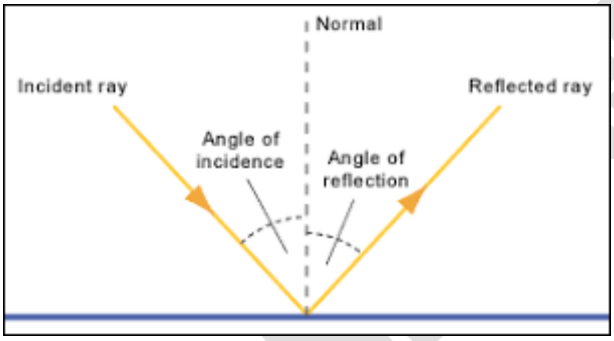
Chapter # 12: GEOMETRICAL OPTICS

Reflection of light:-

When a ray of light moving in one medium fall on the surface of another medium and it

bounces back into the first medium. Then this bouncing back of the light, is called reflection of light.



Laws of reflection:-

First law:

The incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane.

Second law:

The angle of incidence is equal to the angle of reflection.

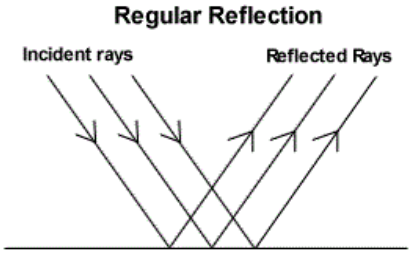
Types of reflection:-

There are two types of reflection.

i. Regular reflection. ii. Irregular reflection.

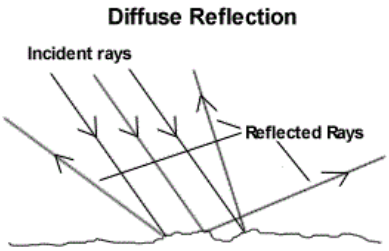
i. Regular reflection:-

Such a reflection in which a smooth surface of a body reflect light only in one direction is called regular reflection.



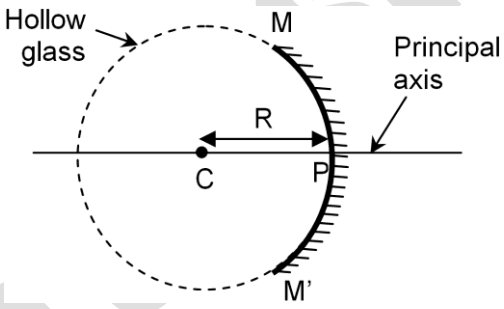
ii. Irregular reflection :-

Such a reflection in which, a rough surface of a body reflect light in many directions, is called irregular reflection.



Spherical Mirrors: -

A mirror whose polished, reflecting surface is a part of a hollow sphere of glass or plastic, is called a Spherical mirror.



Types of Spherical Mirror:-

There are two types of spherical mirror.

i. Concave Mirror.
ii. Convex Mirror.

i. Concave Mirror:-

A spherical mirror, whose inner curved surface is reflecting, is called concave mirror. Both real and virtual images can be formed by a concave mirror.

ii. Convex Mirror:-

A spherical mirror, whose outer curved surface is reflecting, is called convex mirror. Only virtual and erect images formed by a convex mirror.

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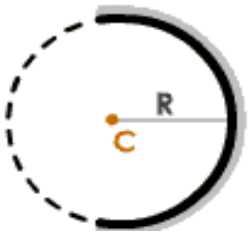
Pole:

The centre or the midpoint of the curved surface of a spherical mirror is called pole. It is also called vertex.

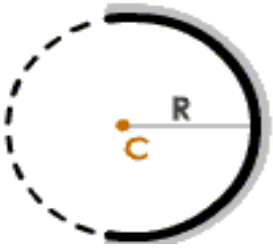
Centre of curvature:-

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



Radius of curvature:-

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



Principal Axis:-

The line that joins centre of curvature and pole of the spherical mirror is called principal axis.

Principal Focus:-

Rays of light after reflection from a concave mirror converge to a point **"F"**. This point is called principal focus of the mirror. The principal focus of concave mirror is called real focus and the principal focus of convex mirror is called virtual focus.

Focal length:-

The distance from the pole to the principal focus, is called focal length. It is represented by **'f'**. Focal length is half of the radius of curvature.

$$f = \frac{R}{2}$$

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Characteristics of focus of a concave and a convex mirror:-

	Concave Mirror		Convex Mirror
i.	The focus of a concave mirror lies in front of mirror	i.	The focus of a convex mirror lies behind the mirror.
ii.	The focus of concave mirror is real focus because the rays of light after reflecting from mirror converge at the focus,	iii.	The focus of convex mirror is virtual focus because the rays of light after reflecting from mirror appear to come from the focus.

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Image location by spherical formula:-

Mirror formula:-

Mirror formula is the relationship b/w distance of object (P), distance of image (q) from the mirror, and focal length of the mirror (f). Mirror formula is written as.

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

Sign conversions:-

Quantity	**When +ive**	**When –ive**
i. object distance	real object	virtual object
ii. Image distance	Real image	Virtual image

iii. Focal length	Concave mirror	Convex mirror

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Refractionof light:-

When a ray of light enters from one transparent medium to another transparent medium then it bends away from its original path. This bending of light from its original path is called refraction of light.

Laws of Refraction

First law:

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

Second Law:

The ratio of the sine of angle of incidence to the sine of angle of refraction is always equal to a constant. this constant is known as refractive index.

$$\frac{\sin i}{\sin r} = constant$$

Here constant = n = refractive index

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

Refractive Index: -

The refractive index of a medium is the ratio of the speed of light **"c"** in air to the speed of light in the medium **"v".**

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

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

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TOTAL INTERNAL REFLECTION

When a ray of light enters from denser medium to rare medium in such a way that the angle of incidence is greater than critical angle then the ray of light does not go out of the denser medium but it is totally reflected inside then this process is called total internal reflection.

Critical Angle:-

The angle of incidence in the denser medium for which the angle of refraction becomes 90^0 in the rare medium is called critical angle.

Explanation:-

When a ray of light traveling in denser medium enters into a rare medium than it bends away from normal. If the angle of incidence increases then angle of refraction also increases. For a particular value of angle of incidence the angle of refraction becomes 90^0. This angle of incidence is called critical angle.

When the angle of incidence becomes greater than critical angle **(i > C)** then the ray of light does not go out of the denser medium and the entire light is reflected back into the denser medium. This is known as total internal reflection.

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CONCEPTUAL QUESTIONS

12.4:- Why or why not concave mirror are suitable for makeup?

Ans: - Concave mirrors are suitable for makeup and shaving because when a person stands b/w the principal focus and pole of concave mirror then it forms enlarge erect and virtual image of the face.

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

Ans:- Convex mirror is used as side mirror in cars because it produce erect image of the object. Also it gives a wider field of view of the road behind the driver. Whereas plane mirror or concave mirror does not give a wider field of view.

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

Ans:- We know that if thickness of lens increases then its focal length decreases. Therefore if a lens is thicker at its center then its focal length will be small. As a result it converges or diverge parallel rays of light at very short distance.

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

Ans:- Converging lens forms a virtual image of an object if the object is placed between principal focus and optical center of the lens. As a result the image formed will be virtual, erect and larger than the object.

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

Ans:- When an object is placed at **2F** then its image is also formed at **2F** on the same side of the lens. In this case the image formed is real, inverted and the size of the image is equal to size of the object.

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

Ans:- We know that the magnification of refracting telescope is given by $\mathbf{M} = \frac{f_0}{f_e}$ where

f_0 = focal length of objective & f_e = focal length of eye-piece

From this relation it is clear that if refracting telescope has large objective lens then its magnification is high. Also refracting telescope gathers more light from a distant object. As a result refracting telescope form clear image of the distant object

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Totally Internal Reflecting Prism:-

Many optical instruments such as cameras, binoculars, periscope, and telescope use right angle prism to reflect a beam of light through an angle of 90^0 or 180^0. When a ray of light strikes a face of prism perpendicularly then it enters the prism without any deviation and strikes the hypotenuse at an angle of 45^0. This angle of incidence of 45^o is greater than critical angle of glass which is 42^0. Therefore the light is totally reflected by the prism.

Lense:-

A lense is a transparent material having two surfaces of which at least one surface is curved. A lense refract light in such a way that an image of the object is formed.

Uses:-

Lenses are used in optical devices such as cameras, eye glass, microscopes, telescopes and projectors.

Types of lenses:-

There are two types of lenses.

1. Convex Lense OR Converging Lense.
2. Concave Lense OR Diverging Lense.

1. Convex Lense:

Such a lense which causes incident parallel rays of light to converge at a single point is called convex lense. It is also called converging lense. This lense is thick at the center but thin at the edges.

2. Concave Lense:

Such a lense which causes incident parallel rays of light to diverge from a point is called concave lense. It is also called diverging lense. This lense is thin at the center and thick at the edges.

Power of a lense:-

If focal length of lense is measured in meters then the reciprocal of the focal length is called power of lense.

$$\text{Power of lense} = \frac{1}{focal\ \ lengt\ h\ in\ meters}$$

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

Unit:- The unit of a power of a Lense is Dioptre.

Representation:- It is represented by symbol "D". If **"f"** is expressed in meter then:

$$D = \frac{1}{m} = m^{-1}$$

Diopter:-

One diopter is the power of a lense whose focal length 1m.

Positive power:-

If the focal length of a convex lense is positive then the power of convex lense is also positive.

Negative power:-

If the focal length of a concave lense is negative then the power of concave lense is also negative.

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Sign Conventions for Lenses:-

Focal length:-

i. Focal length is positive for convex lense (converging).
ii. Focal length is negative for concave lense (diverging lense).

Object Distance:-

i. If the object is towards the left side of the lense then it is called real object and in this case object distance is taken as positive (P = +ive).
ii. If the object is towards the right side of the lense then it is called virtual object and in this case object distance is taken as negative (P = - ive).

Image distance:-

i. If the image is towards the right side of the lense then image distance is taken as
Positive (q = +ive)
ii. If the image is formed towards the left side of the lense then it is called virtual
image and in this case distance is taken as negative (q = - ive)

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Near point:-

The minimum distance of object from the eye at which it produces a sharp image on the retina, is called near point. It is also called **"least distance of distinct vision"**.

If an object is placed close to the eye than near point then the object appeared as blurred. For the people in their early twenties with normal vision this point is located about twenty five centimeters (25cm) from the eye. This distance increases to about 50 cm at the age of 40 year. It becomes 500 cm at age of sixty years.

Far point:-

The maximum distance of a distinct object from the eye on which the fully relaxed eye can focus is called far point.

A person with normal eye sight can see object far away such as stars and planets. Far point of a normal person is located at infinity.

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Defect of Vision:

The inability of the eye to see the image of an object clearly is called defect of vision.

There are two main types of vision.

i. Near sightedness (Myopia)
ii. Far sightedness (Hypermetropia)

Near sightedness:-

The disability of the eye to form distinct image of a far object on its retina is called near sightedness OR Myopia.

In this defect of vision in which a person can see near object clearly but cannot see far object clearly without the aid of spectacles.

Reason:-

Near sightedness is due to the size of eye ball result which is longer than normal size. As a result the rays of light are focused in front of the retina.

Correction:-

The near sightedness of can be corrected by using a glass OR contact lense of diverging nature. As a result of diverging lense the rays of light appeared to come from a far point and they are focused on the retina.

Far sightedness (hypermetropia):-

The disability of eye to form distinct image of a nearby object on its retina is called far sightedness OR Hypermetropia. Due to far sightedness, a person can see distant object clearly but cannot see near object clearly.

Reason:-

Far sightedness is due to size of eye ball which is smaller than the normal size. As a result the image is formed behind the retina.

Correction:-

Far sightedness is corrected by using spectacles of converging lense.

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Accommodation:-

The lense of human eye can adjust its focal length by increasing or decreasing its width. This ability of human eye lense is called accommodation.