Q.1 What is meant by reflection of light? State and explain laws of reflection with diagrams.

(Ans) **Reflection of light**
when a light ray moves in a medium and a resistance appears in its way, then the light ray strike with it such that some of its part is absorb by the resistance and most of its part is bounce back in its own medium. This bounce back of light in its own medium is called reflection of light.

**Laws of reflection**
There are two laws of reflection of light which are first of all introduced by a Muslim Scientist Ibnal Haitham. These laws are stated as:

(i) **First law of reflection**
This law state that “the incident ray, reflected ray and normal to the point of incident all lies in the same plane.

(ii) **Second law of reflection**
This law state that “the angle of incidence is always equal to the angle of reflection.” Mathematically

\[ \angle i = \angle r \]

Q.2 Distinguish between regular and irregular reflection of light? Also give its importance.

(Ans) **Regular reflection of light**
The reflection of light from a smooth shining surface in which the parallel light rays move parallel after reflection is called Regular reflection of light.
Importance
Due to Regular reflection of light a driver can see the rear view by the side mirror of the vehicles. Regular reflection of light is used in the image formation by mirrors and microscope.

Irregular reflection of light
The reflection of light from a rough and uneven shining surface in which all the parallel light rays are scattered in different directions after reflection is called Irregular reflection of light.

Importance
Due to Irregular reflection of light we can receive light before the sun rises and after the sun set. We can get light in such places where there is no direct approach of sun light. Non-luminous objects are also visible due to Irregular reflection of light.

Q3 What is spherical mirror? Discuss the types of spherical mirrors.

(Ans)

Spherical mirror
The part of the spherical shell having its outer or inner surface is shining and reflecting is called spherical mirror.
There are two types of spherical mirrors.

(1) Concave mirror
A spherical mirror whose inner surface is shining and reflecting is called concave mirror. A beam of parallel rays of light passing from a concave mirror focuses at one point after reflection. Therefore a concave mirror is also called converging mirror.
Convex mirror
A spherical mirror whose outer surface is shining and reflecting is called convex mirror. A beam of parallel rays of light passing from a convex mirror scattered in different directions. Therefore a convex mirror is also called diverging mirror.

Q.4 Define the main terms used in spherical mirrors.
(Ans) The terms related with spherical mirrors are:

1. **Center of curvature**
   The center of the sphere from which mirror is taken out is called center of curvature. It is denoted by “C”. As shown below.

2. **Radius of curvature**
   The radius of the sphere from which mirror is taken out is called radius of curvature. It is denoted by “r”. As shown in figure A.

3. **Pole**
   The geometrical central point of the spherical mirror is called pole. It is denoted by “P”. As shown in figure A.

4. **Principal axis**
   The imaginary straight line passing from the pole “P” and center of curvature “C” of the spherical mirror is called principal axis. As shown in figure A.

5. **Aperture**
   The diameter of the circular boundary of the spherical mirror is called aperture. OR
   The area of the spherical mirror exposed to the incident light is called aperture. As shown in figure A.

6. **Principal focus (OR) Focus point**
   The point of a concave mirror at which all the reflected rays are seem to converging is called principal focus or focus point. OR
The point of a convex mirror from which all the reflected light rays are seem to be diverging is called principal focus or focus point. It is denoted by “F”. As shown in figure A.

7. **Focal length**
   The distance between the pole and focus point of the spherical mirror is called focal length. It is denoted by “\( f \)”. OR
   Focal length of the concave mirror is taken positive while the focal length of the convex mirror is taken negative. As shown in figure A.

(Figure A)

**Reflection of Special rays**

i. The ray of light parallel to the principal axis passes through focus point of the concave mirror after reflection.

ii. The ray of light passing through focus point becomes parallel to the principal axis after reflection from the mirror.

iii. The ray of light passing through the center of curvature of the concave mirror is reflected back along the same path.
iv. The ray of light incident at the pole of a concave mirror is reflected back making the same angel of reflection with principal axis as incident ray makes with principal axis.

Q.5 An object is brought from a long distance towards the spherical mirror. Discuss the features of the images with diagram.

(Ans) There are five different types of images formed through a concave mirror by bringing object from a long distance towards the mirror.

**CASE 1**

When an object is placed away from the center of curvature “C” of the concave mirror, its image is formed in between center of curvature “C” and focus point “F”. The image will be real, inverted and smaller in size that of the object. Diagrammatically
CASE 2
When an object is placed at the center of curvature “C” of the concave mirror, its image is formed at the center of curvature “C”. The image will be real, inverted and of the same size that of the object. Diagrammatically

CASE 3
When an object is placed in front of a concave mirror in between the focus point “F” and center of curvature “C”, its image is formed away from the center of curvature “C”. The image will be real, inverted and large in size that of the objects. Diagrammatically

CASE 4
When an object is placed at the focus point “F” of a concave mirror, its image is formed at infinity. The image will be real, inverted and larger in size that of the object. Diagrammatically
CASE 5

When an object is placed in between focus point “F” and pole “P” of the concave mirror, its image is formed behind the mirror. The image will be virtual, erected and large in size that of the object. Diagrammatically

Image formation through convex mirror

When an object is placed in front of a convex mirror, its image is formed behind the mirror. The image will be virtual, erected and smaller in size that of the object. Diagrammatically

Q.6 Prove mirror formula \( \frac{1}{f} = \frac{1}{p} + \frac{1}{q} \) for a concave mirror.

(Ans) Consider an object “AB” is placed away from the center of curvature of a concave mirror, its image “A’B’” is formed in between center of curvature “C” and focus point “F”. The distance of the object from the mirror is “p” and distance of the image from the mirror is “q”. Diagrammatically

It is clear from figure that \( \triangle ABP \) and \( \triangle A'B'P \) are similar. Then
\[ \frac{AB}{BP} = \frac{A'B'}{B'P} \]

OR

\[ \frac{AB}{A'B'} = \frac{BP}{B'P} \quad (1) \]

Similarly \( \triangle PDF \) and \( \triangle ABF \) are similar, therefore

\[ \frac{PD}{PF} = \frac{A'B'}{B'F} \]

Since

\[ \frac{PD}{AB} \approx \frac{AB}{PF} = \frac{A'B'}{B'F} \]

\[ \frac{AB}{A'B'} = \frac{PF}{B'F} \quad (2) \]

Comparing equation (1) and equation (2), we get

\[ \frac{BP}{B'P} = \frac{PF}{B'F} \quad (A) \]

We know from figure that

\[ BP = p, B'P = q, PF = f \text{ and } B'P = q - f \]

Put these values in equation (A), We get

\[ \frac{p}{q} = \frac{f}{q - f} \]

\[ p(q - f) = qf \]

\[ pq - pf = qf \]

Now dividing both sides by \( pqf \)
\[
\frac{pq}{p} - \frac{pf}{q} = \frac{qf}{p}
\]
\[
\frac{1}{f} - \frac{1}{q} = \frac{1}{p}
\]
\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]

It is the required mirror formula for a concave mirror.

**Q.7** What is linear magnification? Also discuss the sign convention.

*(Ans)* **Linear magnification**

The ratio of the size of the image to the size of the object is called Linear magnification. OR

The ratio of the image distance from the mirror to the object distance is called Linear magnification. It is denoted by "M". Mathematically

\[
M = \frac{h_i}{h_o} = \frac{q}{p}
\]

**Sign convention**

The distance of the real image from the mirror is taken positive, where as the distance of the virtual image from the mirror is taken negative. The focal length of a concave mirror is taken positive and for a convex mirror it is negative.

**Q.8** Describe the uses of spherical mirrors.

*(Ans)* Uses of spherical mirrors are as under:

**i. As shaving mirror**

Concave mirror of large focal length is used as shaving mirror. When a person looks his face through this mirror, an enlarge erect and virtual image is seen in the mirror.

**ii. By doctors and dentists**

Dentists use a small concave mirror to have a look of backside of tooth and cavity in it. Doctors also use it to examine ear, nose, throat etc.

**iii. As objective of reflecting telescope**

A concave mirror of large aperture is used as objective in telescope. Greater amount of light is incident from the object, so a clear image can be seen by such telescope.
iv. In microscope
   Concave mirror is used in microscope to concentrate light on the slide.

v. In automobile headlights and search lights
   Concave mirrors are used behind the bulb such that a bulb lies at their principal focus. The rays of light become parallel after reflection. Thus powerful beam of light is obtained in a particular direction by headlights and search lights.

vi. In vehicles
   Convex mirrors are used in vehicles to observe rear view. It makes small, erect and virtual images of the objects behind the vehicle and provides a wide field of view.

Q.9 Explain refraction of light? State the laws of refraction.
   (Ans)
   Refraction of light
   When a light ray enters from one transparent medium into another obliquely, it slightly bends from its original path. This behavior of light is called refraction of light.
   Whenever light ray enters from a rare medium into a denser medium, the ray of light will slightly bends towards the normal.

   ![Diagram of refraction from air to water]

   Whenever light ray enters from a denser medium into a rare medium, the ray of light will slightly bends away from the normal.

   ![Diagram of refraction from water to air]

   Laws of refraction of light
   There are two laws of refraction that are as under.
First law of refraction
This law states that "the incident ray, refracted ray and normal to the point of incident all lies in the same plane."

Snell’s law
This law states that "the ratio of the sine of angle of incidence to the sine of angle of refraction is constant for a given pair of media. Mathematically

\[ n = \frac{\sin \angle i}{\sin \angle r} \]

Q.10 What is meant by refractive index?

Refractive index
It can be defined as "the ratio of the speed of light in air or vacuum to the speed of light in the media." It is denoted by "n". Mathematically

\[ n = \frac{\text{speed of light in air or vacuum}}{\text{speed of light in media}} \]

Where "C" is the speed of light and its value is \(3 \times 10^8 \text{m/sec}\).

Refractive index of some common substances is:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Refractive index</th>
<th>Substance</th>
<th>Refractive index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1.003</td>
<td>Crown glass</td>
<td>1.52</td>
</tr>
<tr>
<td>Ice</td>
<td>1.31</td>
<td>Kerosene oil</td>
<td>1.44</td>
</tr>
<tr>
<td>Water</td>
<td>1.33</td>
<td>Diamond</td>
<td>2.42</td>
</tr>
</tbody>
</table>
Q.11 What is total internal reflection of light? Mention some practical applications of it.

(Ans) **Total internal reflection of light**

When a ray of light move from a denser medium to a rare medium, then the light ray bends away from the normal. As we increase the angle of incidence the corresponding angle of refraction will also increases. At a certain angle of incidence the refracted angle becomes 90°, this angle of incidence is called critical angle \( \theta_c \). Now if the incident angle is increased from critical angle the light ray bounce back in its own medium. This behavior of light is called total internal reflection of light.

There are two conditions for total internal reflection of light.
(i) The light ray must go from a denser medium to a rare medium.
(ii) The angle of incidence must be greater than critical angle.

**Relationship between refractive index and critical angle**

Consider a light ray enter from a denser medium to a rare medium, so that the incident angle is critical angle and the refracted angle is 90°.

\[
n = \frac{\sin 90^\circ}{\sin \theta_c} = \frac{1}{\sin \theta_c}
\]

**Practical applications of total internal reflection of light**

**(1) Periscope**

A device used to see objects which are above or below the eye level. It is usually used in submarine and tanks to see objects from a safer place. A periscope consists of a long tube which is bent at 90° at both ends. At each end a totally reflecting prism is fixed.
An object “AB” is placed in front of a periscope, its image is seen through the periscope. Because each of the prism turns the incident ray of light though 90°.

(2) **The binoculars**
It consists of prisms that reduce the length of the device and produce erect image. The light rays in a pair of binoculars are bent through 180° by each prism in contrast to the periscope where light rays are only bent through 90° by each prism. Figure

(3) **Optical fibers**
An optical fiber is made of a core of high refractive index i.e. glass or plastic. It is normally coated with glass of lower refractive index. A light ray introduced into the optical fiber will be internally reflected at the surface. The thickness of the fiber is equal to the thickness of the human hair that is \( \frac{1}{100} \) of mm.

**Uses**
A bundle of several thousands of such fibers are bound together in a flexible tube called light pipe. This light pipe is used by the surgeons to examine the interior parts of the body. Optical fibers are also used in telecommunication as it carries information faster than other wires like iron, copper, etc.
Endoscope

It is an optical instrument used to view and photograph a hollow organ inside the body such as the bladder, womb, etc. It works on the principle of total internal reflection of light. A video camera is fitted outside the bundle of fibers which can visible the interior organs of the patient which is to be operated.

Q.12 What is meant by an optical prism? How does the angle of deviation can be determined through prism.

(Ans) Prism

It is a transparent body having three rectangular and two triangular surfaces. The three rectangular surfaces inclined to each other making a triangular boundary, while the two triangular surfaces are parallel to each other.

The angle between the two refracting rectangular surfaces opposite to the base is called angle of the prism. Angle of the prism is denoted by” A”.
**Determination of angle of deviation**
Consider the ray of light “PQ” strikes the face AB of the prism. The entering ray bends towards the normal as glass is denser than air and proceeded along “QR” and incident on the face AC of the prism. The ray “RS” bends away from the normal towards the base as air is rare medium and glass is denser. Extend PQ as PT and RS as SE, they meet at point D. Thus the prism deviate the light ray PT through an angle TDS in the form of RS. This angle TDS is called angle of deviation.

![Diagram of light deviation through a prism]

**Relation between refractive index and angle of deviation**
Refraactive index of the prism can be calculated as follow;

\[
n = \frac{\sin(\frac{A + D_m}{2})}{\sin\frac{A}{2}}
\]

Q.13 What is a lens? Explain the main and sub types of lenses.
(Ans) **Lens**
A lens is a transparent material usually made of glass which is bounded by a spherical surface at least from one side. Basically lenses are used to converge or diverge the incident beam of light.
There are two main types of lenses.
(1) **Convex lens**
A type of lens which is thicker at the center and thinner at the edges is called convex lens. It is also called as converging lens, because it focus a parallel beam of light at a point known as focus point of the lens.
There are three sub types of a convex lens.
(i) **Double convex lens**
A convex lens whose both bounded surfaces are convex is known as double convex lens.
(ii) **Plano convex lens**
A convex lens whose one bounded surface is plane and the other is convex is known as Plano convex lens.
(iii) **Concave convex lens**
A convex lens whose one bounded surface is concave and the other is convex is known as concave convex lens.
(2) **Concave lens**
A type of lens which is thinner at the center and thicker at the edges is called convex lens. It is also called as diverging lens, because it scattered the parallel beam of light falls on it.
There are three sub types of concave lens.

(i) **Double concave lens**
A concave lens whose both bounded surfaces are concave is known as double concave lens.

(ii) **Plano concave lens**
A concave lens whose one bounded surface is plane and the other is concave is known as Plano concave lens.

(iii) **Convex concave lens**
A concave lens whose one bounded surface is convex and the other is concave is known as convex concave lens.

---

**Q.14** Define the main terminologies used in lenses?

**(Ans)** The main terminologies used in lenses are;

1. **Optical centre**
The centre point of a lens is called optical centre. It is denoted by “O”.

2. **Principal axis**
The imaginary straight line passing from the optical centre “O” and are perpendicular to both the faces of the lens is called principal axis.

3. **Principal focus**
The point of a convex lens at which all the refracted rays are seem to converging is called principal focus or focus point. OR
The point of a concave lens from which all the refracted light rays are seem to be diverging is called principal focus or focus point. It is denoted by “F”. Lenses have two foci and are at equal distance from the optical centre at either side.

4. **Focal length**
The distance between the optical centre and focus point of the spherical mirror is called focal length. It is denoted by “f”. OR
Focal length of the convex lens is taken positive while the focal length of the concave lens is taken negative.
Q.16 An object is brought from a long distance towards the Lens. Discuss the features of the images with diagram.

(Ans) There are five different types of images formed through a convex lens by bringing object from a long distance towards the lens.

**CASE 1**
When an object is placed away from “2F” of a convex lens, its image is formed in between “2F” and focus point “F” at other side. The image will be real, inverted and smaller in size that of the object. Diagrammatically

**CASE 2**
When an object is placed at “2F” of the convex lens, its image is formed at “2F” at the other side. The image will be real, inverted and of the same size that of the object. Diagrammatically

**CASE 3**
When an object is place in front of a convex lens in between the focus point image from side. will be large
Diagrammatically

**CASE 4**
When an object is placed at the focus point “F” of a convex lens, its image is formed at infinity. The image will be real, inverted and larger in size that of the object. Diagrammatically

![Diagram of CASE 4](image)

**CASE 5**
When an object is placed in between focus point “F” and optical centre of the convex lens, its image is formed in front of the lens. The image will be virtual, erected and large in size that of the object. Diagrammatically

![Diagram of CASE 5](image)

**Image formation through concave lens**
When an object is placed in front of a concave lens, its image is formed in front of the lens. The image will be virtual, erected and smaller in size that of the object. Diagrammatically

![Diagram of Image formation through concave lens](image)

**Sign convention**
The distance of the real image from the lens is taken positive, where as the distance of the virtual image from the lens is taken negative. The focal
length of a convex lens is taken positive and for a concave lens it is negative.

Q.17 Prove lens formula \[ \frac{1}{f} = \frac{1}{p} + \frac{1}{q} \] for a convex lens.

(Ans) Consider an object “AB” is placed in front of a convex lens, its image “A’B’” is formed behind the lens. The distance of the object from the lens is “p” and distance of the image from the lens is “q”. Diagrammatically

It is clear from figure that \( \Delta ABO \) and \( \Delta A'B'O \) are similar. Then

\[ \frac{AB}{OB} = \frac{A'B'}{OB'} \]

OR

\[ \frac{AB}{A'B'} = \frac{OB}{OB'} \] ———— (1)

Similarly \( \Delta ODF \) and \( \Delta ABF \) are similar, therefore

\[ \frac{OD}{OF} = \frac{A'B'}{B'F} \]

Since

\[ \frac{OD}{AB} \approx \frac{OB}{A'B'} \]

\[ \frac{AB}{OF} = \frac{A'B'}{B'F} \]

\[ \frac{AB}{A'B'} = \frac{OF}{B'F} \] ———— (2)

Comparing equation (1) and equation (2), we get
\[
\frac{OB}{OB'} = \frac{OF}{B'F} \quad \ldots \ldots \quad (A)
\]

We know from figure that
\[
OB = p, \quad OB' = q, \quad OF = f \quad \text{and} \quad OB' = q - f
\]

Put these values in equation (A), We get
\[
\frac{p}{q} = \frac{f}{q - f}
\]
\[
p(q - f) = qf
\]
\[
pq - pf = qf
\]

Now dividing both sides by \( pqf \)
\[
\frac{pq}{pqf} - \frac{pf}{pqf} = \frac{qf}{pqf}
\]
\[
\frac{1}{f} - \frac{1}{q} = \frac{1}{pf}
\]
\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]

It is the required lens formula for a convex lens.

Q.18 What is meant by power of a lens?
(Ans) Power of a lens
It can be defined as "the reciprocal of the focal length of a lens in meter is called power of a lens." It is denoted by "D". Its SI unit is dioptre. The power of a convex lens is taken positive, while for a concave mirror it is negative. Mathematically
\[
D = \frac{1}{f(m)}
\]

Q.19 Write note on the following instruments.
(Ans) Simple microscope
A device used to see small objects that cannot be seen though naked eye is called microscope.
Construction
It is a convex lens of short focal length. It is also called magnifying glass. It works on the principle that when an object is placed within its focal length, a magnified, virtual and erect image is formed. The image formed through a microscope is larger than the object, it becomes easy to study small
objects. Watch maker and jewelers used it to observe small pieces which cannot be seen on naked eyes.

**Compound microscope**

It consist of two convex lenses of short focal lengths fitted at the outer end of two tubes. These tubes can slide into one another to adjust the distance between two lenses. The lens which is towards the object is called objective lens (objective) and the lens which is towards our eyes is called eye piece lens (eye piece). The focal length of objective lens is shorter than eye piece lens. As a result the image formed by the microscope is magnified and erect.

**Astronomical telescope**

A device used to see heavenly objects like sun, stars, moon etc are called telescope. It consist of two convex lenses called objective and eye piece which are fitted at the outer ends of two metallic tubes which can slide into one another. The objective of a telescope is of larger focal length and can capture beyond objects, while eye piece is of shorter focal length can magnified objects.
Q.20 Explain the main defects of vision. How each defect can be corrected?

(Ans) There are two main defects of vision.

1. **Short sightedness (myopia)**
   A person having this defect can see the near objects clearly but cannot see the object situated at far distances as much clear and distinctly. The reason of this defect is that the focal length of the eye lens is very small or the eye ball becomes much larger. Therefore the rays of the far objects focus just before the retina.
   This defect can be corrected by using a concave lens of suitable focal length in the spectacles.

2. **Long sightedness (Hypermetropia)**
   A person having this defect can see the far objects clearly but cannot see the near objects clearly. The reason of this defect is that the focal length of the eye lens is very large or the eye ball becomes small. Therefore the rays of the near objects focus behind the retina.
   This defect can be corrected by using a convex lens of suitable focal length in the spectacles.
SHORT QUESTIONS

i. Draw a label diagram to show the:
   (a) Pole   (b) Centre of curvature   (c) Principal axis
   (d) Principal focus   (e) Radius of curvature
   Ans. See Q.4

ii. Define focal length and radius of curvature. What is the relation between focal length and radius of curvature in case of a concave mirror?
   Ans. Radius of curvature
   The radius of the sphere from which mirror is taken out is called radius of curvature. It is denoted by “r”.
   Focal length
   The distance between the pole and focus point of the spherical mirror is called focal length. It is denoted by “f”. OR
   Focal length of the concave mirror is taken positive while the focal length of the convex mirror is taken negative.
   Relation between focal length and radius of curvature
   Focal length is half of the radius of curvature. Mathematically
   \[ f = \frac{r}{2} \]

iii. Name the spherical mirror which has:
   (a) Virtual principal focus   (b) Real principal focus
   Ans. (a) Convex mirror has virtual principal focus.
   (b) Concave mirror has real principal focus.

iv. If the radius of curvature of a concave mirror is 1m, what is its focal length?
   Ans. If radius of curvature of the concave mirror is 1m, then its focal length is 0.5m. Mathematically
   \[ f = \frac{r}{2} = \frac{1}{2} = 0.5m \]

v. For what position of an object, a concave mirror forms an image which is real and equal in size to the object?
   Ans. When an object is placed at the center of curvature “C” of the concave mirror, its image is formed at the center of curvature “C”. The image will be real, inverted and of the same size that of the object. Diagrammatically
vi. For what position of an object a real and diminished image is formed by a concave mirror?
Ans. When an object is placed away from the center of curvature “C” of the concave mirror, its image is formed in between center of curvature “C” and focus point “F”. The image will be real and diminished. Diagrammatically

![Image](image.png)

vii. Give at least three uses of a concave mirror?
Ans. See Q.8

viii. Define refractive index. How is it related to velocity of light on a pair of media?
Ans. See Q.10

ix. How would you make the rays from a luminous bulb parallel by means of a concave mirror?
Ans. It is clear from ray diagram that if we place the luminous bulb at the focus point of the concave mirror, the light rays will move parallel. These light rays meet at infinity.

x. What is meant by linear magnification of an image by a spherical mirror?
Ans. See Q.7

xi. Which type of spherical mirror has a wider field of view?
Ans. The convex mirror has a wider field of view, because it produce virtual, erect and diminished image of an object placed in front of it. It is used in automobile to see the image of the object coming behind the automobiles.

xii. Why does a driver prefer to use a convex mirror as a back view mirror in an automobile?
Ans. A driver prefer to use a convex mirror as a back view mirror in automobile, because it produce virtual, erect and diminished image of an object placed in front of it. As a result the driver can judge about every thing coming behind his vehicle. Thus a convex mirror provides us the way of safe driving.

xiii. A ray of light traveling in water emerges into air. Draw a ray diagram indicating the change in its path?
Ans. Whenever light ray enters from a denser medium into a rare medium, the ray of light will slightly bends away from the normal. As water is denser
medium and air is rare medium, so the ray of light slightly bends away from the normal. Diagrammatically

\[ \text{Air} \]
\[ \text{N} \]
\[ \text{Water} \]
\[ \text{N'} \]

xiv. What is the unit of refractive index?
Ans. Refractive index is the ratio of two similar quantities. Therefore it has no unit. Mathematically

\[ \text{refractive index} = \frac{\text{speed of light in air or vacuum}}{\text{speed of light in media}} \]
\[ n = \frac{C}{V} \]

xv. Which one has higher refractive index, water or glass?
Ans. The refractive index of glass is greater than that of water. The refractive index of water is 1.33, while the refractive index of various glasses ranges from 1.5 to 1.9.

xvi. Define Snell’s law of refraction?
Ans. Snell’s law
This law states that “the ratio of the sine of angle of incidence to the sine of angle of refraction is constant for a given pair of media. Mathematically

\[ n = \frac{\sin \angle i}{\sin \angle r} \]

xvii. Why a pencil half immersed in water and held obliquely, appears to be bent at the water surface?
Ans. It is because of refraction of light, the light rays coming from water (denser medium) into air (rare medium). The light rays bends away from the normal. As a result the pencil appears to be bent at the water surface.

xviii. For what position an object, a real and diminished image formed by convex lens?
Ans. When an object is placed away from “2F” of a convex lens, its image is formed in between “2F” and focus point “F” at other side. The image will be real, inverted and smaller in size that of the object. Diagrammatically

xix. What is the SI unit of power of a lens?
Ans. The unit of the power of a lens is dioptre. It can be defined as" the power of a lens is one dioptre if the focal length of the lens is one meter."

xx. What will be the value of angle of refraction when angle of incidence in denser medium is equal to the critical angle for a given pair of media?
Ans. When a ray of light move from a denser medium to a rare medium, then the light ray bends away from the normal. As we increase the angle of incidence the corresponding angle of refraction will also increases. At a certain angle of incidence the refracted angle becomes 90°, this angle of incidence is called critical angle “$\theta_c$”. The angle of refraction for the given pair of media will be 90°.

xxi. Why do stars twinkle on a clear night?
Ans. The light from the stars travels through different layers of the atmosphere of various densities. Therefore the light rays deviate from its original path time to time. As a result it looks like that stars are twinkling.

xxii. You are given two convex lenses of focal length 7cm and 20cm. which one will you choose as objective lens for making a compound microscope?
Ans. The magnifying power of a compound microscope can be stated as;

$$M = \frac{L}{f_0} (1 + \frac{d}{f_e})$$

Smaller the focal length of objective lens greater will be the magnifying power. So we will choose the lens having focal length 7cm.

xxiii. What type of lens is used to make the eye-piece of a compound microscope?
Ans. The eye-piece of a compound microscope is a convex lens of larger aperture and focal length as compared to objective lens.
xxiv. In a telescope, which one has a shorter focal length, objective or eye-piece?
Ans. The magnifying power of a telescope can be stated as;

\[ M = \frac{f_o}{f_e} \]

We use an eye-piece of short focal length and small aperture.

xxv. A child sitting in a classroom is not able to see clearly the writing on the blackboard?
(a) Name the type of defect from which he suffering?
(b) With the help of ray diagram, show that how this defect can be removed?
Ans. A child sitting in a classroom is not able to see clearly the writing on the blackboard.
(a) The defect from which the child suffering is called short sightedness or myopia.
(b) This defect can be corrected by using a concave lens of suitable focal length in the spectacles.
NUMERICAL PROBLEMS

1. The image of an object is formed by a concave mirror at a distance of 30cm. Find the position of an object if the focal length of concave mirror is 15cm.

   Given data
   
   \[ q = 30cm \]
   \[ f = 15cm \]
   \[ p = ? \]

   We know that
   
   \[ \frac{1}{f} = \frac{1}{p} + \frac{1}{q} \]
   \[ \frac{1}{p} = \frac{1}{f} - \frac{1}{q} \]
   \[ \frac{1}{p} = \frac{1}{f} - \frac{1}{q} = \frac{1}{15} - \frac{1}{30} \]
   \[ \frac{1}{p} = \frac{2 - 1}{30} \]
   \[ \frac{1}{p} = \frac{1}{30} \]
   \[ p = 30cm \]

2. Find the position of an object to be placed in front of a concave mirror of radius of curvature 18cm to get a real image in double in size.

   Given data
   
   \[ p = ? \]
   \[ M = 2 \]
   \[ r = 18cm \]
   \[ f = \frac{r}{2} = \frac{18}{2} = 9cm \]

   We know that
   
   \[ M = \frac{q}{p} \]
   \[ \frac{q}{p} = 2 \]
   \[ q = 2p \]

   We also know that
\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \\
\frac{1}{9} = \frac{1}{p} + \frac{1}{2p} \\
\frac{1}{9} = \frac{2 + 1}{2p} \\
p = \frac{27}{2} = 13.5 \text{cm}
\]

3. A candle flame is situated at a distance of 40cm from a convex mirror if radius of curvature of mirror is 40cm. find the position and nature of the image.

**Given data**

\[p = 40\text{cm}\]

\[r = -40\text{cm}\]

\[f = \frac{r}{2} = \frac{-40}{2} = -20\text{cm}\]

\[q = ?\]

**Nature** = ?

We know that

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \\
\frac{1}{9} = \frac{1}{p} - \frac{1}{f} \\
\frac{1}{q} = \frac{1}{-20} - \frac{1}{40} \\
\frac{1}{q} = -2 - 1 \\
\frac{1}{q} = \frac{-3}{40} \\
q = -\frac{40}{3} = -13.33\text{cm}
\]

Nature: Image is virtual (q = 13.33cm)
4. Determine the refractive index of water if the speed of light in water is $2.25 \times 10^8 m/s$ and velocity of light in air is $3 \times 10^8 m/s$?

**Given data**

$$V = 2 \cdot 25 \times 10^8 m/s$$

$$C = 3 \times 10^8 m/s$$

$$n = ?$$

$$n = \frac{C}{V}$$

$$n = \frac{3 \times 10^8}{2 \cdot 25 \times 10^8}$$

$$n = 1.33$$

5. A ray of light is incident on the surface of Sulphuric acid at $35^\circ$ angle of incident. The refractive index of Sulphuric acid is 1.43. Find the angle of refraction of the refracted ray.

**Given data**

$$m \angle i = 35^\circ$$

$$m \angle r = ?$$

$$n = 1.43$$

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

$$\sin \angle r = \frac{\sin 35^\circ}{1.43}$$

$$\sin \angle r = \frac{0.573}{1.43}$$

$$m \angle r = \sin^{-1}(0.40)$$

$$m \angle r = 23.6^\circ$$

6. An object 5cm high placed in front of a convex lens of focal length 20cm. find the position of the object if a real image 10cm high is to be obtained.

**Given data**

$$h_o = 5cm$$

$$h_i = 10cm$$

$$f = 20cm$$

$$p = ?$$

We know that
\[ M = \frac{q}{p} = \frac{h_i}{h_o} \]
\[ \frac{q}{p} = \frac{10}{5} \]
\[ \frac{q}{p} = 2 \]
\[ q = 2p \]

We also know that
\[ \frac{1}{f} = \frac{1}{p} + \frac{1}{q} \]
\[ \frac{1}{20} = \frac{1}{p} + \frac{1}{2p} \]
\[ \frac{1}{20} = \frac{2 + 1}{2p} \]
\[ 2p = 60 \]
\[ p = 30cm \]

7. Find the focal length of a convex lens whose power is 5 dioptre.

Given data
\[ D = 5\text{dioptre} \]
\[ f = ? \]
\[ D = \frac{1}{f} \]
\[ f = \frac{1}{D} \]
\[ f = \frac{1}{5} \]
\[ f = 0 \cdot 2m = 20cm \]

8. A converging lens of focal length 15cm is placed 20cm in front of a screen. Where should the object be placed if its image is appear on the screen?
Given data

\[ f = 15\text{cm} \]

\[ q = 20\text{cm} \]

\[ p = ? \]

We know that

\[ \frac{1}{f} = \frac{1}{p} + \frac{1}{q} \]

\[ \frac{1}{p} = \frac{1}{f} - \frac{1}{q} \]

\[ \frac{1}{p} = \frac{1}{15} - \frac{1}{20} \]

\[ \frac{1}{p} = \frac{4 - 3}{60} \]

\[ \frac{1}{p} = \frac{1}{60} \]

\[ p = 60\text{cm} \]