UNIT - III: NATURAL PHENOMENA

CHAPTER-9
LIGHT REFLECTION AND REFRACTION

Topic-1

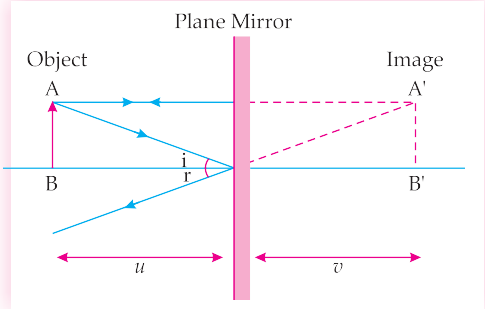
Reflection of Light, Images Formed by Spherical Mirrors

Concepts Covered • Reflection of light, • Laws of reflection of light, • Images formed by plane mirror and spherical mirrors.

Revision Notes

Introduction

- When light falls on a body, it may be absorbed, may be transmitted or light may get reflected back to the same medium.
- **Reflection of light** is the phenomenon of bouncing back off the light rays in the same medium.
- **Laws of Reflection:**
  - **(i)** The incident ray, the reflected ray and the normal, all lie on the same plane at the point of inci-dence.
  - **(ii)** The angle of incidence is equal to the angle of reflection.
- **Real image** is obtained when the rays of light after reflection or refraction actually meet at some point. It can be obtained on the screen and can be seen with the eye.
- **Virtual image** forms when rays of light do not actually meet, but appear to meet when produced backwards. It cannot be obtained on the screen.
- **Image Formed by plane Mirror:**



Characteristics of Image:

(i) Virtual and erect.

Key Words

Spherical mirror: A mirror having a surface which either bulges out or recesses inward and which forms a portion of a sphere.

Solar power plant: It is the device which converts the energy from the Sun into electricity mainly.

(ii) Size of image is equal to the size of the object.

(iii) Image is formed as far as behind the mirror as the object is in front of it.

(iv) Laterally inverted.

- **Lateral Inversion:** The phenomenon due to which the right side of the object appears as left and the left side of the object appears as right. i.e., the image is inverted sideways.
- A **spherical mirror** whose reflecting surface recessed inward, is **concave** mirror.
- The spherical mirror, whose reflecting surface bulges towards light source, is a **convex** mirror.
- Concave mirror mostly forms real images, which can be obtained on the screen. Convex mirror always form virtual images, which cannot be obtained on the screen.
- **Differentiating between a plane mirror, a concave mirror and a convex mirror, without touching them :**

(i) If the formed image is erect, of same size and equidistant as of object, then it is a plane mirror.

(ii) If the formed image formed is erect but smaller in size, then it is a convex mirror.

(iii) If the formed image is erect, real and magnified when the mirror is close to the object, then it is a concave mirror.

Key Words

Pole: The centre of reflecting surface of spherical mirror.

Principal axis: The straight line passing through the pole and centre of curvature.

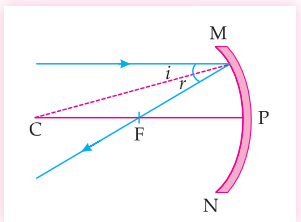
Centre of curvature: It is the centre of sphere of which the given mirror is a part.

- Solar concentrators use huge concave mirrors to focus large amount of solar energy thereby producing high temperature conditions in a **solar power plant.**
- The centre of the reflecting surface of a spherical mirror is called the **pole** of the mirror and it is usually represented by P.
- The horizontal line passing through the centre of curvature and pole of the spherical mirror is known as **principal axis**.
- The **centre of curvature** of a spherical mirror is the centre of the hollow sphere of glass, of which the spherical mirror is a part and is usually represented by C.
- The **radius of curvature** of a spherical mirror is the radius of the hollow sphere of glass, of which the spherical mirror is a part and is usually represented by R.
- The diameter of the reflecting surface, i.e., twice the radius is called its **aperture**.
- Radius of curvature (R) = 2 × focal length (f).

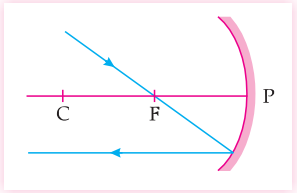
Principal focus: It is the point on principal axis through which the rays of light which are parallel to it pass after reflection or they appear to be arising from this point.

- **Rules for making ray diagrams by concave mirror:**

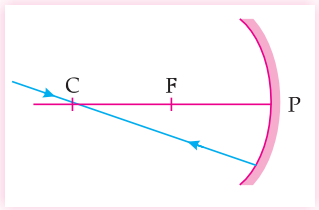
(i) A ray parallel to the principal axis will pass through the principal focus, after reflection.



(ii) A ray passing through the principal focus of concave mirror will be parallel to principal axis after reflection.



(iii) A ray of light passing through the centre of curvature of a concave mirror is reflected back along the same path as it is a normally incident ray.



(iv) A ray incident obliquely to the principal axis of a concave mirror is reflected obliquely making equal angle.

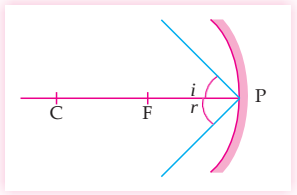


Image formation by a concave mirror for different positions of the object:

Position of Object	Position of Image	Size of Image	Nature of Image
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

Image formation by a convex mirror for different positions of the object:

Position of Object	Position of Image	Size of Image	Nature of Image
At infinity	At the focus F, behind the mirror	Highly diminished, point-sized	Virtual and erect
Between infinity and the pole P of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect

Mirror Formula:

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

Where, v = Image distance

u = Object distance

f = Focal length

Magnification of Spherical Mirrors:

It is the ratio of the height of image to the height of object.

$$m = \frac{\text{Height of image}}{\text{Height of object}}$$

$$m = \frac{h_i}{h_o} = -\frac{v}{u}$$

If 'm' is negative, image is real.

If 'm' is positive, image is virtual.

If $h_i = h_o$ then $m = 1$, i.e., image is equal to object.

If $h_i > h_o$ then $m > 1$ i.e., image is enlarged.

If $h_i < h_o$ then $m < 1$ i.e., image is diminished.

- Magnification of plane mirror is always + 1.

  '+' sign indicates virtual image.

  '1' indicates that image is equal to object's size.
- If 'm' is '+ve' and less than 1, it is a convex mirror.
- If 'm' is '+ve' and more than 1, it is a concave mirror.
- If 'm' is '–ve', it is a concave mirror.

Topic-2

Refraction, Lenses and Power of Lens

Concepts Covered • Refraction, • Laws of refraction, • Refractive index, • Lens formula • Magnification • Power of lens

Revision Notes

- The phenomenon of change in the path of light from one medium to another is called refraction of light.
- The angle formed between the incident ray and the normal is called angle of incidence and the angle formed between the refracted ray and the normal is called angle of refraction.
- The cause of refraction is the change in the speed of light as it goes from one medium to another medium.
- Larger the difference in speed of light between the two media across the interface, the greater will be the deviation and vice-versa.
- When a ray of light passes from a rarer medium to a denser medium, it bends towards the normal. Also, the angle of incidence is greater than the angle of refraction.
- When a ray of light passes from a denser medium to a rarer medium, it bends away from the normal. Also, the angle of incidence is less than the angle of refraction.
- **Laws of refraction:**

  First law: The incident ray, the refracted ray and the normal at the point of incidence all lie on the same plane.

  Second law: The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given color and for the given pair of media. This law is also known as **Snell's law** of refraction.

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

- **Refractive index (n):** The ratio of speed of light in a given pair of media,

$$n = \frac{\text{Velocity of light in medium 1}}{\text{Velocity of light in medium 2}}$$

n_{21} means refractive index of second medium with respect to first medium and,

$$n_{21} = \frac{v_1}{v_2}$$

n_{12} means refractive index of first medium with respect to second medium.

$$n_{12} = \frac{v_2}{v_1}$$

- **Absolute Refractive Index:** Refractive index of a medium with respect to vacuum or air.

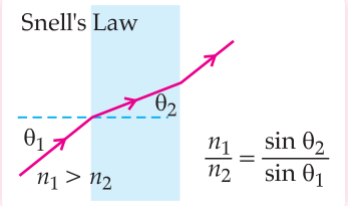
$$n = \frac{c}{v} \text{ where, } c = 3 \times 10^8 \text{ ms}^{-1}$$

- Refractive index of one medium is reciprocal of other's refractive index in a given pair.

$$n_{12} = \frac{1}{n_{21}}$$

- If refractive index of medium 1 w.r.t. air is given as ${}_1n^{air}$ and if refractive index of medium 2 w.r.t. air is given as ${}_2n^{air}$, then refractive index of medium 1 w.r.t. medium 2 = $\frac{{}_1n^{air}}{{}_2n^{air}} = {}_1n^2$
- Refractive index of diamond is the highest till date. It is 2.42. It means speed of light is $\frac{1}{2.42}$ times less in diamond than in vacuum.
- **Lens Formula:** $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Key Diagram



- **Magnification:** $m = \frac{h_i}{h_o} = \frac{v}{u}$
- **Power of a lens:** It is defined as the reciprocal of focal length in meter.
- The degree of **convergence or divergence** of light rays is expressed in terms of power.

$$\text{Power} = \frac{1}{\text{Focal length (in meter)}}$$

$$\text{or, } P = \frac{1}{f}$$

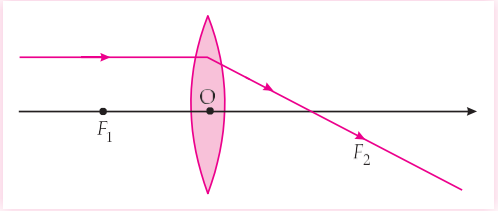
- SI unit of Power is dioptre = (D), 1 D = 1 m^{-1}
- 1 dioptre is the power of lens whose focal length is one meter.

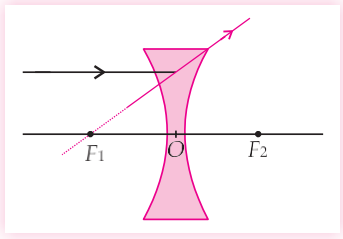
Key Words

Convergence of light rays: Light rays coming together.
Divergence of light rays: Light rays moving away from each other.
Magnification: The measure of the size of image compared to the size of object creating it.

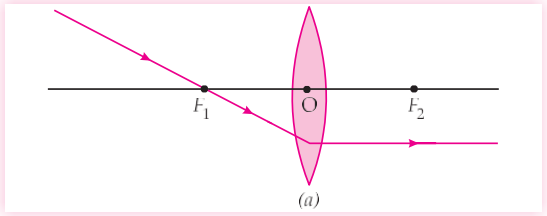
Rules for making ray diagrams by convex and concave lens

(i) A ray of light from the object parallel to the principal axis passes through the focus after refraction.

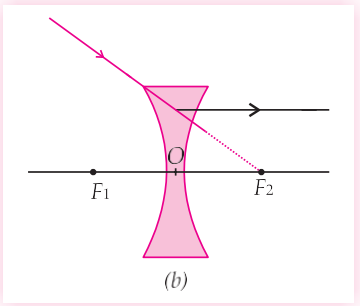




(ii) A ray of light passing through a principal focus becomes parallel to the principal axis after refraction.

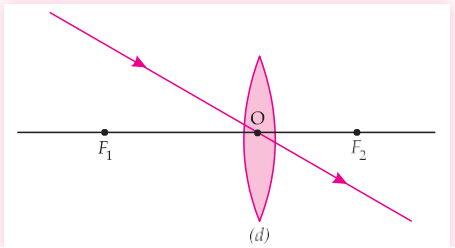


(a)

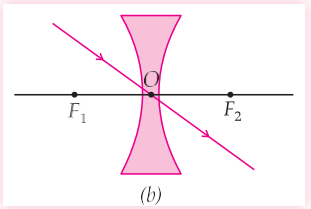


(b)

(iii) A ray of light passing through the optical centre travels undeviated even after refraction.



(d)



(b)

Nature, position and relative size of the image formed by a convex lens for various positions of the object:

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_2	Highly diminished, point-sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Infinitely large or highly enlarged	Real and inverted
Between focus F_1 and optical centre	On the same side of the lens as the object	Enlarged	Virtual and erect

Nature, position and relative size of the image formed by a concave lens for various positions of the object:

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_1	Highly diminished, point-sized	Virtual and erect
Between infinity and optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and erect

Mnemonics

Concept: Image formation by concave mirror
Mnemonics: 54321 to be converted in 12345

At F	1
Between C and F	2
At C	3
Beyond C	4
Infinity	5
Between F and P	Exception

Object	1	2	3	4	5
Image	5	4	3	2	1

Interpretations: If object is at infinity (5) , image will be formed at F (1)
If object is at beyond C (4), image will be formed at between C and F (2) And so on.