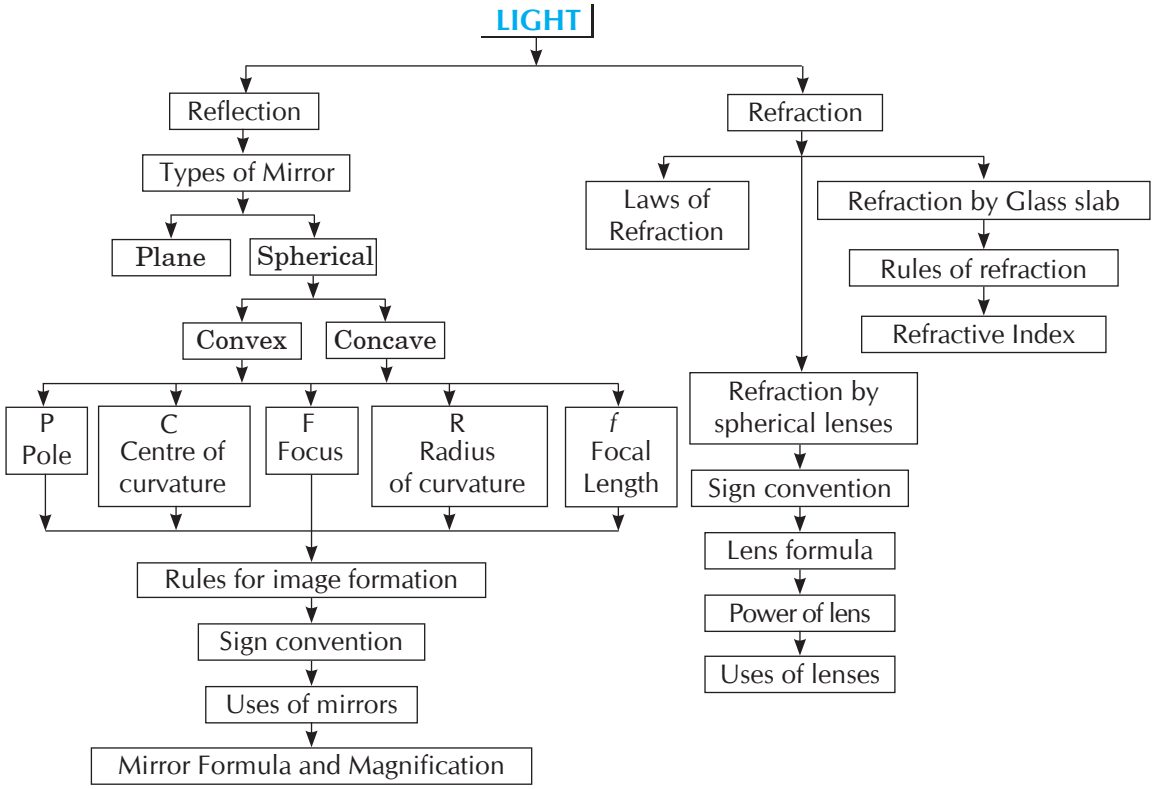
5. Light – Reflection and Refraction

TOPICS COVERED

5.1 Reflection of Light: Image formed by spherical and plane mirrors
5.2 Refraction of Light

CHAPTER MAP

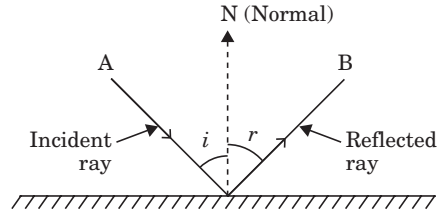


TOPIC 1. Reflection of Light : Image Formed by Spherical and Plane Mirrors

- **Ray of light:** The straight line path of light is called ray of light.
- Light is considered as wave because it shows the phenomenon of diffraction. (If an opaque object becomes very small, then light bends around it.)

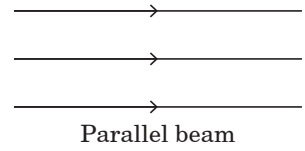
- Light also consists of particles called photons. Light has dual nature, i.e. particles as well as wave like nature.
- Laws of Reflection: (*i*) The angle of incidence is equal to angle of reflection.

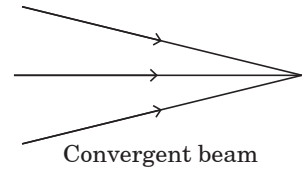
(*ii*) The incident ray, the reflected ray, the normal to the mirror at the point of incidence all lie in the same plane.

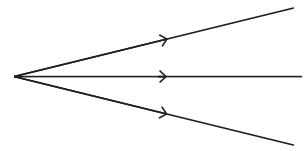


Reflection through plane mirror

- Beam: A bundle of rays originating from the same source of light.
- **Parallel Beam:** When the rays are parallel to each other, then such a beam is referred as parallel beam.
- **Convergent beam:** When then rays actually meet or appear to meet at a point, it is called convergent beam. Parallel rays will converge at focus after reflection from concave mirror.
- **Divergent Beam:** When rays actually diverge or appear to diverge from a point, it is called divergent beam.
- **Reflection:** When light falls on a reflecting surface and come back in the same medium of incident ray, it is called reflection.
- **Incident Ray:** The ray which falls on the reflecting surface.
- **Reflected Ray:** The ray which gets reflected back in the same medium as the medium of incident ray.
- **Normal:** A perpendicular drawn at the point where incident ray and reflected ray meet.
- **Angle of Incidence (*i*):** The angle between incident ray and normal is called angle of incidence.
- **Angle of Reflection (*r*):** The angle between reflected ray and normal is called angle of reflection.


Parallel beam


Convergent beam


Divergent beam

- **Image:** The point of convergence or divergence where light appears to converge or diverge after reflection or refraction is the point where image is formed by a surface image.
- **Real Image:** (*i*) It is formed when light rays after reflection or refraction actually meet or intersect with each other.

(*ii*) It can be obtained on the screen.

(*iii*) It is always inverted and its size depends upon the position of object.

(*iv*) It is formed by both convex lens and concave mirror.

- **Virtual Image:** When light rays appear to meet or intersect after reflection or refraction, then they appear to meet when they are produced in the backward direction.

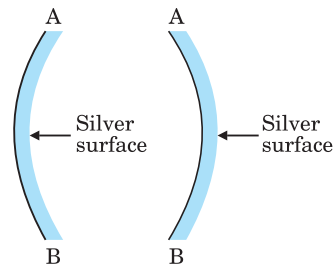
(*i*) It cannot be obtained on the screen.

(*ii*) It is always erect.

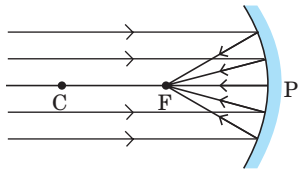
(*iii*) The size of image depends upon the nature of mirror or lens.

(*iv*) It can be formed by both concave and convex lenses and convex mirrors as well as by plane mirrors.

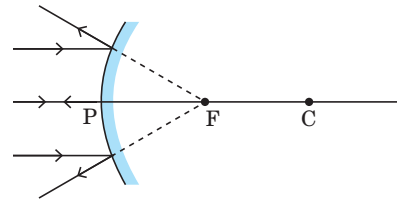
- **Aperture:** The width of reflecting surface from which reflection takes place is called aperture (AB) of the mirror as shown in figure.



- **Pole (P):** The mid point of the reflecting surface.
- **Centre of Curvature:** The centre of that sphere whose spherical mirror is a part is called centre of curvature (C).



Focal Length of Concave Mirror



Focal Length of Convex Mirror

- **Radius of Curvature:** It is radius of that sphere whose spherical mirror is a part. It is the distance between pole (P) and centre of curvature (C) of the mirror. It is twice the focal length, i.e. PC = R, PC = $2f$, where 'f' is focal length.
- **Principal Axis:** The straight line joining the pole and focus is called principal axis.
- **Focus:** The point at which parallel beam meet or appear to meet after reflection is called focus.
- **Focal Length:** It is the distance between pole and focus, PF = 'f'.
- **New Cartesian Sign Conventions:**

(*i*) The object is placed to the left of the mirror.

(*ii*) All distances are measured from pole of the mirror.

(*iii*) All distances measured in the same direction of incident ray are taken as positive and distances measured opposite to the incident ray are taken as negative.

(*iv*) All heights measured above the principal axis are taken positive, while all heights measured after reflection below the principal axis are taken as negative.

- If incident ray passes through 'C', it retraces the same path.
- If magnification is less than 1, size is diminished and if greater than 1, size is enlarged. If it is equal to 1, size of image is equal to the size of object.
- 'f' is taken as positive for convex mirror and negative for concave mirror.

EXERCISE 5.1

I. Multiple Choice Questions (1 Mark)

Choose the correct answer from the given options.

1. Which of the following can make a parallel beam of light when light from a point source is incident on it?

(*a*) Concave mirror as well as convex lens

(*b*) Convex mirror as well as concave lens

(*c*) Two plane mirrors placed at 90° to each other

(*d*) Concave mirror as well as concave lens

2. Under which of the following conditions a concave mirror can form a real image larger than the actual object?

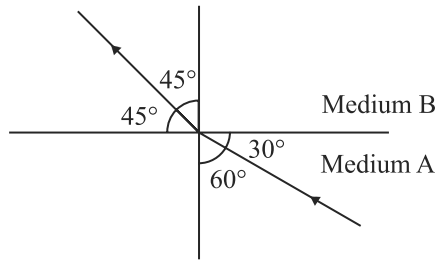
(*a*) When the object is kept at a distance equal to its radius of curvature

(*b*) When object is kept at a distance less than its focal length

(*c*) When object is placed between the focus and centre of curvature

(*d*) When object is kept at a distance greater than its radius of curvature

3. Figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is



(*a*) $\frac{\sqrt{3}}{\sqrt{2}}$ (*b*) $\frac{\sqrt{2}}{\sqrt{3}}$ (*c*) $\frac{1}{\sqrt{2}}$ (*d*) $\sqrt{2}$

4. The mirror which always forms erect image and of same size is
(*a*) Concave (*b*) Convex (*c*) Plane (*d*) Any of these

5. The laws of reflection hold true for:
(*a*) plane mirrors only (*b*) concave mirrors only
(*c*) convex mirrors only (*d*) all reflecting surfaces [*CBSE* 2020]

6. When an object is kept within the focus of a concave mirror, an enlarged image is formed behind the mirror. This image is:
(*a*) real (*b*) inverted
(*c*) virtual and inverted (*d*) virtual and erect [*CBSE* 2020]

7. An object is placed 60 cm in front of a concave mirror. The real image formed by the mirror is located 30 cm in front of the mirror. What is the object's magnification?
(*a*) +2 (*b*) -2 (*c*) +0.5 (*d*) -0.5

8. The image of an object placed in front of a convex mirror is formed at
(*a*) the object itself
(*b*) twice the distance of the object in front of the mirror
(*c*) half the distance of the object in front of the mirror
(*d*) behind the mirror

9. Light waves
(*a*) Require air or another gas to travel through
(*b*) Require an electric field to travel through
(*c*) Require a magnetic field to travel through
(*d*) Can travel through perfect vacuum

10. An object is placed 40.0 cm in front of a convex mirror. The image appears 15 cm behind the mirror. What is the focal length of the mirror?
(*a*) +24 cm (*b*) +11 cm
(*c*) -11 cm (*d*) -24 cm

11. Focal length of a plane mirror is
(*a*) zero (*b*) infinite
(*c*) 25 cm (*d*) -25

12. A man is 6.0 ft tall. What is the smallest size plane mirror he can use to see his entire image
(*a*) 3.0 ft (*b*) 6.0 ft (*c*) 12 ft (*d*) 24 ft

II. Assertion-Reason Type Questions (1 Mark)

For question numbers 1 to 16, two statements are given-one labeled as **Assertion** (A) and the other labeled **Reason** (R). Select the correct answer to these questions from the codes (*a*), (*b*), (*c*) and (*d*) as given below:

(*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.

(*b*) Both 'A' and 'R' are true but 'R' is not correct explanation of the assertion.

(*c*) 'A' is true but 'R' is false.

(*d*) 'A' is false but 'R' is true.

1. **Assertion:** Focal length of convex mirror is +ve.
   Reason: Focal length of concave mirror is –ve.
2. **Assertion:** A full length image of a tall building can be been by using convex mirror.
   Reason: Laws of reflection hold good for all mirrors irrespective of their shape.
3. **Assertion:** A point object is placed at a distance of 26 cm from a convex mirror of focal length 26 cm. The image will not form at infinity.
   Reason: For above given system the equation $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ gives $v = \infty$
4. **Assertion:** Keeping a point object fixed, if a plane mirror is moved, the image will also move.
   Reason: In case of a plane mirror, distance of object and its image is equal from any point on the mirror.
5. **Assertion:** If both plane mirror and object are moved through a distance x , then the image moves through a distance $2x$.
   Reason: When the object is fixed and plane mirror is moved through a distance x. Then the image is also moves through the distance $2x$.
6. **Assertion:** Large concave mirrors are used to concentrate sunlight to produce heat in solar cookers.
   Reason: Concave mirror converges the light rays falling on it to a point.
7. **Assertion:** Plane mirror may form real image.
   Reason: Plane mirror forms virtual image, if objects is real.
8. **Assertion:** A ray of light incident along the normal to the plane mirror retraces its path after reflection from the mirror.
   Reason: A ray of light along the normal has angle of incidence as $\pi/2$ and hence, it retraces its own path after reflection from mirror.
9. **Assertion:** The height of an object is always considered positive.
   Reason: An object is always placed above the principal axis in the upward direction.
10. **Assertion:** When a concave mirror is held under water, its focal length will increase.
    Reason: The focal length of a concave mirror is independent of the medium in which it is placed.
11. **Assertion:** A convex mirror is used as a driver's mirror.
    Reason: Because convex mirror's field of view is large and images formed are virtual, erect and diminished.
12. **Assertion:** A virtual image can be photographed.
    Reason: Only real objects are photographed.

13. **Assertion:** The image formed by a concave mirror is certainly real if the object is virtual.
Reason: The image formed by a concave mirror is certainly virtual if the object is real.
14. **Assertion:** When the object moves with a velocity 2 m/s, its image in the plane mirror moves with a velocity of 4 m/s.
Reason: The image formed by a plane mirror is as far behind the mirror as the object is in front of it.
15. **Assertion:** The mirror used in search lights are concave spherical.
Reason: In concave spherical mirror the image formed is always virtual.
16. **Assertion:** The focal length of the convex mirror will increase, if the mirror is placed in water.
Reason: The focal length of a convex mirror of radius R is equal to, $f = \frac{R}{2}$

Answers 5.1

I. 1. (*a*) Both concave mirror as well as convex lens

2. (*c*) When object is placed between the focus and centre of curvature

3. (*a*) $\because \mu = \frac{n_A}{n_B} = \frac{\text{Sin } i}{\text{Sin } r} = \frac{\text{Sin } 60°}{\text{Sin } 45°} = \frac{\frac{\sqrt{3}}{2}}{\frac{1}{\sqrt{2}}} = \frac{\sqrt{3}}{2} \times \frac{\sqrt{2}}{1} = \frac{\sqrt{3}}{\sqrt{2}}$

4. (*c*) Plane

5. (*d*) Laws of reflection holds good for all reflecting surfaces.

6. (*d*) The image formed will be virtual and erect.

7. (*d*) – 0.5

8. (*d*) behind the mirror

9. (*d*) Can travel through perfect vacuum

10. (*d*) –24 cm

11. (*b*) infinite

12. (*a*) 3.0 ft

II. 1. (*b*) Both 'A' and 'R' are true but 'R' is not correct explanation of the assertion.

2. (*b*) Both 'A' and 'R' are true but 'R' is not correct explanation of the assertion.

3. (*c*) 'A' is true but 'R' is false.

4. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.

5. (*c*) 'A' is true but 'R' is false.

6. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.

7. (*b*) Both 'A' and 'R' are true but 'R' is not correct explanation of the assertion.

8. (*c*) 'A' is true but 'R' is false.

Angle of incidence = Angle between incident ray normal to the mirror = 0°

9. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.
10. (*d*) 'A' is false but 'R' is true.
11. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.
12. (*c*) 'A' is true but 'R' is false.
13. (*c*) 'A' is true but 'R' is false.
14. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.
15. (*c*) 'A' is true but 'R' is false.
16. (*d*) 'A' is false but 'R' is true.

TOPIC 2. Refraction of Light

Refraction: The bending of light when it passes from an optically rarer medium to an optically denser medium or vice-versa.

Causes of Refraction: Refraction is due to different speeds of light in different medium.

Laws of Refraction:

(*i*) The ratio of sine of the angle of incidence to the sine of the angle of refraction is constant. This law is called Snell's law of refraction.

(*ii*) The incident ray, the refracted ray and the normal all lie in the same plane.

Snell's Law: $n = (\sin i / \sin r)$, where '*i*' is the angle of incidence, '*r*' is angle of refraction and n has a constant value, called refractive index of the medium, if the light travels from vacuum or air to the medium. [*CBSE* 2020]

$$n = \frac{\text{Speed of light in air (vacuum)}}{\text{Speed of light in a medium}}$$

- The greater the refractive index, more the light will bend and slower will be the speed of light in that medium. Refractive index of air is l. The refractive index of any other medium will be greater than l and cannot be smaller than l.
- The bottom of a tank or a pond containing water appears to be raised due to refraction.
- When a thick glass slab is placed over a printed matter, the letter appears to be raised when viewed through the glass slab due to refraction.
- The extent of refraction is different for different medium because they differ in refractive index.
- The ability of a medium to refract light is also expressed in terms of optical density.
- The one which has a higher refractive index is called optically denser medium whereas the medium with lower refractive index is called optically rarer medium.
- The speed of light is more in rarer medium than denser medium.
- Speed of light slows down when it enters a denser medium from a rarer medium, therefore it bends towards the normal. When it travels from denser to rarer medium its speed increases, therefore, it bends away from the normal.

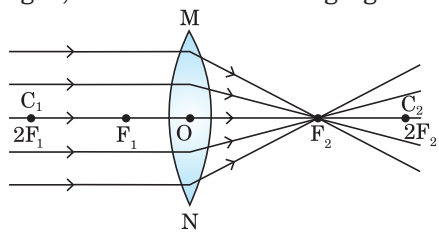
Refraction by spherical lenses:

(*i*) People use spectacles for reading.

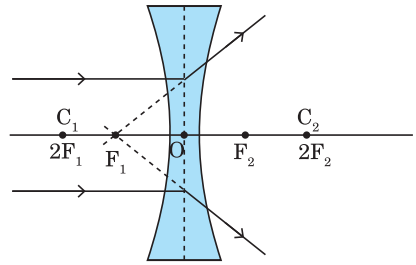
(*ii*) Watch makers use small magnifying glass to see tiny parts of watch.

Lens: A transparent material bound by two transparent surfaces of which atleast one surface is spherical is called lens.

Double convex lens: If both the spherical surfaces are bulging outwards, it is called double convex lens. It is thicker at the middle and thinner on edges, it is convex lens. Convex lens converges a parallel beam of light, so it is called converging lens.



Double concave lens: If both the spherical surfaces are curved inward, it is called double concave lens. It is diverging lens. It is thicker on the edges but thinner at the middle.



Centre of Curvature: The centre of that sphere whose lens forms a part is called centre of curvature of lens. It is denoted by 'C'. There are two centre of curvatures in a lens represented by C_1 and C_2 ($2F_1$, $2F_2$).

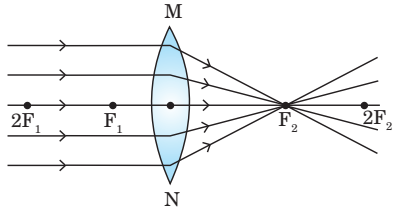
Principal axis: It is an imaginary line passing through C_1 and C_2.

Optical Centre: The central point of a lens is called optical centre 'O'. A ray passing through 'O' passes without suffering any deviation.

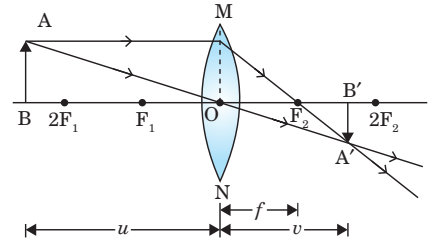
Aperture: The effective diameter of the circular outline of the spherical lens is called aperture.

- Parallel rays to the principal axis after refraction from the lens, passes through the focus. Light coming from sun are parallel rays and concentrate at the focus, that is why a piece of paper get burnt.
- In case of concave lens, parallel rays after refraction diverge and appears to meet at the focus.
- There is another principal focus on the other side of the lens where parallel rays meet after refraction. The two principal focus are called F_1 and F_2.
- The distance between optical centre and principal focus is called focal length.

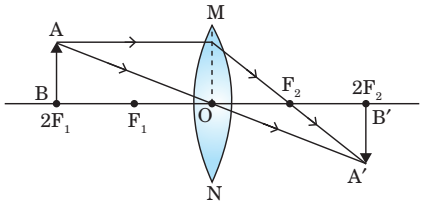
Nature and position of images formed by convex lens when object is placed at different positions:



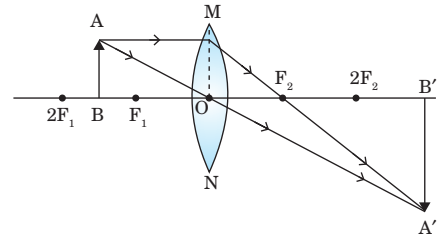
(a)



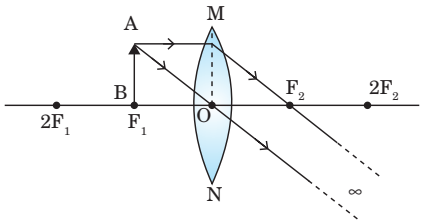
(b)



(c)



(d)



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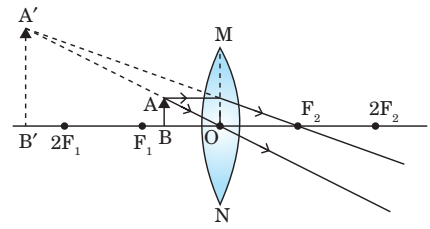
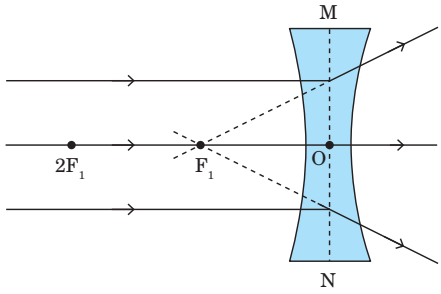
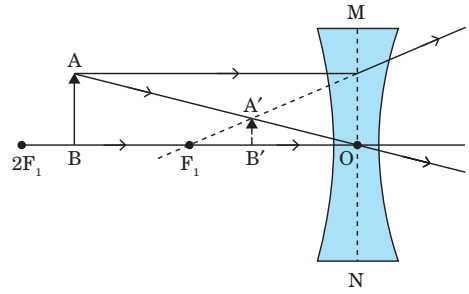


(f)

Nature, position and relative size of the image formed by a concave lens:



(a)



(b)

Sign conventions in spherical lenses:

(*i*) All distances are measured from optical centre.

(*ii*) The distances measured in the same direction of incident ray are taken positive and all distances measured opposite to incident ray are taken negative.

(*iii*) All the heights measured above the principal axis are taken positive and below the principal axis are taken negative.

Lens formula:

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

$$\text{Magnification} = \frac{h'}{h} = \frac{\text{height of image}}{\text{height of object}} = \frac{v}{u} = \frac{\text{distance of image from O}}{\text{distance of object from O}}$$

Power of lens:

[*CBSE* 2020]

(*i*) A convex lens with shorter focal length bends the light rays through large angles, by focusing them closer to the optical centre. These are used as reading glasses.

(*ii*) A concave lens of shorter focal length causes higher divergence than the one with longer focal length and is used to see distant objects.

(*iii*) The degree of convergence or divergence of light rays is expressed in terms of power of lens. It is defined as reciprocal of focal length.

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

(*iv*) When focal length is measured in metres the SI unit of power of the lens is dioptre, ($1D = 1\ m^{-1}$).

(*v*) Power of lens is positive for convex lens and negative for concave lens.

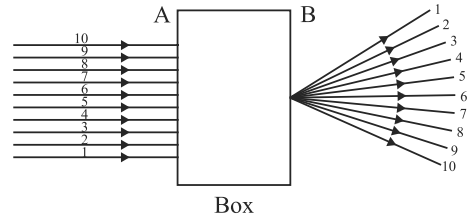
(*vi*) In a microscope, the large aperture objectives are prepared, as they reduce blurring.

EXERCISE 5.2

I. Multiple Choice Questions (1 Mark)

Choose the correct answer from the given options.

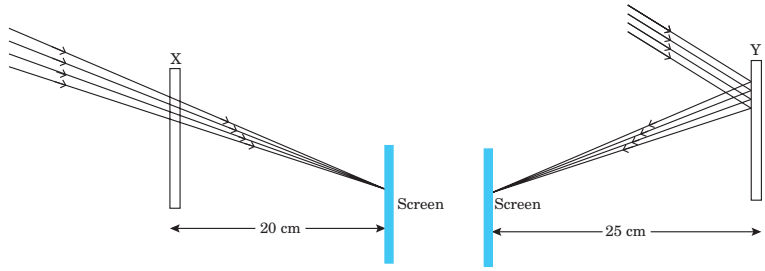
1. A beam of light is incident through the holes on side A and emerges out of the hole on the other face of the box as shown in the figure. Which of the following could be inside the box?



(*a*) Concave lens
(*b*) Rectangular glass slab
(*c*) Prism
(*d*) Convex lens

2. Magnification produced by a rear view mirror fitted in vehicles
(*a*) is less than one (*b*) is more than one
(*c*) is equal to one
(*d*) can be more than or less than one depending upon the position of the object in front of it

3. Study the given ray diagrams and select the correct statement from the following:



(*a*) Device X is a concave mirror and device Y is a convex lens, whose focal lengths are 20 cm and 25 cm respectively.
(*b*) Device X is a convex lens and device Y is a concave mirror, whose focal lengths are 10 cm and 25 cm respectively.
(*c*) Device X is a concave lens and device Y is a convex mirror, whose focal lengths are 20 cm and 25 cm respectively.
(*d*) Device X is a convex lens and device Y is a concave mirror, whose focal lengths are 20 cm and 25 cm respectively. [*AI* 2017]

4. A student obtains a blurred image of a distant object on a screen using a convex lens. To obtain a distinct image on the screen he should move the lens
(*a*) away from the screen
(*b*) towards the screen

(*c*) to a position very far away from the screen
(*d*) either towards or away from the screen depending upon the position of the object.
[*AI* 2017]

5. A real Image is formed by the light rays after reflection or refraction when they
(A) Actually meet or intersect with each other.
(B) Actually converge at a point
(C) Appear to meet when they are produced in backward direction
(D) Appear to diverge from a point.
When of the given statements are correct ?
(*a*) (A) and (D) (*b*) (B) and (D)
(*c*) (A) and (B) (*d*) (B) and (D) [*CBSE* 2020]

6. Consider the following properties of virtual images:
(A) Cannot be projected on the screen (B) Are formed by Concave and Convex lens.
(C) Are always erect. (D Are always inverted.
The correct properties are
(*a*) (A) and (D) (*b*) (A) and (B)
(*c*) (A), (B) and (C) (*d*) (A), (B) and (D) [*CBSE* 2020]

7. Where should an object be placed in front of a convex lens to get a real image of the size of the object?
(*a*) At the principal focus of the lens (*b*) At twice the focal length
(*c*) At infinity
(*d*) Between the optical centre of the lens and its principal focus.

8. Velocity of light in air is 3×10^8 m/s. While its velocity in a medium is 1.5×10^8 m/s. Then, refractive index of this medium is
(*a*) 3 (*b*) 5 (*c*) 0.5 (*d*) 2

9. An object is situated at a distance of $f/2$ from a convex lens of focal length f. Distance of image will be
(*a*) $+(f/2)$ (*b*) $+(f/3)$ (*c*) $+(f/4)$ (*d*) $-f$

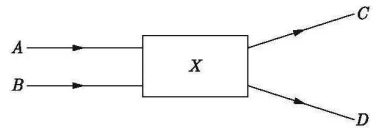
10. The refractive index of dens flint glass is 1.65 and for alcohol, it is 1.36 with respect to air, then the refractive index of the dens flint glass with respect to alcohol is
(*a*) 1.31 (*b*) 1.21 (*c*) 1.11 (*d*) 1.11

11. Refractive index of diamond with respect to glass is 1.6. If the absolute refractive index of glass is 1.5, then the absolute refractive index of diamond is
(*a*) 1.4 (*b*) 2.4 (*c*) 3.4 (*d*) 4.4

12. A convex lens A of focal length 20 cm and a concave lens B of focal length 5 cm are kept along the same axis with a distance d between them. If a parallel beam of light falling on A leaves B as a parallel beam, then the distance d in cm will be
(*a*) 25 (*b*) 15 (*c*) 30 (*d*) 50

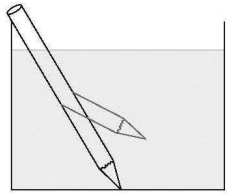
13. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?
(*a*) A convex lens of focal length 50 cm. (*b*) A concave lens of focal length 50 cm.
(*c*) A convex lens of focal length 5 cm. (*d*) A concave lens of focal length 5 cm.

14. Light rays A and B fall on optical component X and come out as C and D.



The optical component is a
(*a*) concave lens (*b*) convex lens (*c*) convex mirror (*d*) prism

15. Which statement best describes the property of light waves illustrated in the diagram below?



(*a*) some materials absorb light waves.
(*b*) some materials refracted by some materials.
(*c*) light waves are refracted by some materials.
(*d*) light waves are emitted by some materials.

II. Assertion-Reason Type Questions (1 Mark)

For question numbers 1 to 8, two statements are given-one labeled as **Assertion** (A) and the other labeled **Reason** (R). Select the correct answer to these questions from the codes (*a*), (*b*), (*c*) and (*d*) as given below:

(*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.
(*b*) Both 'A' and 'R' are true but 'R' is not correct explanation of the assertion.
(*c*) 'A' is true but 'R' is false.
(*d*) 'A' is false but 'R' is true.

1. Assertion: When ray enter from air to water obliquely, it bends towards the normal.
Reason: It is because water is denser medium than air.

2. Assertion: Ray of light incident obliquely at same angle would the most in glycerine out of water, mustard oil, glycerine and kerosens.
Reason: Glycerine has lowest refractive index.

3. Assertion: If a spherical mirror is dipped in water, its focal length remains unchanged.
Reason: For sign convention in spherical lenses, all distances are measured from principal focus.

4. Assertion: The speed of light increases when travel from rarer to denser medium.
Reason: The speed of light is more in rarer medium.

5. Assertion: If the rays are diverging after emerging from a lens; the lens must be convex.
Reason: The concave lens can give diverging rays.

6. Assertion: Light travels faster in glass than in air.
Reason: Glass is denser than air.

7. Assertion: Refractive index has no units.
Reason: The refractive index is a ratio of two similar quantities.

8. Assertion: Higher is the refractive index of a medium or denser the medium, lesser is the velocity of light in that medium.
Reason: Refractive index is inversely proportional to velocity.

Answers 5.2

I. 1. (*a*) Concave lens **2.** (*a*) is less than one

3. (*d*) Device X is a convex lens and device Y is a concave mirror, whose focal lengths are 20 cm and 25 cm respectively.

4. (*d*) either towards or away from the screen depending upon the position of the object.

5. (*c*) **6.** (*c*)

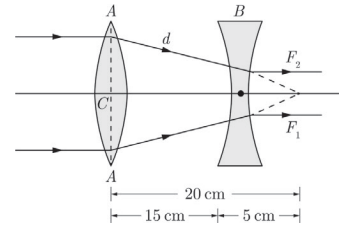
7. (*b*) At twice the focal length **8.** (*d*) 2

9. (*d*) $-f$ **10.** (*b*) 1.21

11. (*b*) 2.4

12. (*b*) 15

The situation is shown in figure. In the absence of concave lens, the parallel beam will be focussed at f_2 i.e. at a distance 20 cm from the lens A. The focal length of concave lens is 5 cm. i.e. if this lens is placed at 5 cm from f_2, then the beam will become parallel. So, d = 15 cm.



13. (*c*) A convex lens of focal length 5 cm.

14. (*a*) concave lens

15. (*c*) light waves are refracted by some materials.

II. 1. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.

2. (*c*) 'A' is true but 'R' is false.

3. (*c*) 'A' is true but 'R' is false. **4.** (*d*) 'A' is false but 'R' is true.

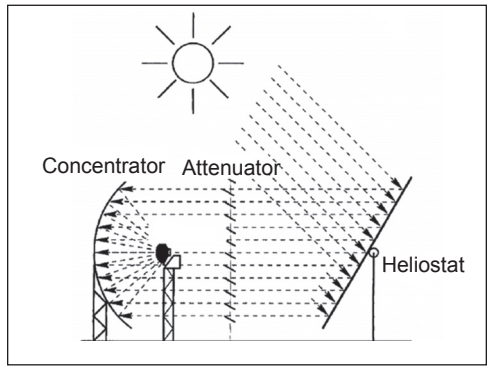
5. (*d*) 'A' is false but 'R' is true. **6.** (*d*) 'A' is false but 'R' is true.

7. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.

8. (*a*) Both 'A' and 'R' are true and 'R' is correct explanation of the assertion.

CASE STUDY QUESTIONS

1. The following diagram is of the solar furnace. It is used to generate heat using sun radiation. The solar furnace consists of flat solar tracking heliostat, a parabollic collecting mirror, an attenuator or shutter, and the test zone area.



(*i*) What is solar furnace?

(*a*) Uses concentrated solar power to produce high temperatures for industry

(*b*) Uses solar energy to evaporate water and collect it within the same closed system

(*c*) Uses solar energy to dry substances

(*d*) Uses solar energy to dry liquids

(*ii*) Select the material that can be used as a heliostat surface to reflect maximum radiation

(*a*) Ribbon silicon. (*b*) Polycrystalline silicon.

(*c*) Convex mirror (*d*) Plane mirror

(*iii*) The device that can control the amount of light entering the furnace

(*a*) Concentrator (*b*) Heliostat (*c*) Attenuator (*d*) None of the above

(*iv*) Name the Parabolic mirror used in this process

(*a*) Convex mirror (*b*) Plane mirror

(*c*) Concave mirror (*d*) Combination of convex and concave mirror

(*v*) What are the types of solar furnaces?

(*a*) Indirect and concentrating solar power technology

(*b*) Active and direct (*c*) Passive and heliostat

(*d*) Direct and heliostat

Ans. (*i*) (*a*) (*ii*) (*d*) (*iii*) (*c*) (*iv*) (*c*) (*v*) (*d*)

2. The atmosphere reflects, scatters, and absorbs solar radiation, reducing the amount of sunlight that reaches Earth's surface. Some atomospheric gases absorb specific wavelengths of solar radiation. Water vapour is a strong absorber of incoming infrared energy, causing a significant reduction in the amount of solar radiation reaching the ground during humid conditions. Ozone, during its formation and dissociation, absorbs harmful ultraviolet radiation that can lead to sunburn and skin cancer. Haze, dust, smoke, and air pollutants in general block incoming solar energy to some extent wherever present. Clouds strongly reflect, scatter, and absorb incoming sunlight. High, thin circus absorb some sunlight while dense clouds, if thick enough, can produce almost night time conditions.

(*i*) What is solar radiation?

(*a*) Energy radiated from the sun in all directions

(*b*) Energy radiated from earth in all directions

(*c*) Radiation travelling in space

(*d*) Energy radiated from sun that travels in one direction only

(*ii*) What type of radiation does earth emit?

(*a*) UV (*b*) Visible (*c*) Infrared (*d*) Longitudinal

(*iii*) The ozone layer absorbs what range of wavelengths of the sun's radiation?

(*a*) 0.80 nm – 1.50 nm (*b*) 200 nm – 315 nm

(*c*) 450 nm – 570 nm (*d*) 600 nm – 750 nm

(*iv*) What factors affect the amount of solar energy that reaches the earth's surface?

(*a*) Cloud cover, air pollution, (*b*) Latitude of a location,

(c) Time of the year (*d*) All of the above

(*v*) Which of the following UV radiations is responsible for causing sun burns and skin cancer?

(*a*) UV-A (*b*) UV-B (*c*) UV-C (*d*) All of the above

Ans. (*i*) (*a*) (*ii*) (*c*) (*iii*) (*b*) (*iv*) (*d*) (*v*) (*b*)

3. Double convex lens: If both the spherical surfaces are bulging outwards, it is called double convex lens. It is thicker at the middle and thinner on edges it is convex lens. Convex lens converges a parallel beam of light, so it is called a converging lens.

Double concave lens: If both the spherical surfaces are curved inward, it is called double concave lens. It is a diverging lens. It is thicker one the edges but thinner at the middle.

(*i*) What are Concave lenses?

(*a*) Thicker from the centre than at the edge

(*b*) Thinner from the centre than at the edge

(*c*) Thicker from both the positions

(*d*) Thinner from both the positions

(*ii*) As an object gets closer to the focal point of a convex lens from infinity, its image

(*i*) Becomes smaller (*ii*) Is magnified

(*iii*) Becomes closer to the lens (*iv*) None of these

(*iii*) How will the image formed by a convex lens be affected if the central portion of the lens is blackened ?

(*a*) No image will be formed by the lens

(*b*) The central portion of the image will be absent

(*c*) The full image will be formed but it will be less bright

(*d*) There will be two images, one due to each exposed portions

(*iv*) When will the convex lens give a real image?

(*a*) Beyond optical centre (*b*) Beyond focus

(*c*) Beyond centre of curvature (*d*) Between focus and curvature

(*v*) Which one of the following statements is true for convex mirrors?

(*a*) They always give a real, erect, diminished image.

(*b*) They have a wide field of view

(*c*) They can produce a parallel beam of light.

(*d*) They always give a virtual, erect, magnified image.

Ans. (*i*) (*b*) (*ii*) (*b*) (*iii*) (*c*) (*iv*) (*b*) (*v*) (*b*)

4. Study these tables related to refractive index and answer the questions that follow:

Material medium	Refractive index
Air	1.0003
Ice	1.31
Water	1.33
Alcohol	1.36
Kerosene	1.44
Fused quartz	1.46
Turpentine oil	1.47
Benzene	1.50

Material medium	Refractive index
Crown glass	1.52
Canada Balsam	1.53
Rock salt	1.54
Carbon disulphide	1.63
Dense flint glass	1.65
Ruby	1.71
Sapphire	1.77
Diamond	2.42

(*i*) Which of the following is correct?

(*a*) $\frac{\text{Speed of light in water}}{\text{Speed of light in air}} = 1.33$ (*b*) $\frac{\text{Speed of light in air}}{\text{Speed of light in water}} = 1.33$

(*c*) Speed of light in water = 1.33 (*d*) None of these

(*ii*) Which of the following is optically denser than water?

(*a*) Kerosene (*b*) Air (*c*) Ice (*d*) None of these

(*iii*) Which of the following has highest refractive index?

(*a*) Diamond (*b*) Glycerine (*c*) Water (*d*) Air

(*iv*) What happens to ray, when it enters a denser medium from rarer medium?

(*a*) Ray bends towards the normal (*b*) Ray bends away from the normal

(*c*) Speed of light ray increases (*d*) None of the above

(*v*) What is the speed of blue light in crown glass?

(*a*) 3×10^8 ms^{-1} (*b*) 1.97×10^8 ms^{-1} (c) 4.56×10^8 ms^{-1} (*d*) 3.5×10^8ms^{-1}

Ans. (*i*) (*b*) (*ii*) (*a*) (*iii*) (*a*) (*iv*) (*a*) (*v*) (*b*)

5. Is there a relationship between the radius of curvature R and focal length *f*, of a spherical mirror? For spherical mirrors of small apertures, the radius of curvature is found to be equal to twice the focal length. We put this as R = 2*f*. This implies that the principal focus of a spherical mirror lies midway between the pole and centre of curvature.

(*i*) Mirrors having a curved reflecting surface are called as:

(*a*) Plane mirror (*b*) Spherical mirrors (*c*) Simple mirror (*d*) None of the above

(*ii*) The radius of a sphere; of which the reflecting surface of a spherical mirror is a part; is called the.....

(*a*) Centre of curvature (*b*) radius of curvature

(*c*) Poled (*d*) Aperture

(*iii*) The diameter of the reflecting surface of a spherical mirror is called .....

(*a*) Aperture (*b*) The radius of curvature

(*c*) Centre of curvature (*d*) Pole

(*iv*) The distance from the pole to focus is called.....

(*a*) Pole (*b*) Aperture (*c*) Principal Axis (*d*) Focal length

(*v*) The focal length is equal to half of the .....

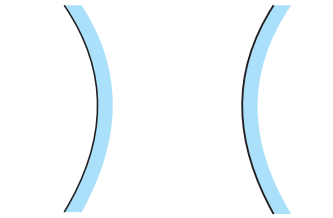
(*a*) Axis (*b*) Centre of curvature

(*c*) The radius of Curvature (*d*) None of these

Ans. (*i*) (*b*) (*ii*) (*b*) (*iii*) (*d*) (*iv*) (*d*) (*v*) (*c*)

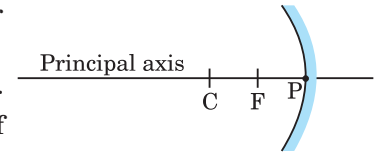
QUICK REVISION NOTES

- An object reflects light that falls on it. This reflected light enables us to see things.
- Light is electromagnetic radiation and a form of energy.
- Light does not require any medium for its propagation.
- A highly polished surface such as mirror, reflects most of the light falling on it.
- Laws of reflection is applicable to all types of reflecting surfaces including spherical surfaces.
- Image formed by a plane mirror
  - The image is always virtual and erect.
  - The size of image is equal to the size of the object.
  - Image is formed behind the mirror at the same distance as the object is in front of mirror.
  - The image is laterally inverted, i.e. your left hand will look like your right hand in the image. Spherical mirror are a part of sphere whose one surface in highly polished.
- Concave mirror has curved surface inwards towards the centre.
- Convex mirror has curved surface outwards.
- The mid point of the spherical mirror is called **pole(P)**. It lies on the surface of mirror.
- The reflecting surface of a spherical mirror forms a sphere which has a centre called *centre of curvature* (C) of the spherical mirror.
- The radius of sphere of which the reflecting surface is a part is called *radius of curvature*.
- The line passing through 'P' and 'C' is called *principal axis*.

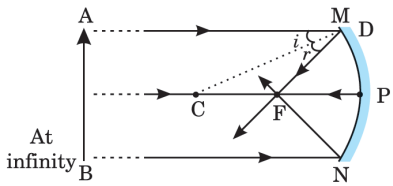


Concave mirror Convex mirror

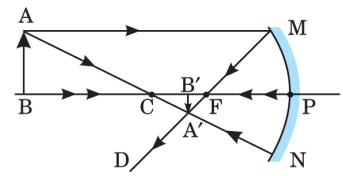
- The point at which parallel rays to the principal axis meet after reflection is called *principal focus*.
- R = 2*f*, i.e. radius of curvature is equal to twice the focal length.
- Image formation by a concave mirror for different positions of the object:



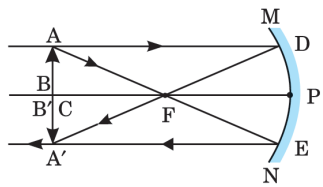
Position of Object	Position of Image	Size of Image	Nature of Image
1. At infinity (distant object)	At the focus	Highly diminished, point sized	Real and inverted
2. Beyond C	Between C and F	Smaller in size	Real and inverted
3. At C	At C	Equal size	Real and inverted
4. Between C and F	Beyond C	Enlarged	Real and inverted
5. At F	At infinity	Highly enlarged	Real and inverted
6. Between P and F	Behind the mirror	Enlarged	Virtual and erect



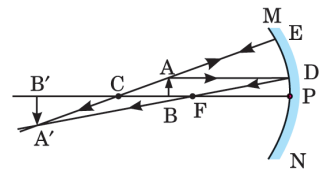
(a)



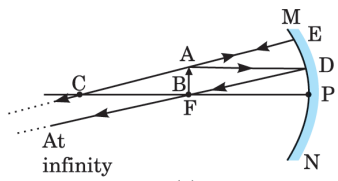
(b)



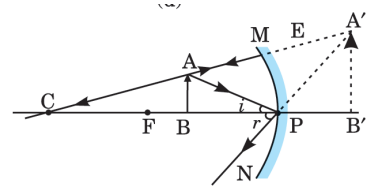
(c)



(d)



(e)



(f)

- – Concave mirrors are used in torches, search lights, vehicles head light, shaving mirrors.
  – Dentists use concave mirrors to get large images of teeth.
  – Large concave mirrors are used to concentrate the light in solar furnaces.
- In case of convex mirror if the position of object is at infinity, size of image will be highly diminished, point sized, virtual and erect.
- In convex mirror if the object is between 'P' and infinity, image will be formed between 'P' and 'F', size of image will be diminished, virtual and erect.
- Convex mirrors are used as rear view mirror in vehicles.

- Mirror formula: $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ where 'f' is focal length, 'u' is the distance of the object from the pole of mirror and v is the distance of image from pole of the mirror.
- Magnification, m = $\frac{h'}{h}$, where h' is height of image, 'h' is height of object.
- Bending of a ray of light when it passes from a medium to another is called refraction.
- If ray enters from rarer to denser medium, it bends towards the normal and if it enters from denser to rarer medium, it bends away from the normal.
- Laws of refraction are applicable in refraction.
- $\eta = \frac{\sin i}{\sin r}$ where 'n' is refractive index, of the medium, 'i' is angle of incidence and 'r' is angle of refraction.
- The refractive index of medium 2 with respect to medium 1,

  $\eta_{21} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}} = \frac{v_1}{v_2}$; $\eta_{12} = \frac{\text{Speed of light in medium 2}}{\text{Speed of light in medium 1}} = \frac{v_2}{v_1}$

  Absolute refractive index of medium (η_m) = $\frac{\text{Speed of light in air}}{\text{Speed of light in medium}} = \frac{c}{v}$
- Position, relative size, nature of image formed by convex lens:

Position of Object	Position of Image	Relative size of image	Nature of Image
1. At infinity	At focus F_2	Highly diminished, point sized	Real and inverted
2. Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
3. At $2F_1$	At $2F_2$	Same size	Real and inverted
4. Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
5. At F_1	At infinity	Highly enlarged	Real and inverted
6. Between F_1 and (optical centre) O	On the same side of the object	Enlarged	Virtual and erect

- Image formed by Concave lens:

Position of Object	Position of Image	Relative size of image	Nature of Image
1. At infinity	At focus, F_1	Highly diminished, point sized	Virtual and erect
2. Between infinity and optical centre O	Between focus, F_1 and O (optical centre)	Diminished	Virtual and erect

- Lens formula: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$
- Power of lens, $P = \frac{1}{f}$. If f is in metre then unit of power is dioptre (D). Power of a convex lens is positive, and of a concave lens is negative.
- The net power of combination of lenses, $P = P_1 + P_2 + P_3 + \ldots\ldots$.

IMPORTANT FORMULAE

1. Relationship between focal length (f) and radius of curvature of a mirror (R):
   $f = \frac{R}{2}$ where 'f' focal length, 'R' is radius of curvature.
2. **Mirror formula:** $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ where 'v' is distance of image from the pole.
   'u' is distance of object from the pole.
   'f' is focal length of the mirror.
3. Magnification (m) of mirror = $\frac{\text{Height of image}}{\text{Height of object}} = \frac{h_i}{h_o} = -\frac{v}{u}$
   m = –ve for real image, m is +ve for virtual image,

	Image
$h_i = h_o$	Size equal
$h_i > h_o$	Enlarged
$h_i < h_o$	Diminished

4. $\mu = \frac{\sin i}{\sin r}$ = constant, μ is refractive index.
5. Refractive index (n_{21}) = $\frac{\text{Velocity of light in medium 1}}{\text{Velocity of light in medium 2}} = \frac{v_1}{v_2}$
   n_{21} means refractive index of second medium w.r.t. first medium.
6. **Absolute refractive index:** $n = \frac{c}{v}$ where $c = 3 \times 10^8$ m s^{-1},
   'v' is velocity of light in medium.
7. $n_{21} = \frac{1}{n_{12}}$
8. **Lens formula:** $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
   f is +ve for convex lens and –ve for concave lens.
9. Magnification of a lens, $m = \frac{h_i}{h_o} = \frac{v}{u}$
10. Magnification of plane mirror is always +1.
11. Power of lens, $P = \frac{1}{f}$, power of convex lens = +ve and for concave lens = –ve.
    When focal length (f) is in cm, then P = $\frac{100}{f}$ Dioptre (D).
12. $P \propto \frac{1}{\text{thickness}}$
    Power of lens combination, $P = P_1 + P_2 + \ldots$

COMMON ERRORS

Errors	Corrections
• Students write wrong mirror and lens formulae and interchange them.	☞ Mirror formula: $\boxed{\frac{1}{u}+\frac{1}{v}=\frac{1}{f}}$ whereas Lens formula: $\boxed{\frac{1}{v}-\frac{1}{u}=\frac{1}{f}}$.
• Students are not able to make correct ray diagram.	☞ Rule should be understood and applied for making correct ray diagram.
• Students do mistake in position, nature and size of image.	☞ Students should learn the summarised tables of ray diagrams to avoid mistake.
• Students do not write formula and units in numerical.	☞ Always write formula first and write answer in correct units,
• Students do not write correct sign of focal length.	☞ Focal length of convex lens is positive, concave is negative. Learn sign conventions for both mirror and lens.
• Students do not write correct unit of power and focal length.	☞ Power in dioptre (D) is m^{-1}, so focal length will be in m. If focal length is given in cm, convert into m by dividing with 100.
• Students predict nature of image wrongly in convex mirror and concave lens.	☞ Nature of image is virtual, erect and diminished in both.
• Students are not able to differentiate between refractive index and absolute refractive index.	☞ n is refractive index, i is angle of incidence, r is angle of refraction. $\boxed{n=\frac{\sin i}{\sin r}}$
• Refractive index of second medium with respect to first medium is wrongly interpreted by many students.	☞ $\boxed{n_{21}=\frac{\text{Velocity of light in medium 1}}{\text{Velocity of light in medium 2}}}$ Absolute refractive index $=\frac{c}{v}$ $=\frac{\text{Velocity of light in vacuum or air}}{\text{Velocity of light in given medium}}$
• Students put wrong sign of magnification in mirror and lens.	☞ In mirror, $m=\frac{-v}{u}$ whereas in lens, $m=\frac{v}{u}$.
• Students calculate power wrongly for bifocal lens.	☞ Power (P) is additive property but (P) of convex lens is positive and (P) of concave lens is negative.

ASSIGNMENT

Total Marks : 10

I. Multiple Choice Questions (8 × 1 = 8)

Choose the correct answer from the given options.

1. The laws of reflection hold good for
(*a*) plane mirror only (*b*) concave mirror only
(*c*) convex mirror only (*d*) all mirrors irrespective of their shape

2. A student obtains a blurred image of a distant object on a screen using a convex lens. To obtain a distinct image on the screen he should move the lens
(*a*) away from the screen
(*b*) towards the screen
(*c*) to a position very far away from the screen
(*d*) either towards or away from the screen depending upon the position of the object.
[*AI* 2017]

3. An object is placed at 100 mm in front of a concave mirror which produces an upright image (erect image). The radius of curvature of the mirror is:
(*a*) Less than 100 mm (*b*) Between 100 mm and 200 mm
(*c*) Exactly 200 mm (*d*) More than 200 mm

4. An object at a distance of 30 cm from a concave mirror gets its image at the same point. The focal length of the mirror is
(*a*) – 30 cm (*b*) 30 cm (*c*) – 15 cm (*d*) +15 cm

5. A concave mirror of focal length 20 cm forms an image having twice the size of object. For the virtual position of object, the position of object will be at
(*a*) 25 cm (*b*) 40 cm (*c*) 10 cm (*d*) At infinity

6. If a man's face is 25 cm in front of concave shaving mirror producing erect image 1.5 times the size of face, focal length of the mirror would be
(*a*) 75 cm (*b*) 25 cm (*c*) 15 cm (*d*) 60 cm

7. Two big mirrors A and B are fitted side by side on a wall. A man is standing at such a distance from the wall that he can see the erect image of his face in both the mirrors. When the man starts walking towards the mirrors, he finds that the size of his face in mirror A goes on increasing but that in mirror B remains the same:
(*a*) Mirror A is concave and mirror B is convex
(*b*) Mirror A is plane and mirror B is concave
(*c*) Mirror A is concave and mirror B is plane
(*d*) Mirror A is convex and mirror B is concave

8. If an object is placed 21 cm from a converging lens, the image formed is slightly smaller than the object. If the object is placed at a distance of 19 cm from the lens, the image formed is slightly larger than the object. The approximate focal length of the lens is:
(*a*) 20 cm (*b*) 18 cm (*c*) 10 cm (*d*) 5 cm

II. Assertion-Reason Type Questions (2 × 1 = 2)

Note: Use instructions as given in topical exercises of the chapter.

1. **Assertion:** Parallel rays meet at focus after refraction.
Reason: Rays from distant objects are parallel rays.

2. **Assertion:** When ray enter from air to water obliquely, it bends towards the normal.
Reason: It is because water is denser medium than air.