{1/2}$, i.e., after three half – lives, the activity will drop to $A_0/8$. It means activity drops to one – eighth of original activity in a time of $3T_{1/2}$.
Therefore, $3T_{1/2} = 15$. This means half – life $T_{1/2}$ of the sample will be 5 days. .

EXAMPLE 18.3

A radioactive element has a half – life of 40 minutes. The initial count rate was 1000 per minute. How long will it take for the count rate to drop to (a) 250 per minutes (b) 125 per minutes (c) Plot a graph of the radioactive decay of the element. ***(U.B+A.B)***

Solution:

Given data:

Half-life radioactive elements = 40 minutes

Initial count rate per minute = 1000

To Find:

(a) Drop count rate 250 per minute = ?

(b) Drop count rate 125 per minute = ?

(c) Graph of radioactive decay = ?

Calculation:

The initial count rate is 1000, therefore,

$$1000 \xrightarrow{40\text{ min.}} 500 \xrightarrow{40\text{ min.}} 250 \xrightarrow{40\text{ min.}} 125$$

(a) As clear from above, it takes 2 half – lives for the count rate to decrease from 1000 to 250 per min, hence

Time taken = 2×40 min. = 80 min.

(b) It takes 3 half – lives for the count rate to decrease from 1000 to 125 per min, hence

Time taken = 3×40 min. = 120 min = 2 h

(c) Graph is shown as under:

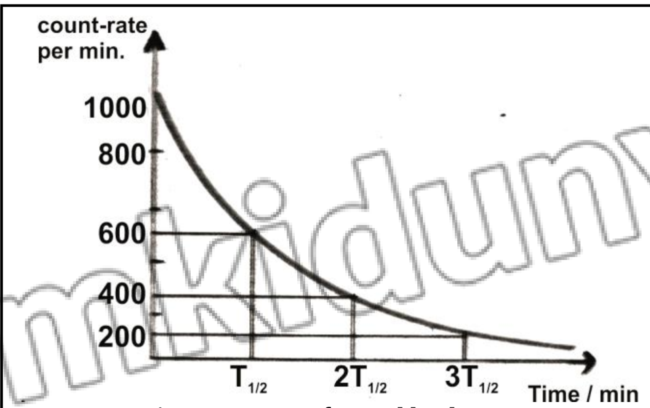


Figure: Decay of Unstable Element

Result:

Hence, it will take 80 minute for count rate to drop 250 per minutes and it will take 2 h for count rate it drop 125 per minutes.

18.6 RADIOISOTOPES AND THEIR USES

LONG QUESTIONS

Q.1 Describe stable and unstable nuclide with examples of radioisotopes.*(K.B+U.B+A.B)*

Ans: **STABLE AND UNSTABLE NUCLIDE**

Definition:

"The stable and non-radioactive elements can also be changed into radioactive elements by bombarding them with protons, neutrons or alpha particles. Such artificially produced radioactive elements are called radioactive isotopes or radioisotopes".

Example:

Examples of radioisotopes production are:

Bombardment of Neutron:

- $^{1}_{0}n + \; ^{23}_{11}Na \longrightarrow \; ^{24}_{11}Na + \text{Gamma } (\gamma) \text{ rays}$

neutron	stable sodium nuclide	a sodium radioisotope	

Bombardment of Alpha Particle:

- $^{4}_{2}He + \; ^{27}_{13}Al \longrightarrow \; ^{30}_{15}P + \; ^{1}_{0}n$

alpha particle	stable aluminum nuclide	a phosphorous radioisotope	

Radioisotopes:

Nuclei which do not emit radiations naturally are called stable nuclei. In general most of the nuclei with atomic number **1** to **82** are stable nuclei. While the elements whose atomic number is greater than **82** are naturally unstable. They emit different types of radiations all the time, and hence continuously change from one type of element to another.

Q.2 Describe the uses of radioisotopes with its applications in different fields? *(A.B)*

(LHR 2015, FSD 2016, SHW 2016)

Ans: **USES OF RADIOISOTOPES**

Radioisotopes are frequently used in medicine, industry and agriculture for variety of useful purposes.

Applications:

Following are few applications of radioisotopes in different fields.

1. **Tracers:**

Uses in Medical Field:

- Radioactive tracers are chemical compounds containing some quantity of radioisotope.
- They can be used to explore the metabolism of chemical reactions inside the human body, animal or plant.
- Radioisotopes are used as tracers in medicine, industry and agriculture.
- For example, radio iodine-131 readily accumulates in the thyroid gland and can be used for the monitoring of thyroid functioning.
- For the diagnosis of brain tumor phosphorous-32 is used.
- The malignant part of the body absorbs more quantity of Isotopes, and this helps in tracing the affected part of the body.

Uses in Industry:

- In industry tracers can be used to locate the wear and tear of the moving parts of the machinery.
- They can be used for the location of leaks in underground pipes.
- By introducing a suitable radioactive tracer into the pipe, the leak can be conveniently traced from higher activity in the region of crack in the pipe.

Uses in Agriculture:

- In agriculture radio phosphorous-32 is used as a tracer to find out how well the plants are absorbing the phosphate fertilizer which is crucial to their growth.
- To check the action of a fertilizer, researchers combine a small amount of radioactive material with the fertilizer and then apply the combination to a few plants. The amount of radioactive fertilizer taken up by the plants can be easily measured with radiation detectors.

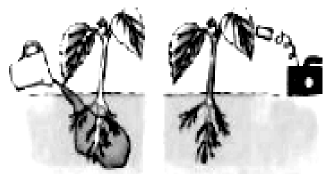


Figure: Study of Action of Fertilizers

2. Medical Treatment:

- Radioisotopes are also used in nuclear medicines for curing various diseases.
- Radioactive **cobalt-60** is used for curing cancerous tumors and cells. The radiations kill the cells of the malignant tumor in the patient.

3. Carbon Dating: **(DGK 2016, BWP 2016, SHW 2016)**

Radioactive carbon-14 is present in small amount in the atmosphere. Live plants use carbon dioxide and therefore become slightly radioactive.

When a tree dies, the radio carbon-14 present inside the plant starts decaying. Since the half-life of carbon-14 is 5730 years, the age of a dead tree can be calculated by comparing the activity of carbon-14 in the live and dead tree.

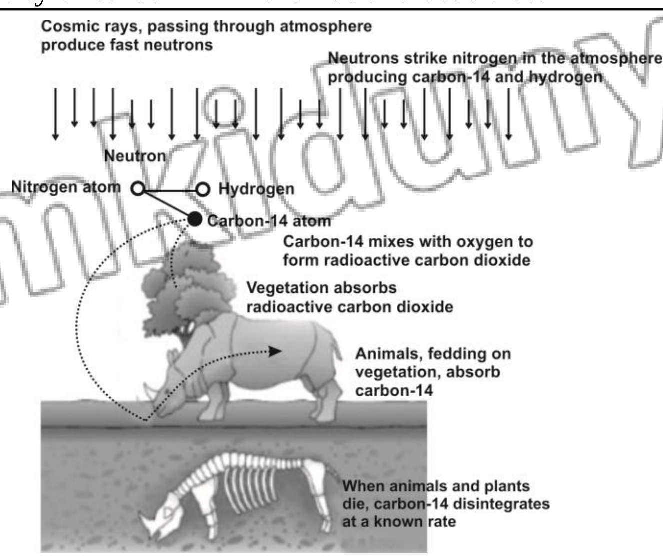


Figure: Carbon Cycle

The activity of the live tree remains almost constant as the carbon-14 is being replenished while the carbon-14 in the dead tree is no more replenished. Therefore, by measuring the activity in the ancient relic, scientists can estimate its age.

Estimation of Age of Geological Specimens:

Other radioisotopes are also used to estimate the age of geological specimens.

- Some rocks contain the unstable potassium isotope *K*-40. This decays to the stable argon nuclide *Ar*-40 with half-life of 2.4×10^8 years.
- The age of rock sample can be estimated by comparing the concentrations of *K*-40 and *Ar*-40.

18.6 SHORT QUESTIONS

Q.1 What are radioisotopes? *(K.B)*

Ans: *Given on Page # 394*

What are stable nuclides? *(K.B)*

Ans: *Given on Page # 394*

Q.2 What are unstable nuclides? *(K.B)*

Ans: *Given on Page # 394*

Q.3 Differentiate between stable and unstable nuclides? *(K.B)* **(SGD 2017)**

Ans: **DIFFERENTIATION**

The differences between stable and unstable nuclides are as follows:

Stable Nuclei	Unstable Nuclei
Definition	
• Nuclei which do not emit radiations naturally are called stable nuclei.	• Nuclei which emit radiations naturally are called unstable nuclei.
Atomic numbers of stable and unstable nuclei	
• Most of the nuclei whose atomic number is from 1 to 82 are stable nuclei.	• The elements, whose atomic number is greater than 82, are naturally unstable.
Variation	
• They do not change from one type of element to another.	• They continuously change from one type of element to another.

Q.4 What is a radioactive tracer? *(K.B)*

Ans: *Given on Page # 394*

Q.5 How can radioactivity help in the treatment of cancer? *(A.B)*

Ans: *Given on Page #* 394

Q.6 How a radioisotope can be used to determine the effectiveness of fertilizer? *(A.B)*

Ans: *Given on Page #395*

Q.7 Write uses of radioisotopes. *(A.B)*

Ans: *Given on Page # 395*

Q.8 Write uses of tracers. *(A.B)*

Ans: *Given on Page # 394*

MULTIPLE CHOICE QUESTIONS

1. **Stable nuclei have atomic number between: *(K.B)***
(A) 1 – 82 (B) 2 – 89
(C) 2 – 88 (D) 2 – 85

2. **Elements are naturally unstable having atomic number greater than: *(K.B)***
(A) 84 (B) 89
(C) 82 (D) 88

3. $\mathbf{{}^{4}_{2}He + {}^{27}_{13}Al \longrightarrow ? + {}^{1}_{0}n}$ ***(K.B)***
(A) ${}^{24}_{11}Na$ (B) ${}^{30}_{15}P$
(C) ${}^{23}_{11}Na$ (D) ${}^{24}_{13}Na$

4. **Which chemical compounds containing some quantity of radioisotope? *(K.B)***
(A) Radioactive tracer (B) Hard compounds
(C) High energy compounds (D) Soft compounds

5. **Which compound readily accumulates in the thyroid gland and can be used for monitoring of thyroid functioning? *(A.B)***
(A) I – 131 (B) I – 130
(C) I – 132 (D) I – 129

6. **Which compound is used for diagnosis of brain tumor? *(A.B)***
(A) Phosphorus -32 (B) Iodine -131
(C) Hydrogen-3 (D) Neon -152

7. **Radioactive isotope is used for curing cancerous tumors and cells: *(A.B)***
(A) P -32 (B) I-131
(C) C-14 (D) Co-60

8. **When a tree dies radioactive isotope present in plant starts decaying? *(A.B)***
(A) C -14 (B) P - 32
(C) I - 131 (D) Co - 60

9. **The half –life of C-14 is: *(K.B)*** **(LHR 2015)**
(A) 5720 years (B) 5730 years
(C) 5700 years (D) 5202 years

10. **The half-life of stable *Ar*-40 is: *(K.B)***
(A) 2.4×10^{8} years (B) 2.9×10^{4} years
(C) 2.5×10^{9} years (D) 2.4×10^{11} years

11. **Half-life of plutonium $\left({}^{236}_{96}Pu\right)$ is 2.85 years and ${}^{242}_{94}Pu$ is: *(K.B)*** **(LHR 2014)**
(A) 3.79×10^{5} years (B) 7.1×10^{8} years
(C) 2.85 years (D) 7.1×10^{10} years

12. **Half-life of ${}^{60}_{27}Co$ is: *(K.B)***
(A) 20 years (B) 40 years
(C) 50 years (D) 30 years

EXAMPLE 18.4

The C-14:C-12 ratio in a fossil bone is found to be 1/4th that of the ratio in the bone of a living animal. The half-life of C-14 is 5730 years. What is the approximate age of the fossil? *(U.B+A.B)*

Solution:

Given data:

C = 14: C – 12 ratio in fossil bone = 1/4th
Half-life of C-14 = 5730 years

To Find:

Approximate age of fossil = ?

Calculation:

Ratio has been reduced by factor of 4. Therefore, two half-life have passed.
Approximate age of fossil = 2 × 5730 = 11460 years

Result:

Hence, approximate age of fossil is 11460 years.

18.7 FISSION REACTION
18.8 NUCLEAR FUSION

LONG QUESTIONS

Q.1 Define and explain the phenomenon of nuclear fission? *(K.B+U.B+A.B)*
(SGD 2016, DGK 2016)

Ans: **FISSION REACTION**

Definition:

"Nuclear fission takes place when a heavy nucleus, such as **U-235**, splits, or fissions, into two smaller nuclei by absorbing a **slow moving (low-energy) neutron".**

Schematic Diagram:

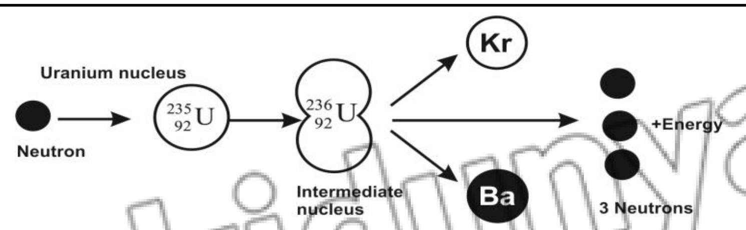


Figure: Nuclear Fission Reaction

General Equation:

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U^{*} \longrightarrow X+Y+\text{neutron}$$

where **U*–236** is an Intermediate state that lasts only for a fraction of second before splitting into nuclei **X** and **Y**, called fission fragments.

Discovery:

Nuclear fission was first observed in **1939** by **Otto Hahn and Fritz Strassman.** The uranium nucleus was split into two nearly equal fragments after absorbing a slow moving (low-energy) neutron. The process also resulted in the production of typically two or three neutrons per fission event. On the average, **2.47** neutrons are released per event as represented by the expression.

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

In nuclear fission, the total mass of the products is less than the original mass of the heavy nucleus. Measurements showed that about **200 MeV** of energy is released in each fission event. This is a large amount of energy relative to the amount released in chemical processes.

Example:

If we burn 1 tonne of coal, then about 3.6×10^{10} J of energy is released. But, during the fission of 1 kg of Uranium –235 about 6.7×10^{11} J of energy is released.

Fission Chain Reaction:

We have seen that neutrons are emitted when U-235 undergoes fission. These neutrons can in turn trigger other nuclei to undergo fission with the possibility of a chain reaction Calculations show that if the chain reaction is not controlled, it will proceed too rapidly and possibly results in the sudden release of an enormous amount of energy (an explosion).

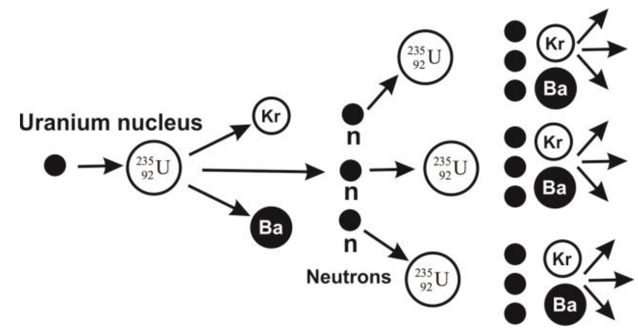


Figure: Fission Chain Reaction

Controlled Fission Chain Reaction:

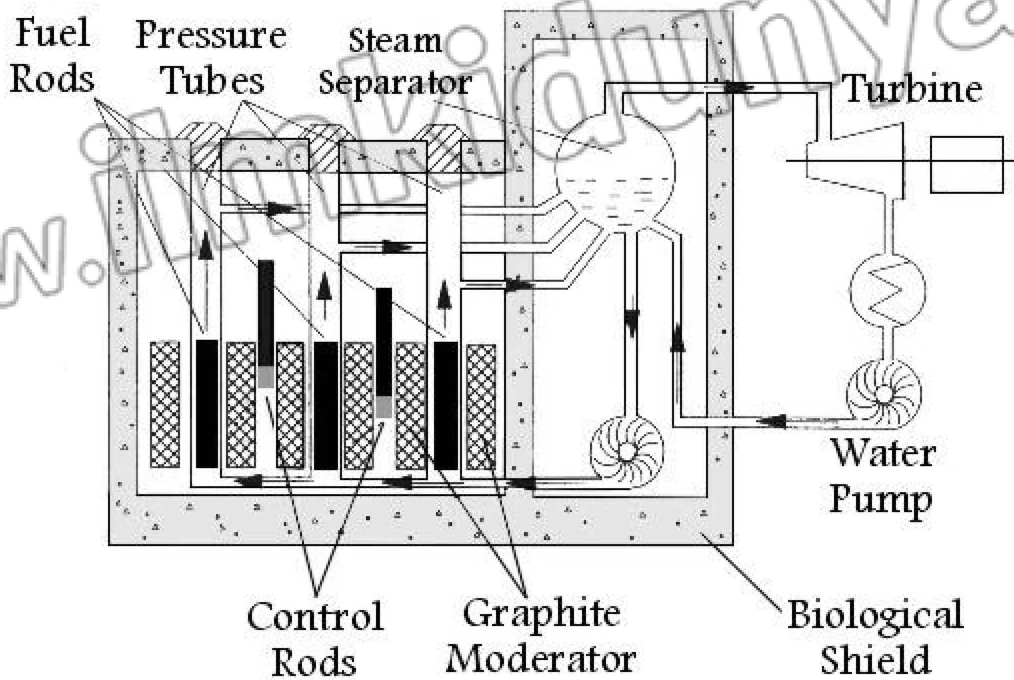
This fission chain reaction is controlled in nuclear reactors. A nuclear reactor provides energy for useful purposes. In this sort of self-sustained reaction extra neutrons liberated in fission reactions are absorbed using some material to slow down the chain reaction.

Fission in a nuclear reactor:

In a nuclear reactor in a nuclear power station, a controlled chain reaction takes place and thermal energy (heat) is released at a steady rate. The energy is used to make steam for the turbines, as in a conventional power station. In many rectors, the nuclear fuel is uranium dioxide, the natural uranium being enriched with extra uranium-235. The fuel is in sealed cans (or tubes).

Maintaining the reaction:

To maintain the chain reaction in a reactor, the neutrons have to be slowed down, otherwise many of them get absorbed by the uranium-235. To slow them a material called a moderator is needed. Graphite is sued in some reactors, water in others. The rate of there reaction cadmium, materials which absorb neutrons.



18.7, 18.8 SHORT QUESTIONS

Q.1 What is nuclear fission? *(K.B)*

Ans: *Given on Page # 398*

Q.2 Briefly explain how heat is produced in a nuclear reactor? *(K.B+U.B)*

Ans: **NUCLEAR REACTOR**

The fission of U-235 may be represent as:

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + \text{Energy}$$

Where Q is the amount of energy released and it is nearly equal to 200 Mev. This energy is appeared in the form of heat.

Q.3 What do you know about fission chain reaction? *(K.B)*

Ans: **FISSION CHAIN REACTION**

Neutrons are emitted when U-235 undergoes fission. These neutrons can in turn trigger other nuclei to undergo fission with the possibility of a chain reaction. Calculations show that if the chain reaction is not controlled, it will proceed too rapidly and possibly results in the sudden release of an enormous amount of energy (an explosion).

Q.4 Define fission fragment. *(K.B)*

Ans: *Given on page # 398*

Q.5 Define fusion reaction. *(K.B)*

(LHR 2013, GRW 2014, 2015, SHW2016, DGK 2016, SGD 2016, RWP 2016)

Ans: **FUSION REACTION**

Definition:

"When two light nuclei combine to form a heavier nucleus, the process is called nuclear fusion".

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

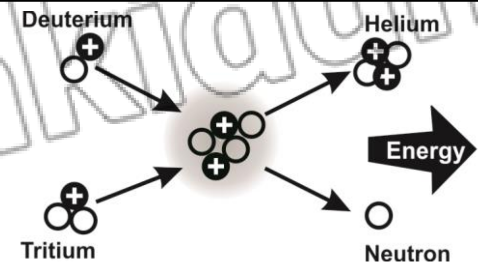


Figure: <u>**Nuclear Fission Reaction**</u>

Q.6 Why the mass of final nucleus is always less than the masses of original nuclei? *(K.B+U.B)*

Ans:

MASS OF NUCLEUS

The mass of final nucleus is always less than the masses of original nuclei. According to mass energy relation this loss of mass converts into energy.

Example:

If an atom of Deuterium is fused with an atom of tritium, then the helium nucleus of alpha particle is formed.

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

Q.7 Differentiation between nuclear fission and nuclear fusion. *(K.B)*

Ans:

DIFFERENTIATION

The differences between nuclear fission and nuclear fusion are as follows:

Nuclear Fission	Nuclear Fusion
Definition	
• Nuclear fission takes place when a heavy nucleus, such as U-235, splits, or fissions, into two smaller nuclei by absorbing a slow moving (low-energy) neutron.	• When two light nuclei combine to form a heavier nucleus, the process is called nuclear fusion.
Temperature	
• It does not require temperature.	• Extremely high temperature is require for fusion to take place.
Nuclear waste	
• At the end of the reaction nuclear waste is left behind.	• No nuclear waste is left at the end of fusions reaction.

Q.8 How fusion reaction is the source of energy? *(K.B)*

Ans:

FUSION REACTION

Energy coming from Sun and stars is supposed to be the result of fusion of hydrogen nuclei into Helium nucleus with release of energy. The temperature at the centre of the Sun is nearly 20 million Kelvin which makes the fusion favorable. According to this reaction, four hydrogen nuclei fuse together to form a Helium nucleus along with 25.7 MeV of energy.

18.7, 18.8 MULTIPLE CHOICE QUESTIONS

1. **Mass energy equation and theory of relativity was given by: *(K.B)***
   (A)Newton (B) Quantum
   (C) Einstein (D) Volta
2. **Nuclear fission was first observed in 1939 by: *(K.B)***
   (A)Otto Hahn and Fritz Strassman (B) Otto Hahn and Curie
   (C)Fritz and Curie (D) Otto Hahn and Rutherford
3. **In each fission reaction energy released: *(K.B)***
   (A) 210meV (B) 299mV
   (C) 200 MeV (D) 255meV
4. **During fission of 1kg of Uranium -235 energy released is: *(K.B)***
   (A) 67×10^{10}J (B) 65×10^{8}J
   (C) 60×10^{8}J (D) 66×10^{9}J
5. **1eV = ?** **(For your information Pg. #185)**
   (A) 1.6×10^{-19} J (B)1.6×10^{-18} J
   (C) 1.6×10^{-17} J (D)1.6×10^{-16} J
6. **How much energy is released by burning 1 tonne of coal? *(K.B)***
   (A) 3.6×10^{10}J (B) 3.6×10^{11}J
   (C) 4.6×10^{10}J (D) 4.6×10^{11}J
7. **When two light nuclei combine to form a heavier nucleus, this process is called: *(K.B)***
   (A) Nuclear fission (B) Nuclear fusion
   (C) Bombardment (D) Disintegration
8. **The temperature of the centre of Sun is: *(K.B)***
   (A) 20 million kelven (B) 2 million kelvin
   (C) 24 million kelvin (D) 29 million kelvin
9. **________ hydrogen nuclei fuse together to form a helium nucleus. *(K.B)***
   (A) 1 (B) 2
   (C) 3 (D) 4

18.9 HAZARDS OF RADIATIONS AND SAFETY MEASURES

LONG QUESTIONS

Q.1 Discuss uses and the hazards of radiations? Describe the precaution to minimize radiations dangers (safety measures). *(K.B+A.B)*

Ans: **<u>HAZARDS OF RADIATIONS AND SAFETY MEASURES</u>**

Although, radiations are very useful in medicine, agriculture and industry, they can also cause considerable damage if not used with precautions. Radioactive, nuclear materials are now widely used in nuclear power plants, nuclear-powered submarines, intercontinental ballistic missiles etc. Some of the harmful effects on human beings due to large doses or prolonged small doses of radiations are:

<u>Hazards of Radiation</u>:

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.

Nuclear Accident at Chernobyl

During the nuclear accident at Chernobyl, Russia, the explosion of the nuclear reactors melted through a few meters thick concrete housing. This caused a massive destruction of local community and also contaminated vegetation and livestock in the large surrounding area. Millions of dollars were lost as the contaminated vegetable and livestock had to be destroyed.

Safety Precautions:

Radiations cannot detect 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.

18.9 SHORT QUESTIONS

Q.1 Discuss uses and the hazards of radiations. ***(A.B)*** **(GRW 2013, DGK 2016)**

Ans: ***Given on Page # 402***

18.9 MULTIPLE CHOICE QUESTIONS

1. Hazards of radiation for humans are: ***(K.B)***

(A) Leukemia (B) Sterility
(C) Blindness (D) All given

MCQ'S ANSWER KEY (TOPIC WISE)

18.1 ATOM AND ATOMIC NUCLEUS

18.2 NATURAL RADIOACTIVITY

18.3 BACKGROUND RADIATIONS

1	2	3	4	5	6	7	8	9	10	11	12
A	A	A	A	B	B	A	B	C	B	A	B
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
C	D	B	D	B	C	A	D	C	A	C	C
25	**26**										
B	A										

18.4 NUCLEAR TRANSMUTATIONS

1	2	3	4	5	6	7	8	9	10	11	12
A	C	D	C	A	A	A	A	A	B	A	A
13											
A											

18.5 HALF LIFE AND ITS MEASUREMENT

1	2	3	4
C	A	B	A

18.6 RADIOISOTOPES AND THEIR USES

1	2	3	4	5	6	7	8	9	10	11	12
A	C	B	A	A	A	D	A	A	A	C	D

18.7 FISSION REACTION

18.8 NUCLEAR FUSION

1	2	3	4	5	6	7	8	9
C	A	C	A	A	B	B	A	B

18.9 HAZARDS OF RADIATIONS AND SAFETY MEASURES

1
B

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

Choose the correct answer from the following choices:

i. Isotopes are atoms of same element with different: ***(K.B)***

(a) atomic mass (b) atomic number
(c) number of protons (d) number of electronics

ii. One of the isotopes of uranium is $^{238}_{92}U$. The number of neutrons in this isotope is: ***(K.B)***

(a) 92 (b) 146
(c) 238 (d) 330

iii. Which among the following radiations has more penetrating power? ***(K.B)***

(a) a beta particle (b) a gamma ray
(c) an alpha particle (d) all have the same penetrating ability

iv. What happens to the atomic number of an element which emits one alpha particle? ***(K.B)***

(a) increases by1 (b) stays the same
(c) decreases by2 (d) decreases by1

v. The half-life of a certain isotope is 1 day. What is the quantity of the isotope after 2days? ***(K.B)***

(a) one-half (b) one-quarter
(c) one-eighth (d) none of these

vi. When Uranium (92 protons) ejects a beta particle, how many protons will be in the remaining nucleus? ***(K.B)***

(a) 89 protons (b) 90 protons
(c) 91 protons (d) 93 protons

vii. Release of energy by the Sun is due to: ***(K.B)***

(a) nuclear fission (b) nuclear fusion
(c) burning of gases (d) chemical reaction

viii. When a heavy nucleus splits into two lighter nuclei, the process would: *(K.B)*

(a) release nuclear energy (b) absorb nuclear energy
(c) release chemical energy (d) absorb chemical energy

ix. The reason carbon-dating works is that: *(K.B)*

(a) plants and animals are such strong emitters of carbon-14
(b) after a plant or animals dies, it stops taking in fresh carbon-14
(c) there is so much non-radioactive carbon dioxide in the air
(d) when plants or animals die, they absorb fresh carbon-14

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
b	b	b	c	a	d	b	a	b

REVIEW QUESTIONS

18.1. What is difference between atomic number and atomic mass number? Give a symbolical representation of a nuclide. *(K.B+U.B)*

Ans: (See Topic 18.1, Short Question-10)

18.2. What do you mean by the term radioactivity? Why some elements are radioactive but some are not ? *(K.B)*

Ans: **RADIOACTIVITY**

Definition:

"Radioactivity is such a process in which the elements with the charge number greater than 82 naturally keep on radiating**"**.

The spontaneous emission of radiation by unstable nuclei is called natural radioactivity.

Reason of radioactivity:

An isotope will be radioactive if its nuclei are unstable. Large atomic nuclei with more than 82 protons and their associated complement of neutrons are inherently unstable uranium and plutonium are examples of such elements. Small atomic nuclei may also be radioactive if the ratio of neutrons to protons exceeds certain limits. Even tiny hydrogen, the smallest of atoms, has a radioactive isotope. If the atom is stable it will not emit radiations.

18.3. How can you make radioactive elements artificially? Describe with a suitable example. *(K.B)*

Ans: **ARTIFICIAL RADIOACTIVITY**

Any stable element, besides the natural radioactive element, can be made radioactive for this purpose very high energy particles (protons, neutrons or alpha particles) are bombarded on the stable element. This bombardment excites the nuclei and the nuclei after becoming unstable become radioactive element. Such radioactive elements are called artificially produced radioactive elements.

Example:

Rutherford was a Scottish scientist, who discovered artificial radioactivity. Through the bombardment of alpha particles against the nuclei of ^{14}N Rutherford produced ^{17}O and protons. Through this observation, Rutherford concluded that atoms of one specific element can be made into atoms of another element through this discovered process of artificial radioactivity

18.4. What are the three basic radioactive decay processes and how do they differ from each other? *(K.B+U.B+A.B)*

Ans: (See Topic 18.4, Long Question-1)

18.5. Write the alpha decay process for $^{234}_{91}Pa$. Identify the parent and daughter nuclei in this decay. *(K.B+U.B)*

Ans: **ALPHA DECAY PROCESS**

$^{234}_{91}Pa \rightarrow ^{230}_{89}Ac + ^{4}_{2}He + \text{Energy}$

It means in alpha decay, the proton number or atomic number Z of the parent nuclide reduces by 2 and its mass number or nucleon number A decreases by 4.

$^{234}_{91}Pa \Rightarrow$ Parent nuclei

$^{230}_{89}Ac \Rightarrow$ Daughter nuclei

18.6. Explain whether the atomic number increase during nuclear decay. Support your answer with an example. *(K.B)*

Ans: **INCREASE IN ATOMIC NUMBER**

Yes, atomic number can increase during nuclear decay. During the β-decay atomic number of atom can be increased.

Beta (β) –Decay:

$^{A}_{Z}X$	$\rightarrow$	$^{A}_{Z+1}Y$	+	$^{0}_{-1}e$		+ Energy
Parent nuclide		Daughter nuclide		beta (β) -particle		

Example:

$^{13}_{6}C$	$\rightarrow$	$^{14}_{7}N$	+	$^{0}_{-1}e$	+	Energy
Carbon			nitrogen		beta (β) particle	

In beta (β) –decay, the parent nuclide has its protean number Z increased by 1 but its mass number or nucleon number A remains unchanged.

18.7. What do you understand by half-life of a radioactive element? *(K.B+U.B+A.B)*

Ans: (See Topic 18.5, Long Question-1)

18.8. What is meant by background radiations? Enlist some sources of background radiations. *(K.B)*

Ans: (See Topic 18.3, Short Question-16)

18.9. Describe two uses of radioisotopes in medicine industry or research? *(A.B)*

Ans: **USE OF RADIOACTIVE ISOTOPE**

In Medicine:

- Radioactive cobalt-60 is used for curing cancerous tumors and cells. The radiations kill the cells of the malignant tumor in the patient.
- Isotopes of Iodine-131 are used for diagnosis of goiter in thyroid gland.

In Industry or Research:

- The radioisotopes are used in a chemical reaction to follow a radioactive element during the reaction and ultimately to determine the structure. For example, C-14 is used to label CO_2.
- Radioactive isotopes are used to generate electricity by carrying out controlled nuclear fission reaction in nuclear reactors.

Example:

When U-235 is bombarded with slow moving neutrons, the Uranium nucleus breaks up to produce Barium-139 and krypton-94 and three neutrons.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{139}_{56}ba + ^{94}_{36}Kr + 3^{1}_{0} + Energy$$

A large amount of energy is released which is used to convert water into steam in boilers. The steam then drives the turbines to generate electricity.

18.10. What are two common radiation hazards? Briefly describe the precautions that are taken against them. ***(K.B)***

Ans: ` **COMMON RADIATION HAZARDS**

The two common radiation hazards are as follows:

- Radiation burns, mainly due to beta and gamma radiations, which may cause redness and sores on the skin.
- Blindness or formation of cataract in the eye.

Precautions:

The precautions of radiation hazards are as follows:

- The sources should only be handled with tongs and forceps.
- The user should use rubber gloves and hands should be washed carefully after the experiment.
- All radioactive sources should be stored in thick lead containers.
- Never point a radioactive source towards a person.
- Frequent visits to the radiation sensitive areas should be avoided.

18.11. Complete this nuclear reaction: $^{235}_{92}U \rightarrow ^{140}_{54}X + ? + 2^{1}_{0}n.$ Does this reaction involve fission or fusion? Justify your answer. ***(K.B)***

Ans: **COMPLETING REACTION**

$$^{235}_{92}U \rightarrow ^{140}_{54}X + ^{94}_{38}Sr = 2^{1}_{0}n + Energy$$

(Xenon) (Strontium) (Neutron)

It is a fission reaction. Because the process of breaking up of nucleus of a heavy atom such as Uranium into two nuclei nearly of the same size with the release of energy is called fission reaction.

18.12. Nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction. Justify this statement with plausible arguments. ***(C.B+A.B)***

Ans: **COMPARISON OF FUSION AND FISSION REACTION**

Nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction. In case of fusion reaction, fusion reactors cannot sustain a chain reaction so they never melt down like fission reactors. Fusion reaction produces very less or, if the right atoms are chosen, no radioactive waste. In case of nuclear fission large radioactive waste is produced and disposal of radioactive waste is a complicated problem. For nuclear power, fusion is the better choice.

18.13. A nitrogen nuclide $^{14}_{8}N$ decays to become an oxygen nuclide by emitting an electron. Show this process with an equation. ***(K.B)***

Ans: **EQUATION**

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$$

18.14. Determine which of these radioactive decay processes are possible: ***(K.B)***

(a) $^{214}_{84}P_o \rightarrow ^{208}_{82}P_b + ^{4}_{2}He$ **(b)** $^{230}_{90}Th \rightarrow ^{226}_{88}R_a + ^{4}_{2}He$

(c) $^{233}_{91}P_a \rightarrow ^{233}_{92}U + ^{0}_{-1}\beta$ **(d)** $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}\beta$

Ans: **<u>POSSIBILITY OF RADIOACTIVE DECAY PROCESSES</u>**

(a) $^{214}_{84}P_o \rightarrow ^{208}_{82}P_b + ^{4}_{2}He$ Not possible

(b) $^{230}_{90}Th \rightarrow ^{226}_{88}R_a + ^{4}_{2}He$ Possible

(c) $^{233}_{91}Pa \rightarrow ^{233}_{92}U + ^{0}_{-1}\beta$ Possible

(d) $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}\beta$ Possible

CONCEPTUAL QUESTIONS

18.1 Is it possible for an element to have different types of atoms? Explain.

Ans: **<u>POSSIBILITY OF DIFFERENT ATOMS IN AN ELEMENT</u>**

Usually an element has same types of atoms. However, certain elements have different types of atoms. These atoms have same atomic mass numbers, but different atomic number. For example, there are three different types of atoms of hydrogen elements $^{1}_{1}H, ^{2}_{1}H$ and $^{3}_{1}H$. These different atoms of same element are known as isotopes.

18.2 Which nuclear reaction would release more energy, the fission reaction of the fusion reaction? Explain

Ans: **<u>COMPARISON OF NUCLEAR ENERGY</u>**

Energy released in fusion reaction is large as compared to that of fission reaction. For example, in the proton-proton fusion reaction about 6.4. MeV energy is released which is much greater than the per nucleon energy released per nucleon for fission reaction which is about 1 MeV.

18.3 Which has more penetrating power, alpha particle or gamma ray photon? Explain.

Ans: **<u>PENETRATING POWER</u>**

<u>Definition</u>:

"The strength of radiation to penetrate a certain material is called penetration power**"**.

<u>Reason</u>:

Alpha particle is a massive particle as compared to a gamma-ray photon. Also photon is neutral out charge on alpha particle is +2e. Hence, alpha particle has greater ionization power and, therefore, has less penetrating power than that of gamma-ray photon.

18.4 What is the difference between natural and artificial radioactivity?

Ans: **<u>DIFFERENTIATION</u>**

The differences between natural and artificial radioactivity are as follows:

Natural Radioactivity	Artificial Radioactivity
Occurrence	
• In natural radioactivity, some elements emit radiations naturally due to their unstable state.	• Some stable elements can also be transformed into radioactive elements. Such process is called artificial radioactivity.
Example	
• $^{14}_{6}C$ is natural radioactive isotope of carbon.	• When N-14 is bombarded with neutron, it changes into C – 14 i.e. $^{14}_{7}N + ^{1}_{0}N \longrightarrow ^{14}_{6}C + ^{1}_{1}H$

18.5 How long would you likely have to wait to watch any sample of radioactive atoms completely decay?

Ans: **<u>COMPLETE DECAY OF ATOM</u>**

During one half-life, half of the parent nuclei of radioactivity element change into daughter nuclei. However, the total decay time of any radioactive element is indefinite. Thus, we have to wait for infinite amount of time to observe the complete decay.

18.6 Which type of natural radioactivity leaves the number of protons and the number of neutrons in the nucleus unchanged?

Ans: **<u>RADIOACTIVE DECAY CAUSING NO CHANGE</u>**

During gamma-decay process, the number of protons and the number of neutrons remains unchanged e.g.

$${}^{60}_{27}\overset{*}{\text{Co}} \longrightarrow {}^{60}_{27}\text{Co} + {}^{0}_{0}\gamma + \text{Energy}$$

18.7 How much of 1-gram sample of pure radioactive matter would be left after four-half lives?

Ans: **<u>CALCULATION OF HALF LIFE</u>**

Using the formula;

$$\text{Remaining} = \text{Original} \times \frac{1}{2^t}$$

We get

$$\text{Remaining} = 1\text{g} \times \frac{1}{2^4}$$

$$= \frac{1}{16}\text{g}$$

18.8 Tritium, ${}^{3}_{1}\text{H}$ is radioactive isotope of hydrogen. It decays by emitting an electron. What is the daughter nucleus?

Ans. **<u>β-DECAY</u>**

The decay process is

$${}^{3}_{1}\text{H} \longrightarrow {}^{3}_{2}\text{X} + {}^{0}_{-1}\text{e}$$

Thus, the daughter nuclei ${}^{3}_{2}X$ is of helium element i.e. ${}^{3}_{2}\text{He}$

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 ${}^{16}_{7}N$?

Ans: **<u>INFORMATION ABOUT NITROGEN ATOM</u>**

Form the nuclide ${}^{14}_{7}N$, We know that it is one of the isotopes of nitrogen. It has 7 protons, 7 electron and 7 neutrons. As compared to ${}^{14}_{7}\text{N}$, ${}^{16}_{7}\text{N}$ has two extra neutrons in its nucleus as its atomic mass number increases by 2.

NUMERICAL PROBLEMS

18.1 The half-life of $^{16}_{7}N$ is 7.3s. A sample of this nuclide of nitrogen is observed for 29.2s. Calculate the fraction of the original radioactive isotopes remaining after this time. **(LHR 2014)**

Solution:

Given Data:

Half-life of $^{16}_{7}N$ = $T_{1/2}$ = 7.3

Total Time = 29.2 s

To Find:

N = ?

Calculations:

We know that

$$\text{No. of Half-life} = t = \frac{\text{Total Time}}{T_{1/2}}$$

$$t = \frac{29.2\,s}{7.3\,s} = 4$$

$$\text{Remaining fraction} = \text{Original} \times \frac{1}{2^t}$$

$$N = N_0 \times \frac{1}{2^4}$$

$$\frac{N}{N_0} = \frac{1}{16}$$

Result:

Hence, the fraction of the original radioactive isotope remaining after 4 half-lives will be 1/16th.

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. **(MTN 2017, BWP2017, FSD2017)**

Solution:

Given Data:

Half-life of Co-60 = $T_{1/2}$ = 5.25 years

Total Time = 26 years

To Find:

Remaining fraction = N= ?

Calculations:

We know that

$$\text{No. of Half-life} = t = \frac{\text{Total Time}}{T_{1/2}}$$

$$t = \frac{26\text{ years}}{5.25\text{ years}} = 5$$

$$N = N_0 \times \frac{1}{2^t} \Rightarrow N = N_0 \times \frac{1}{2^5}$$

$$\frac{N}{N_0} = \frac{1}{32}$$

Result:

Hence, the fraction of the original isotope remaining after 5 half-lives will be $\frac{1}{32}$.

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? **(LHR 2014, SHW2017, DGK2017, FSD2017)**

Solution:

Given Data:

Half-life of Carbon-14= $T_{1/2}$ = 5370 Years

Quantity of sample remaining = N=1/8

N_0 = 1

To Find:

Total Time = ?

Calculations:

$$N = N_0 \times \frac{1}{2^t} \Rightarrow 1/8 = 1 \times \frac{1}{2^t}$$

$$\frac{1}{2^3} = \frac{1}{2^t} \Rightarrow t = 3$$

Total Time = No. of half-lives × half-life

Total Time = t × $T_{1/2}$

Or Time = 3 × $T_{1/2}$

Or Time = 3 × 5730 years

Time = 1.72×10^4 years

Result:

Hence, Carbon will drop to 1/8 of its original quantity after 1.72×10^4 years.

18.4 Technetium-99 m is a radioactive element and is used to diagnose brain, thyroid, liver and kidney disease. 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:

Given Data:

Half-life $= T_{1/2} = 6$ hours

Total Time = 36 hours

Original quantity $= N_o = 200$ mg

To Find:

Sample remaining = N =?

No. of Half-life = t = ?

We know that

$$\text{No. of Half-life} = t = \frac{\text{Total Time}}{T_{1/2}}$$

$$t = \frac{36\,\text{hours}}{6\,\text{hours}} = 6$$

$$\text{Remaining amount} = \text{Original} \times \frac{1}{2^t}$$

$$= 200\text{ mg} \times \frac{1}{2^6}$$

$$= \frac{200\text{ mg}}{64}$$

Remaining amount = 3.125 mg

Result:

Hence, remaining sample will be 3.125mg.

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 minutes.

Solution:

Given Data:

Half-life $T_{1/2} = 10$ min.

Initial count rate = 368 counts per min.

Final count rate = 23 count per min.

To Find:

Time taken = ?

Calculations:

Half-life of radioactive element = 10 min

Initial count rate = 368 c/min

After 10 min = 184 c/min

After 20 min = 92 c/min

After 30 min = 46 c/min

After 40 min = 23 c/min

Result:

Hence, count rate will reach to 23 count per min in 40 min.

18.6 In an experiment to measure the half-life of a radioactive element, the following results were obtained:

Count rate	**400**	**200**	**100**	**50**	**25**
Time (in minutes)	**0**	**2**	**4**	**6**	**8**

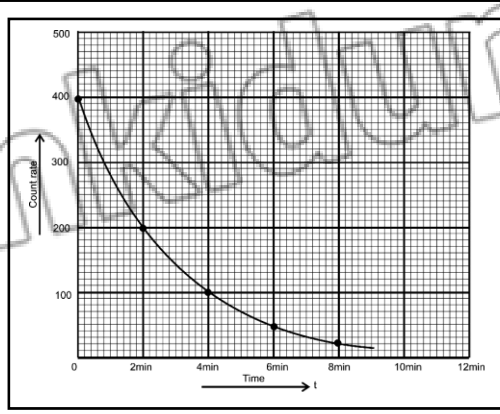
Plot a graph between the count rate and time in minutes. Measure the value for the half-life of the element from the graph.

Solution:

Scale:

One big division = 2 min. (along x-axis)

One big division = 100 counts (along y-axis)



Result:

From the graph, it is clear that half-life of the radioactive element is 2 minutes.

18.7 A sample of certain radioactive element has a half-life of 1500 years. If it has an activity of 32000 counts per hour at the present time, then plot a graph of the activity of this sample over the period in which it will reduce to 1/16 of its present value.

Solution:

Half-life $T_{1/2}$ = 1500 years

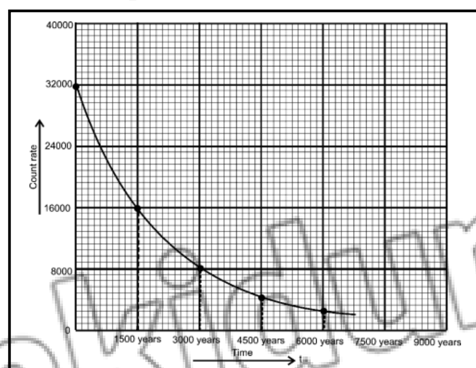
Activity = 32000 counts per hour

$\frac{1}{16}$ th of the activity $= \frac{32000}{16} = 2000$

Scale:

One big division = 1500 years (along x-axis)

One big division = 4000 counts per hour



Result:

Hence, the graph shows the period in which it will reduce to $1/6^{th}$ of its present value.

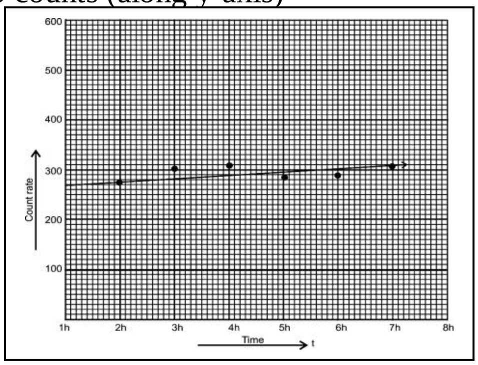
18.8 Half-life of a radioactive element was found to be 4000 years. The count rates per minute for 8 successive hours were found to be 270, 280, 300, 310, 285, 290, 305, 312. What does the variation in count rates show? Plot a graph between the count rates and time in hours. Why the graph is a straight line rather than an exponential?

Solution:

Scale:

One big division = 1 hour (along x-axis)

One big division = 100 counts (along y-axis)



Result:

Variation in count rates shows the random nature of radioactive decay, the graph is almost a horizontal line rather than an exponential curve, which is due to long half-life as compared to period of 8 hours.

18.9 Asches 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 camfire made?

(GRW 2014, SHW2017, SGD2017, RWP2017)

Solution:

Given Data:

$N_0 = 1$

Activity of C – 14 from ashes = N = $\frac{1}{8}$ th of fresh wood

Half life of C – 14 = $T_{1/2}$ = 5730 years

To Find:

No. of Half-life = ?

Total Time = ?

Calculations:

$N = N_0 \times \frac{1}{2^t} \Rightarrow 1/8 = 1 \times \frac{1}{2^t}$

$\frac{1}{2^3} = \frac{1}{2^t} \Rightarrow t = 3$

No. of half-lives = t = 3

Time = No. of half-lives × $T_{1/2}$

t = 3 × 5730 years

t = 17190 years

Result:

Hence, Asches show that campfire was made 17190 years ago.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. **(6×1=6)**

1. Matter is built from small particles called:
(A) Atoms (B) Ions
(C) Radicals (D) Molecules

2. How many types of radiation are emitted by radioactive substance?
(A) 1 (B) 2
(C) 3 (D) 5

3. Radiation present in atmosphere due to different radioactive substances:
(A) Background radiations (B) α-radiations
(C) β-radiations (D) γ-radiations

4. $^{14}_{6}C \longrightarrow ? + ^{0}_{4}e + \text{Energy}$
(A) $-^{0}_{1}e$ (B) $^{4}_{2}He$
(C) $^{14}_{6}e$ (D) $^{14}_{7}N$

5. High energy gamma rays can penetrate in air, at least of:
(A) 1 Km (B) 2 Km
(C) 3 Km (D) 4 Km

6. Which compound readily accumulates in the thyroid gland and can be used for monitoring of thyroid functioning?
(A) I-131 (B) I-130
(C) I-132 (D) I-129

Q.2 Give short answers to following questions. **(5×2=10)**
i. What is atomic number?
ii. Define natural radioactivity.
iii. Define ionization.
iv. What are stable nuclides?
v. Write uses of radioisotopes.

Q.3 Answer the following questions in detail. **(4+5=9)**
a) What do you understand by the half-life of a radioactive elements? Explain with the help of an example.
b) 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 quantity?

Note:
Parents or guardians can conduct this test in their supervision in order to check the skill of students.