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)

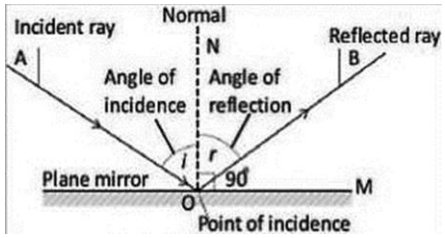


Figure: Reflection of Light

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)

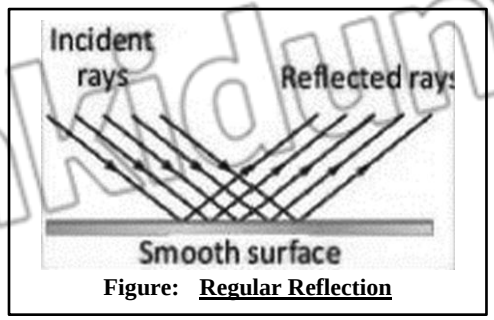


Figure: Regular Reflection

- 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)

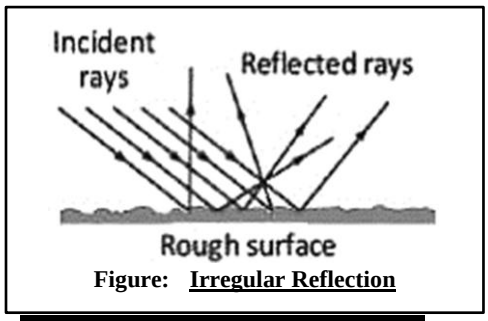


Figure: Irregular Reflection

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**".**

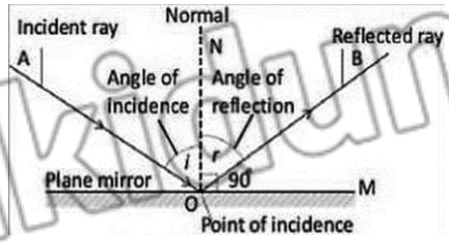


Figure: Reflection of Light

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.

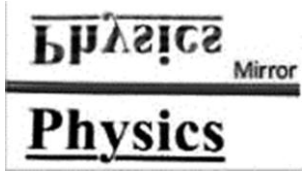


Figure: Plane Mirror

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.

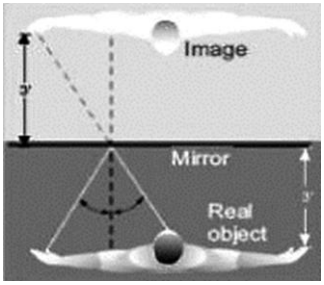


Figure: Flat Mirror

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)

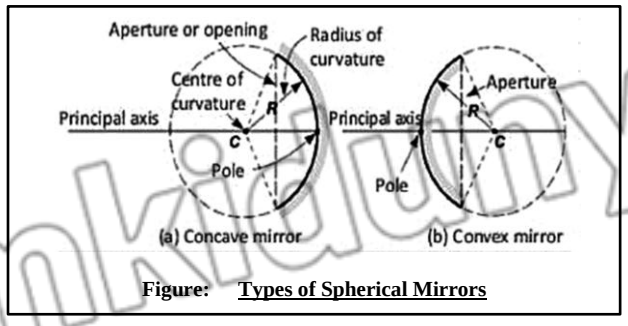


Figure: Types of Spherical Mirrors

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.

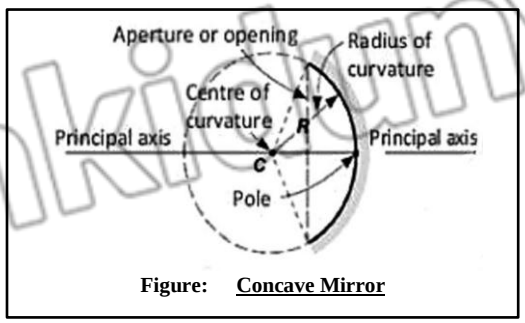


Figure: Concave Mirror

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.

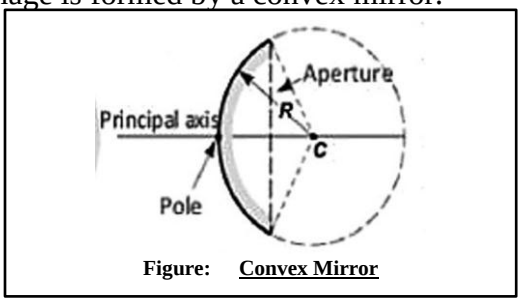


Figure: Convex Mirror

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.

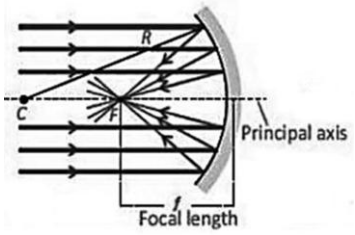


Figure: Principal Focus of Concave Mirror

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).

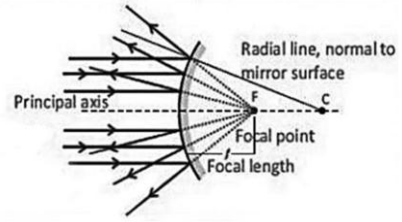


Figure: Principal Focus of Convex Mirror

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.

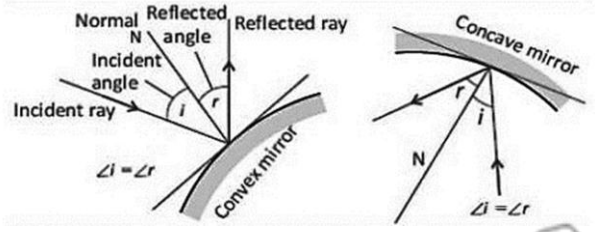


Figure: Reflection of Light by Spherical Mirrors

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: **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 of water? **(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.

Q.8 Which mirrors are used in headlights? **(For your Information Pg. # 39)**

Ans: **PARABOLIC MIRRORS**

Parabolic mirrors are used in headlights.

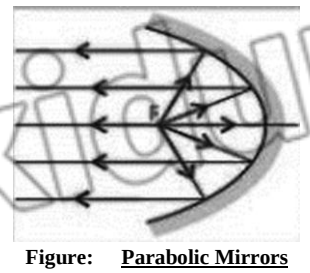


Figure: Parabolic Mirrors

Q.9 Write down the nature of image 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: **IMAGE NATURE**

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.

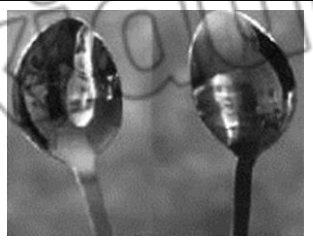


Figure: Spoon as a Spherical Mirror

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.

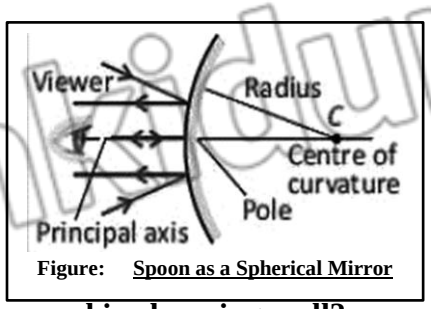


Figure: Spoon as a Spherical Mirror

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:

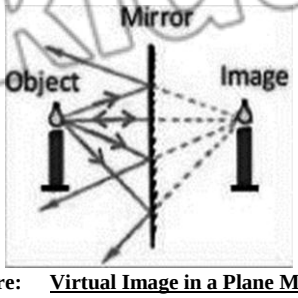


Figure: Virtual Image in a Plane Mirror

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.

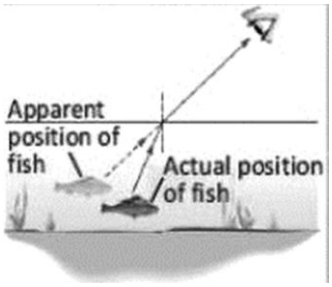


Figure: Position of Fish in Water

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:

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

Calculation:

By using formula, we have

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

Or $$\frac{1}{q}=\frac{1}{f}-\frac{1}{p}$$

$$\frac{1}{q}=-\frac{1}{46\text{cm}}-\frac{1}{66\text{cm}}$$

$$\frac{1}{q}=-\frac{1}{27\text{cm}} \Rightarrow q=-27cm$$

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.

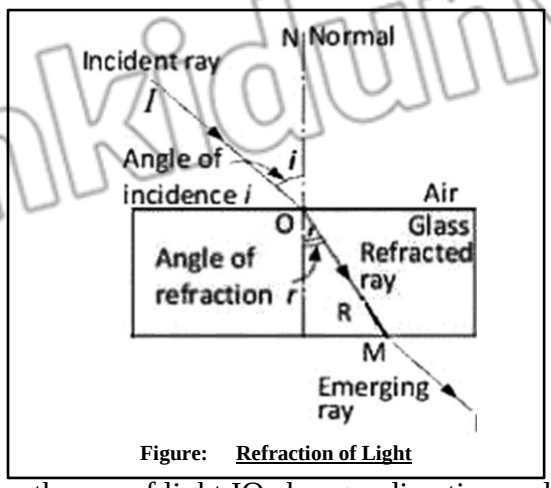


Figure: Refraction of Light

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 $2.3\times10^8 ms^{-1}$, while in glass, it is approximately $2.0\times10^8 ms^{-1}$. 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:

$$\text{Refractive Index} = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$$

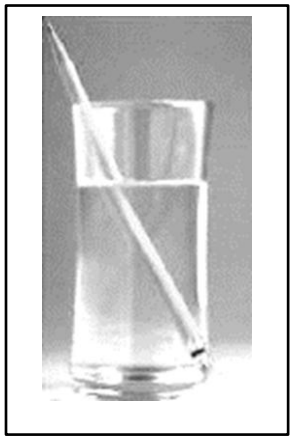
Or $$n = \frac{c}{v}$$

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".

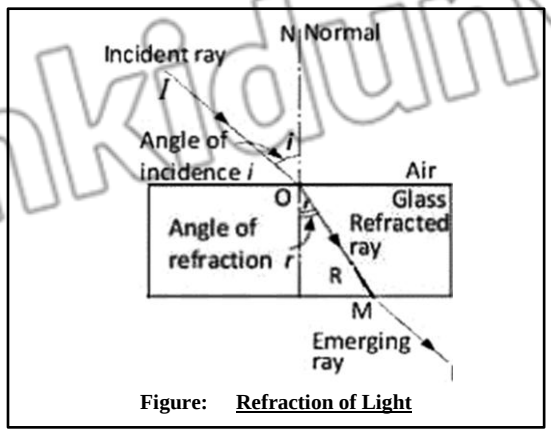


Figure: Refraction of Light

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:

$$\text{Refractive index} = \frac{\text{speed of light in air}}{\text{speed of light in medium}}$$

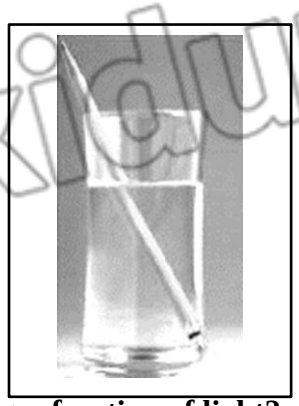
$$n = \frac{c}{v}$$

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.

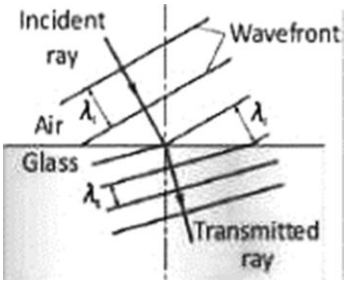


Figure: Changes during Refraction

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.

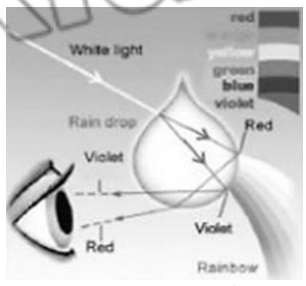


Figure: Dispersion of Light

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) $\frac{\sin i}{\sin r} = cons\tan t$ (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. $? = \frac{\textbf{speed of light in vacuum}}{\textbf{speed of light in medium}}$

(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°.

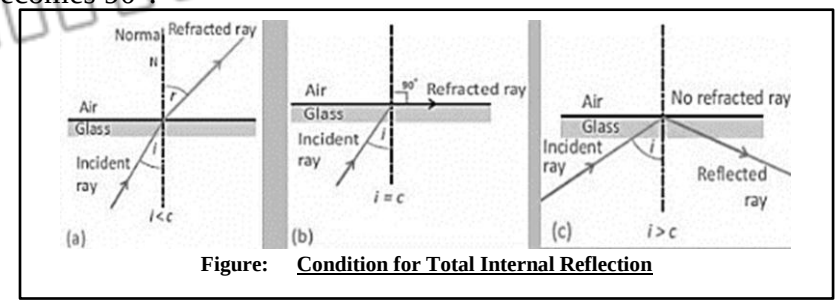


Figure: Condition for Total Internal Reflection

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, $r = 90°$ $\quad\therefore i = c$

$$n = \frac{\sin 90°}{\sin c}$$

$$n = \frac{1}{\sin c}$$

$$\text{cinc} = \frac{1}{n} \Rightarrow c = \sin^{-1}\left[\frac{1}{n}\right]$$

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.

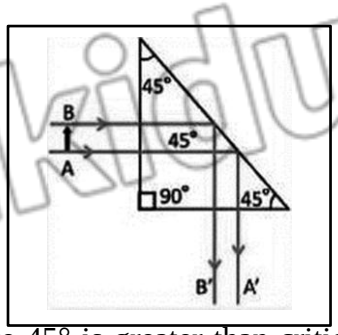
Ans: **TOTALLY INTERNAL REFLECTING PRISM**

Definition:

"Such prisms which reflect a beam of light through 90° or 180° by total internal reflection are called totally internal reflecting prisms**"**.

Working:

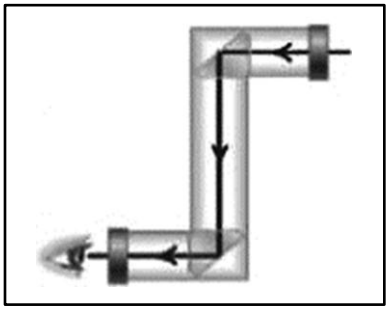
One of the angles of a right-angled prism is 90°. When a ray of light strikes a face of prism perpendicularly, it enters the prism without deviation and strikes the hypotenuse at an angle of 45° (As shown in Fig.).



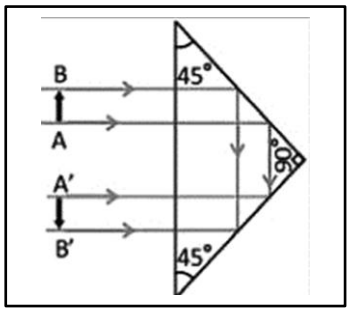
Since the angle of incidence 45° is greater than critical angle of the glass which is 42°, the light is totally reflected by the prism through an angle of 90°.

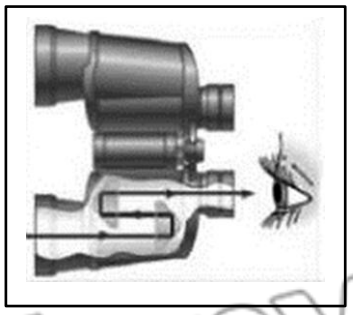
Uses:

- Two such prisms are used in periscope (As shown in Fig.).



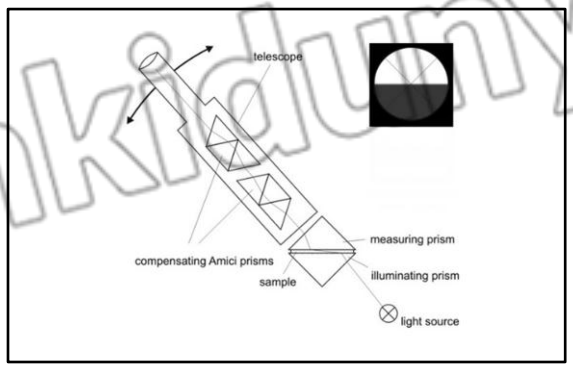
- When the light is totally reflected by the prism by an angle of 180°.Two such prisms are used in binoculars.





- 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).

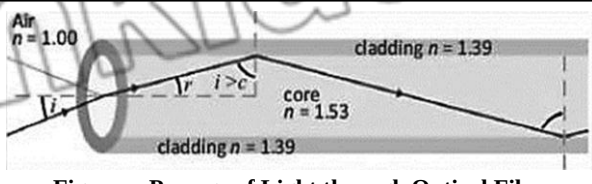


Figure: Passage of Light through Optical Fibre

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.

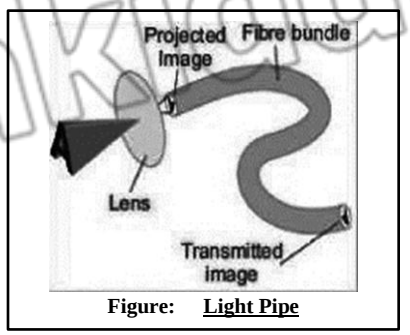


Figure: Light Pipe

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.

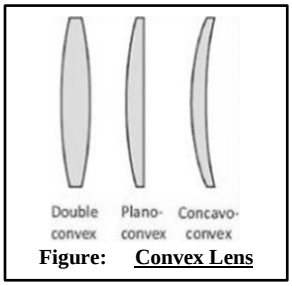


Figure: Convex Lens

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.

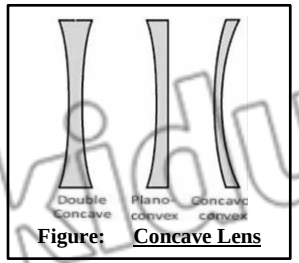


Figure: Concave Lens

Q.4 Describe the following lens terminologies.

- **Principal axis**
- **Focal length**
- **Optical Centre**
- **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).

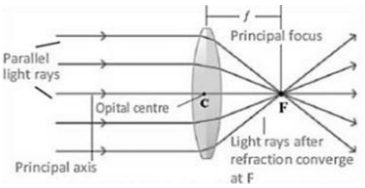


Figure: Convex Lens

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).

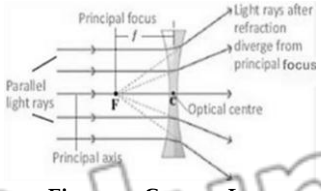


Figure: Concave Lens

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:

$$\text{Power of lens} = \frac{1}{\text{focal length in metre}} \Rightarrow P = \frac{1}{f \text{ in metre}}$$

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:

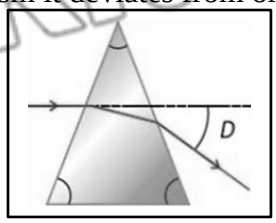
The power of a concave lens is negative, for it has negative focal length.

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:

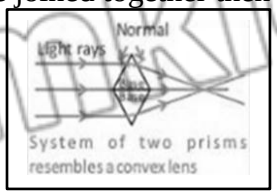
COMBINATION OF TWO PRISMS

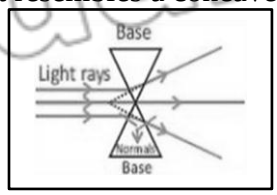
When Bases Combined:

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:

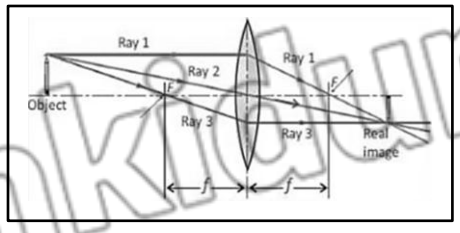
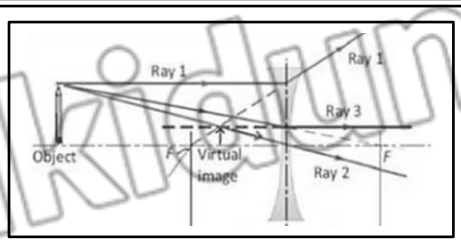


Image Formation in Concave Lens:

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.



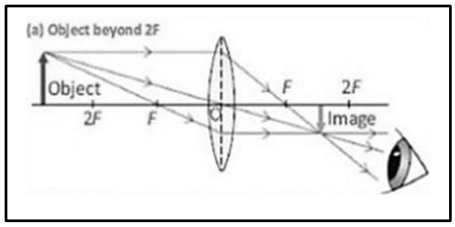
Q.2 Explain the image formation in convex lens with the help of ray diagram. Also describe the nature of image by convex lens depending upon the location of object.

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.

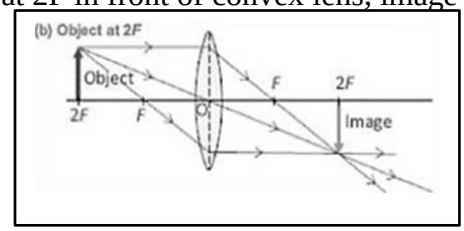


Nature:

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.

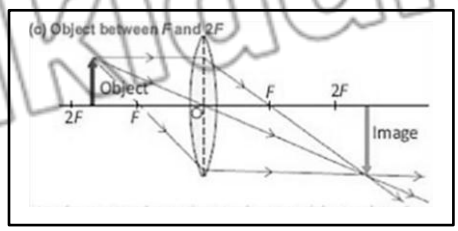


Nature:

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.

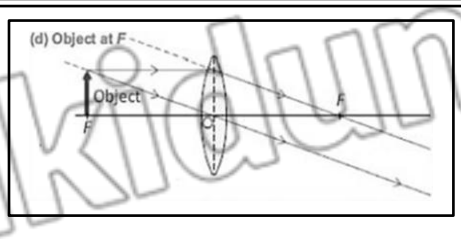


Nature:

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

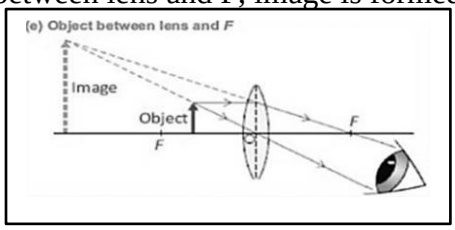
Object at F:

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**

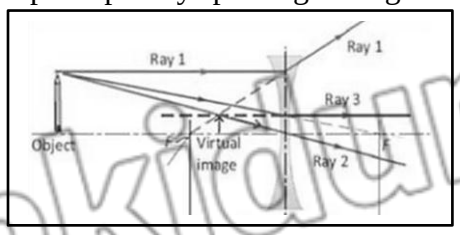
The characteristics of three principal rays, passing through the convex lens are as follows:

- 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.

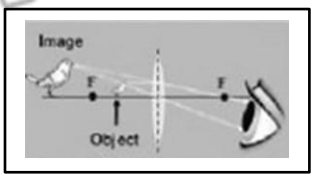
- A lens with a long focal length is thin; its surfaces are not very strongly curved.
- A lens with a short focal length is fatter; its surfaces are more strongly curved.

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.

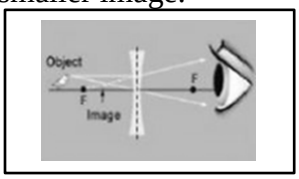


Q.6 When do we have the same ray diagram of diverging lens as that of converging lens? **(Physics Insight Pg. # 50)**

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:

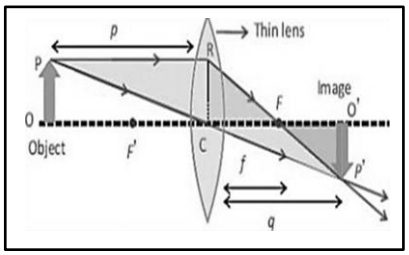
$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

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:

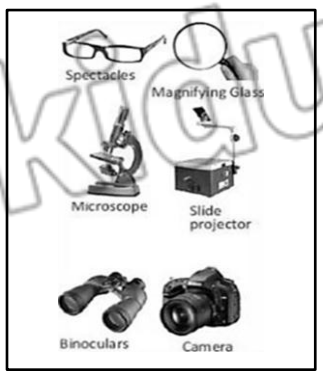
Optics also includes the study of the eye itself because the human eye forms an image with a lens.

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

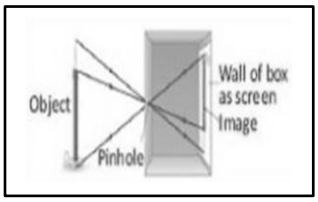


Q.7 What is a pinhole camera? How can we make pinhole camera without lens?

(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:

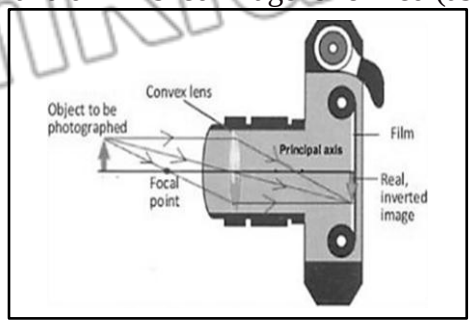
A simple camera consists of a light-proof box with a converging lens in front and a light sensitive plate or film at the back. The lens focuses images to be photographed onto the film. In simple lens camera, the distance between lens and film is fixed which is equal to the focal length of the lens.

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.

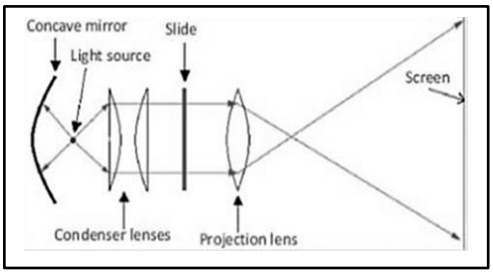
Ans:

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.

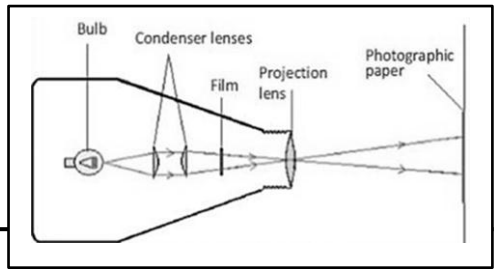
Ans:

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:

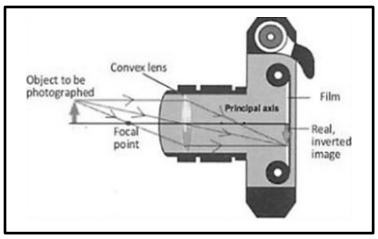
We get a real, inverted and enlarged image.

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:

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:

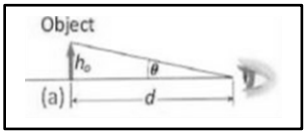
The object is placed nearer to the lens than the principal focus such that an upright, virtual and magnified image is seen clearly at 25cm from the normal eye.

Magnifying Power:

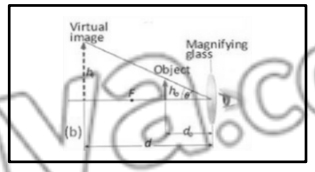
It is ratio of angular size of final image produced by magnifying glass to the angular size of object seen without magnifying glass.

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.

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

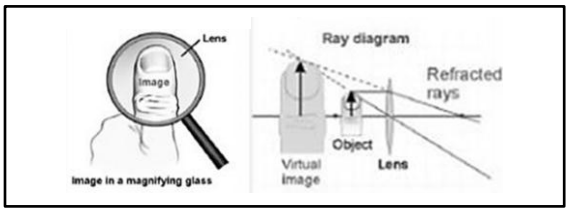
A magnifying glass is a convex lens which is used to produce magnified image of small objects. Hence it is also called a simple microscope.

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

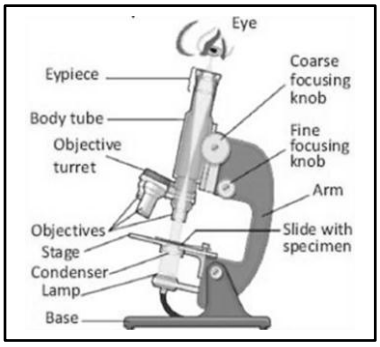
LONG QUESTIONS

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**"**.



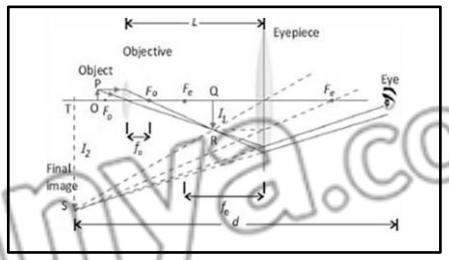
Features:

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: **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? **(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.

Ans: **COMPOUND MICROSCOPE**

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: **ASTRONOMICAL TELESCOPE**

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: **TELSECOPE**

Definition:

"Telescope is an optical instrument which is used to observe distant objects using lenses or mirrors".

Refracting Telescope:

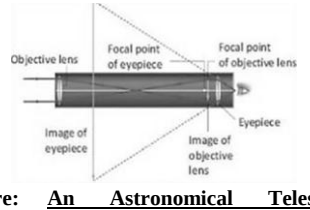


Figure: **An Astronomical Telescope Creates a Virtual Image that is Inverted Compared to that**

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 $M = \frac{f_0}{f_e}$

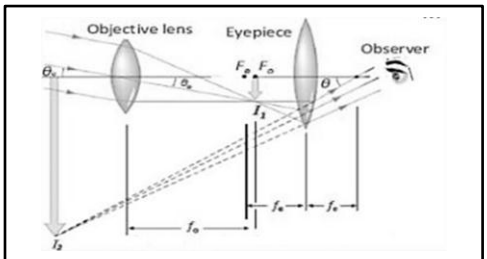


Figure: Ray Diagram of Refracting

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:

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.

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:

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.

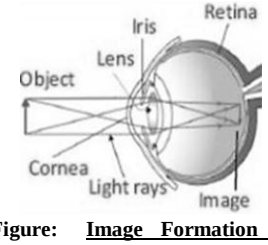


Figure: Image Formation in Human Eye

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.

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

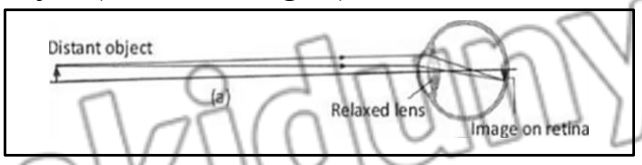
Definition:

"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.

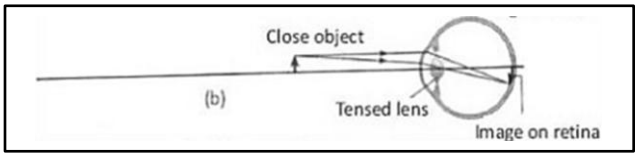
For Distant Objects:

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.

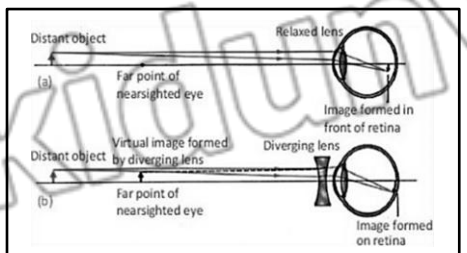


Figure: Correction of Nearsightedness

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)

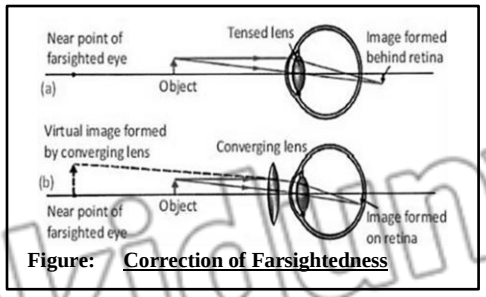


Figure: Correction of Farsightedness

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 $$\frac{1}{q}=\frac{1}{16\,cm}-\frac{10}{105\,cm}$$

$$=\frac{105-160}{(16)(105)\,cm}$$

$$=-\frac{55}{(16)(105)\,cm}$$

$$q = -30.54 \text{ cm}$$

(b) By using formula, we have

or $$\frac{h_i}{h_o}=\frac{q}{p}$$

by putting the values

$$\frac{h_i}{30\,cm}=\frac{30.54\,cm}{10.5\,cm}$$

$$h_i=\frac{30.54\,cm}{10.5\,cm}\times 30\,cm$$

$$h_i = 87.26\,\text{cm}$$

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

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

$$= \frac{1+1}{20\,cm}$$

$$= \frac{2}{20\,cm}$$

$$f = \frac{20\,cm}{2}$$

$$f = 10\ cm$$

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

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

$$\frac{1}{q} = \frac{19.3 - 8.7}{(8.7)\,(19.3)\,cm}$$

$$\frac{1}{q} = \frac{10.6}{167.9\,cm}$$

$$q = \frac{167.9\,cm}{10.6}$$

$$q = 15.83\ cm$$

(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

$$h_i = \frac{15.84\,cm}{19.3\,cm} \times 13.2\ cm$$

$$h_i = \frac{209.09\,cm}{19.3}$$

$$h_i = 10.83\ cm$$

(b) When the object is twice as far from the mirror, then

$p = 19.3\ cm \times 2 = 38.6\ cm$

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) **Image nature:**

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.

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

$$p = \frac{12\,cm}{3}$$

$p = 4$cm

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^o

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

$$n = \frac{\sin \hat{i}}{\sin \hat{r}}$$

$$\text{Or } \sin r = \frac{\sin i}{n}$$

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

$$\sin C = \left(\frac{1}{n}\right)$$

$$\text{or} \quad C = \sin^{-1}\left(\frac{1}{n}\right)$$

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

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

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

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

$2p = 60 \text{ cm}$

$p = \frac{60\,cm}{2}$

$p = 30 \text{ cm}$

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?

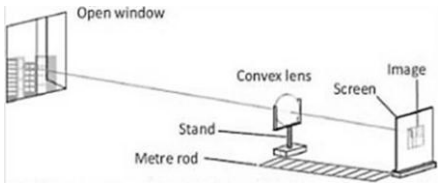


Figure: **Approximate Method of Finding Focal Length of a Convex Lens**

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.