Chapter 10: Light: Mirrors and Lenses

Exercises — Keep the Curiosity Alive

Q1 A light ray is incident on a mirror and gets reflected by it (Fig. 10.21). The angle made by the incident ray with the normal to the mirror is 40°. What is the angle made by the reflected ray with the mirror?
(i) 40°
(ii) 50°
(iii) 45°
(iv) 60°

SOLUTION

By the law of reflection, angle of incidence = angle of reflection.
Angle of incidence (with the normal) = 40°
Therefore, angle of reflection (with the normal) = 40°

The question asks for the angle with the MIRROR surface, not with the normal.
Angle with mirror = 90° − angle with normal = 90° − 40° = 50°

Answer: (ii) 50°

Q2 Fig. 10.22 shows three different situations where a light ray falls on a mirror:
(i) The light ray falls along the normal.
(ii) The mirror is tilted, but the light ray still falls along the normal to the tilted surface.
(iii) The mirror is tilted, and the light ray falls at an angle of 20° from the normal.
Draw the reflected ray in each case (use a ruler and protractor for accurate drawing). What is the angle of reflection in each case?

SOLUTION

Case (i) — Ray falls along the normal (angle of incidence = 0°):
Angle of incidence = 0°
By law of reflection: angle of reflection = 0°
The reflected ray travels back along the same path as the incident ray (retraces its path).

Case (ii) — Mirror is tilted, ray still falls along the normal (angle of incidence = 0°):
Even though the mirror is tilted, since the ray falls along the normal to the (now tilted) surface, the angle of incidence = 0°.

By law of reflection: angle of reflection = 0°
The reflected ray again retraces the incident ray's path.

Case (iii) — Mirror is tilted, ray falls at 20° from the normal:
Angle of incidence = 20°
By law of reflection: angle of reflection = 20°
Draw the reflected ray on the other side of the normal at 20° from the normal.

Answer: (i) 0°, (ii) 0°, (iii) 20°

Q3 In Fig. 10.23, the cap of a sketch pen is placed in front of three types of mirrors.
Match each image with the correct mirror.
Image — Mirror:
(i) — Plane mirror
(ii) — Convex mirror
(iii) — Concave mirror

SOLUTION

Plane mirror: Forms a virtual, erect image of the same size as the object.
Convex mirror: Forms a virtual, erect image that is always diminished (smaller than object).
Concave mirror: When the object is placed close (within focal length), it forms a virtual, erect, magnified image.

In each panel of Fig. 10.23, compare the size of the image in the mirror with the actual sketch-pen cap kept in front:
Image (i) — The image in the mirror is smaller than the actual cap (diminished) → Convex mirror.
Image (ii) — The image in the mirror is larger than the actual cap (magnified) → Concave mirror.
Image (iii) — The image in the mirror is the same size as the actual cap (undistorted) → Plane mirror.

Answer: (i) → Convex mirror; (ii) → Concave mirror; (iii) → Plane mirror

Q4 In Fig. 10.24, the cap of a sketch pen is placed behind a convex lens, a concave lens, and a flat transparent glass piece — all at the same distance. Match each image with the correct type of lens or glass.
Image — Lens/glass type:
(i) — Flat transparent glass piece
(ii) — Convex lens
(iii) — Concave lens

SOLUTION

Flat transparent glass piece: Does not converge or diverge light; the object appears the same size.
Convex lens: Converges light; when the object is within the focal length it forms a virtual, magnified image — the object appears larger.
Concave lens: Diverges light; always forms a virtual, erect, diminished image — the object appears smaller.

In each panel of Fig. 10.24, compare how the cap (placed behind the lens/glass) appears when viewed through it:
Image (i) — The cap appears larger/magnified (it fills the lens) → Convex lens.
Image (ii) — The cap appears smaller/diminished → Concave lens.
Image (iii) — The cap appears the same size, undistorted → Flat transparent glass piece.

Answer: (i) → Convex lens; (ii) → Concave lens; (iii) → Flat transparent glass piece

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Q5 When the light is incident along the normal on the mirror, which of the following statements is true:
(i) Angle of incidence is 90°
(ii) Angle of incidence is 0°
(iii) Angle of reflection is 90°
(iv) No reflection of light takes place in this case

SOLUTION

Angles in optics (incidence and reflection) are always measured from the NORMAL to the surface, not from the surface itself.
When light falls 'along the normal', it travels in the same direction as the normal — the angle between the ray and the normal is 0°.
Therefore, angle of incidence = 0°.

By law of reflection: angle of reflection = 0° (ray reflects straight back along the normal).

Option (i) is wrong: 90° would be along the surface, not along the normal.
Option (iii) is wrong for the same reason.
Option (iv) is wrong: reflection does occur — the ray returns along the same path.

Answer: (ii) Angle of incidence is 0°

Q6 Three mirrors — plane, concave and convex are placed in Fig. 10.25. On the basis of the images of the graph sheet formed in the mirrors, identify the mirrors and write their names above the mirrors.

SOLUTION

Identifying mirrors from how they distort a graph-sheet grid:

Plane mirror: Reflects the grid without any change in size or shape. The squares in the reflection look identical to the actual grid — undistorted.

Concave mirror: The reflecting surface curves inwards (like a bowl). It converges reflected light. The grid appears magnified and the lines appear to converge toward the centre of the mirror.

Convex mirror: The reflecting surface curves outwards. It diverges reflected light. The grid appears diminished and the lines appear to spread outward (wider field of view, smaller image).

Identify each mirror in Fig. 10.25 by matching: undistorted grid = plane mirror; magnified/converging grid = concave mirror; diminished/spreading grid = convex mirror.

Answer: Undistorted grid → Plane mirror; Magnified, converging grid → Concave mirror; Diminished, wider-spread grid → Convex mirror

Q7 In a museum, a woman walks towards a large concave mirror (Fig. 10.26). She will see that:
(i) her erect image keeps decreasing in size.
(ii) her inverted image keeps decreasing in size.
(iii) her inverted image keeps increasing in size and eventually it becomes erect and magnified.
(iv) her erect image keeps increasing in size.

SOLUTION

A concave mirror forms different types of images depending on the object's distance from the mirror.

When the woman is very far from the mirror (object beyond C, i.e., beyond 2f):
→ Image is real, inverted, and diminished (smaller than object).

As she walks closer (object between C and F, i.e., between 2f and f):
→ Image remains real and inverted, but grows larger.

When she is at the focal point (object at F):
→ Image forms at infinity (no clear image seen in the mirror).

When she is very close to the mirror (object between F and the mirror, i.e., within focal length):
→ Image becomes virtual, erect, and magnified.

Summary of journey: inverted image (far away) → inverted image grows → at focal point image at infinity → inside focal length image becomes erect and magnified.

Answer: (iii) her inverted image keeps increasing in size and eventually it becomes erect and magnified.

Q8 Hold a magnifying glass over text and identify the distance where you can see the text bigger than they are written. Now move it away from the text. What do you notice? Which type of lens is a magnifying glass?

SOLUTION

Observation when holding magnifying glass close to text:
When the text is within the focal length of the lens, you see a virtual, erect, and magnified image — the text appears bigger.

Observation as you move the magnifying glass away from the text:
When the text moves beyond the focal length, the image becomes inverted

(upside down). Moving further away, the image shrinks and eventually blurs completely.

A magnifying glass is a CONVEX lens (also called a converging lens). It is thicker in the middle than at the edges and converges light to a focal point.

When the object is within its focal length, a convex lens acts as a simple magnifier — producing a virtual, erect, magnified image on the same side as the object.

Answer: A magnifying glass is a convex lens. It magnifies text when held close (within focal length); moving it farther inverts the image.

Q9 Match the entries in Column I with those in Column II.

Column I:

(i) Concave mirror

(ii) Convex mirror

(iii) Convex lens

(iv) Concave lens

Column II:

(a) Spherical mirror with a reflecting surface that curves inwards.

(b) It forms an image which is always erect and diminished in size.

(c) Object placed behind it may appear inverted at some distance.

(d) Object placed behind it always appears diminished in size.

SOLUTION

(i) Concave mirror → (a): A concave mirror has a reflecting surface that curves inwards (like the inside of a bowl). This is the defining physical description of a concave mirror.

(ii) Convex mirror → (b): A convex mirror always forms a virtual, erect, and diminished image regardless of the object's position. Its field of view is wide but the image is always smaller.

(iii) Convex lens → (c): A convex (converging) lens forms a real, inverted image when the object is placed beyond the focal length. So an object placed at a suitable distance can appear inverted.

(iv) Concave lens → (d): A concave (diverging) lens always forms a virtual, erect, and diminished image — the object always appears smaller through it.

Answer: (i)→(a); (ii)→(b); (iii)→(c); (iv)→(d)

Q10 The following question is based on Assertion/Reason.
Assertion: Convex mirrors are preferred for observing the traffic behind us.
Reason: Convex mirrors provide a significantly larger view area than plane mirrors.
Choose the correct option:
(i) Both Assertion and Reason are correct and Reason is the correct explanation for Assertion.
(ii) Both Assertion and Reason are correct but Reason is not the correct explanation for Assertion.
(iii) Assertion is correct but Reason is incorrect.
(iv) Both Assertion and Reason are incorrect.

SOLUTION

Assertion: Convex mirrors are preferred for rearview mirrors in vehicles — TRUE.
A convex mirror always forms a virtual, erect, and diminished image. It has a wider field of view than a plane mirror of the same size, allowing the driver to see more of the traffic behind.

Reason: Convex mirrors provide a significantly larger view area than plane mirrors — TRUE.
Because the reflecting surface curves outward, it captures light from a wider angle, giving a much larger field of view than a flat (plane) mirror.

Is the Reason the correct explanation for the Assertion? YES.
The very reason convex mirrors are used in vehicles is their wider field of view — more traffic is visible in the rearview mirror compared to a plane mirror.

Answer: (i) Both Assertion and Reason are correct and Reason is the correct explanation for Assertion.

Q11 In Fig. 10.27, note that O stands for object, M for mirror, and I for image. Which of the following statements is true?
(i) Figure (a) indicates a plane mirror and Figure (b) indicates a concave mirror.
(ii) Figure (a) indicates a convex mirror and Figure (b) indicates a concave mirror.
(iii) Figure (a) indicates a concave mirror and Figure (b) indicates a convex mirror.
(iv) Figure (a) indicates a plane mirror and Figure (b) indicates a convex mirror.

SOLUTION

In Fig. 10.27 both diagrams show the object O in front of the mirror M and the image I behind the mirror (a virtual, erect image). They differ only in the SIZE of the image relative to the object:

Figure (a): The image I is smaller than the object O (diminished), erect, and behind the mirror.
→ A CONVEX mirror always forms a virtual, erect, diminished image behind the reflecting surface — this matches Figure (a).

Figure (b): The image I is larger than the object O (magnified), erect, and behind the mirror.
→ A CONCAVE mirror forms a virtual, erect, magnified image behind the mirror when the object is placed within its focal length — this matches Figure (b).

Therefore, Figure (a) = convex mirror and Figure (b) = concave mirror.

Answer: (ii) Figure (a) indicates a convex mirror and Figure (b) indicates a concave mirror.

Q12 Place a pencil behind a transparent glass tumbler (Fig. 10.28a). Now fill the tumbler halfway with water (Fig. 10.28b). How does the pencil appear when viewed through the water? Explain why its shape appears changed.

SOLUTION

Observation:
When the tumbler is empty, the pencil appears straight and normal through the glass.
When the tumbler is half-filled with water, the pencil appears bent or broken at the water surface — the part of the pencil in water looks displaced or shifted from the part above the water.

Explanation — Refraction of Light:
Water is an optically denser medium than air. When light travels from a denser

medium (water) to a less dense medium (air), it bends AWAY from the normal at the interface.

The light rays coming from the portion of the pencil submerged in water bend as they exit from water into air at the water surface.
This bending makes the submerged portion of the pencil appear to be at a different (shallower) position than it actually is.

As a result, the pencil appears bent or broken at the water's surface — this effect is caused by REFRACTION of light at the water-air boundary.

Answer: The pencil appears bent at the water surface due to refraction of light at the water-air interface. Light bends when passing from the denser medium (water) to the less dense medium (air), making the submerged part appear displaced from its actual position.