UNIQUE STUDY POINT

By Sumeet Sahu

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Unique Study Point, Amitesh Nagar, Indore, MP | Contact: 8103405051

Class: X	**Subject:** Science	**Session:** 2025-26
Chapter: 09 - Light - Reflection and Refraction	**Time:** 1½ Hours	**Max. Marks:** 40

General Instructions:

1. All questions are compulsory.
2. This question paper contains 20 questions divided into five sections A, B, C, D and E.
3. Section A contains 10 MCQs of 1 mark each.
4. Section B contains 4 questions of 2 marks each.
5. Section C contains 3 questions of 3 marks each.
6. Section D contains 1 question of 5 marks.
7. Section E contains 2 Case Study Based questions of 4 marks each.

SECTION A - Multiple Choice Questions (1 mark each)

1. A concave mirror produces a magnification of +3. The image is:

(a) Real and enlarged

(b) Real and diminished

(c) Virtual and enlarged

(d) Virtual and diminished

2. Which of the following statements is correct for the image formed by a plane mirror?

(a) Virtual, behind the mirror and enlarged

(b) Virtual, behind the mirror and of same size

(c) Real, behind the mirror and of same size

(d) Real, in front of the mirror and enlarged

3. An object is placed between the pole and focus of a concave mirror. The image will be formed:

(a) Behind the mirror

(b) At the focus

(c) At the center of curvature

(d) Beyond the center of curvature

4. The phenomenon of light changing its direction when it passes from one transparent medium to another is called:

(a) Reflection

(b) Refraction

(c) Dispersion

(d) Diffraction

5. For a lens, 1 dioptre of power is equal to:

(a) Focal length 1 cm

(b) Focal length 1 m

(c) Focal length 10 cm

(d) Focal length 100 cm

6. A ray of light is incident normally on a plane mirror. The angle of reflection will be:

(a) 0°

(b) 45°

(c) 90°

(d) 180°

7. The refractive index of kerosene is 1.44 and that of water is 1.33. In which medium does light travel faster?

(a) In kerosene

(b) In water

(c) Same in both

(d) Cannot be determined

8. An object is placed at 2F in front of a convex lens. The image will be formed at:

(a) F

(b) 2F

(c) Between F and 2F

(d) Beyond 2F

9. Which of the following lenses would you prefer to use while reading small letters?

(a) Concave lens of focal length 50 cm

(b) Convex lens of focal length 50 cm

(c) Concave lens of focal length 5 cm

(d) Convex lens of focal length 5 cm

10. An optically denser medium has:

(a) Higher refractive index and higher density

(b) Higher refractive index and may have lower density

(c) Lower refractive index and higher density

(d) Same refractive index as rarer medium

SECTION B - Short Answer Questions (2 marks each)

11. List four characteristics of the image formed by a plane mirror.

12. A concave lens of focal length 20 cm forms an image 15 cm from the lens. Calculate the object distance.

13. What is meant by the power of a lens? Write its SI unit. Is the power of a concave lens positive or negative?

14. Why does a ray of light bend when it travels from one medium to another? Explain.

SECTION C - Short Answer Questions (3 marks each)

15. Compare and contrast convex and concave mirrors in terms of:

(a) Shape of reflecting surface

(b) Nature of images formed

(c) One practical use of each

16. A convex mirror used on a bus has a focal length of 20 cm. If a car is located 10 m from the mirror, find the position and nature of the image.

17. Draw a ray diagram to show how a concave lens diverges a beam of parallel rays of light. Mark the principal axis, optical center, and principal focus on your diagram.

SECTION D - Long Answer Question (5 marks)

18. (a) Define magnification produced by a mirror. Write its formula in terms of height of object and image.

(b) An object 3 cm high is placed at a distance of 8 cm from a convex lens of focal length 5 cm. Find:

(i) Position of the image

(ii) Height of the image

(iii) Nature of the image

SECTION E - Case Study Based Questions (4 marks each)

19. Case Study 1: Headlights of Vehicles

The headlights of vehicles use concave mirrors to produce powerful parallel beams of light. A small bulb is placed at the principal focus of a large concave mirror. When the bulb is switched on, the light rays emanating from it fall on the concave mirror. Since the source is at the focus, the reflected rays become parallel to the principal axis and travel as a parallel beam. This helps illuminate the road ahead for a long distance. Parabolic mirrors (a special type of concave mirror) are often used for better results.

Based on the above information, answer the following questions:

(a) Why is a concave mirror used in vehicle headlights instead of a convex mirror? (1 mark)

(b) Where should the bulb be placed to get a parallel beam of light? (1 mark)

(c) What would happen if the bulb is placed between the pole and focus? (1 mark)

(d) State one more application where concave mirrors are used in a similar way. (1 mark)

20. Case Study 2: Mirage in Deserts

On a hot sunny day, when you look along a road, distant parts of the road appear to have a pool of water. This optical illusion is called a mirage. It is caused by the refraction of light in layers of air having different densities due to different temperatures. The layer of air near the hot road surface is less dense than the layer above it. Light rays from the sky bend as they pass through these layers and undergo total internal reflection near the ground. This creates an inverted image of the sky that looks like water on the road.

Based on the above information, answer the following questions:

(a) What causes a mirage? (1 mark)

(b) Which phenomenon of light is responsible for mirage? (1 mark)

(c) Why is the air near the hot road surface less dense? (1 mark)

(d) What do we actually see when we observe a mirage? (1 mark)

DETAILED ANSWER KEY - PAPER 03

SECTION A - Answers to MCQs

1. (c) Virtual and enlarged

A positive magnification (+3) indicates that the image is virtual and erect. The magnitude 3 means the image is three times larger than the object. This occurs when the object is placed between the pole and focus of a concave mirror.

2. (b) Virtual, behind the mirror and of same size

A plane mirror always forms a virtual image that is located behind the mirror at the same distance as the object is in front. The image is of the same size as the object and is laterally inverted.

3. (a) Behind the mirror

When an object is placed between the pole (P) and focus (F) of a concave mirror, a virtual, erect, and enlarged image is formed behind the mirror. The image cannot be projected on a screen.

4. (b) Refraction

Refraction is the phenomenon in which light changes its direction (bends) when it passes from one transparent medium to another. This happens due to the change in the speed of light in different media.

5. (b) Focal length 1 m

Power of lens (in dioptre) = 1/focal length (in meter)
For P = 1 D, f = 1/1 = 1 meter
Therefore, 1 dioptre is the power of a lens having focal length of 1 meter.

6. (a) 0°

When a ray is incident normally (perpendicular) on a mirror, the angle of incidence is 0°. According to the law of reflection, angle of incidence = angle of reflection. Therefore, angle of reflection = 0°. The ray retraces its path.

7. (b) In water

Refractive index n = c/v (where c is speed in vacuum, v is speed in medium)
Higher refractive index means lower speed of light in that medium.
Since water has lower refractive index (1.33) than kerosene (1.44), light travels faster in water.

8. (b) 2F

When an object is placed at 2F (twice the focal length) in front of a convex lens, the image is formed at 2F on the opposite side of the lens. The image is real, inverted, and of the same size as the object.

9. (d) Convex lens of focal length 5 cm

For reading small letters, we need magnification. A convex lens of small focal length (5 cm) when used as a magnifying glass (object placed between focus and lens) provides greater magnification than a lens with longer focal length.

10. (b) Higher refractive index and may have lower density

Optical density is different from mass density. An optically denser medium has higher refractive index (light travels slower). For example, kerosene (n=1.44) is optically denser than water (n=1.33), even though kerosene has lower mass density than water.

SECTION B - Answers to Short Answer Questions

11. Characteristics of Image in Plane Mirror

The four characteristics of the image formed by a plane mirror are:

1. **Virtual:** The image cannot be obtained on a screen; it is formed behind the mirror
2. **Erect:** The image is upright with the same orientation as the object
3. **Same size:** The image is of the same size as the object (magnification = 1)
4. **Laterally inverted:** Left and right sides are interchanged in the image
5. **Distance:** Image distance behind mirror equals object distance in front (additional characteristic)

12. Calculating Object Distance

Given:

Focal length, f = -20 cm (concave lens, so negative)

Image distance, v = -15 cm (virtual image for concave lens, same side as object)

Object distance, u = ?

Using lens formula:

$1/v - 1/u = 1/f$

$1/u = 1/v - 1/f$

$1/u = 1/(-15) - 1/(-20)$

$1/u = -1/15 + 1/20$

$1/u = (-4 + 3)/60$

$1/u = -1/60$

u = -60 cm

The object is placed at a distance of 60 cm in front of the lens.

13. Power of a Lens

Definition: The power of a lens is defined as the reciprocal of its focal length (in meters). It represents the ability of a lens to converge or diverge light rays.

Formula: P = 1/f (where f is in meters)

SI Unit: The SI unit of power of a lens is dioptre, denoted by D.
1 dioptre = 1 m^{-1}

Sign: The power of a concave lens is always negative because its focal length is negative. For example, if f = -0.5 m, then P = -2 D.

14. Bending of Light Ray

A ray of light bends when it travels from one medium to another due to the change in the speed of light in different media.

Explanation:
- Light travels with different speeds in different media
- When light enters from one medium to another at an angle (obliquely), one part of the wavefront enters the new medium first and slows down (or speeds up)
- This causes the wavefront to change direction, making the light ray bend
- The extent of bending depends on the refractive indices of the two media
- When moving from rarer to denser medium, light slows down and bends towards the normal
- When moving from denser to rarer medium, light speeds up and bends away from the normal
- If light enters perpendicular to the surface (normal incidence), there is no bending

SECTION C - Answers to Short Answer Questions

15. Comparison of Convex and Concave Mirrors

(a) Shape of reflecting surface:
- **Convex mirror:** The reflecting surface curves outward (bulges out). It is also called a diverging mirror.
- **Concave mirror:** The reflecting surface curves inward (caves in). It is also called a converging mirror.

(b) Nature of images formed:

- **Convex mirror:** Always forms virtual, erect, and diminished (smaller) images regardless of object position. Images are always formed behind the mirror.
- **Concave mirror:** Can form both real and virtual images depending on object position. Images can be enlarged, same size, or diminished. When object is beyond focus, image is real and inverted; when object is within focus, image is virtual and enlarged.

(c) Practical uses:

- **Convex mirror:** Used as rear-view mirrors in vehicles because they provide a wider field of view and always show erect images.
- **Concave mirror:** Used in solar cookers/furnaces to concentrate sunlight, in torches and headlights to produce parallel beams, and by dentists to see enlarged images of teeth.

16. Image by Convex Mirror

Given:

Focal length, f = +20 cm (convex mirror, so positive)

Object distance, u = -10 m = -1000 cm

Image distance, v = ?

Using mirror formula:

$1/f = 1/v + 1/u$

$1/v = 1/f - 1/u$

$1/v = 1/20 - 1/(-1000)$

$1/v = 1/20 + 1/1000$

$1/v = (50 + 1)/1000$

$1/v = 51/1000$

$v = 1000/51$

$v \approx +19.6$ cm

Position: The image is formed at approximately 19.6 cm behind the mirror.

Nature: The image is virtual (positive v), erect, and diminished. The image is formed very close to the focus of the mirror, as expected for a distant object in a convex mirror.

17. Ray Diagram for Concave Lens

Ray Diagram should show:

1. Draw a horizontal line representing the principal axis
2. Draw a concave lens (thinner at middle, thicker at edges) with its center on the principal axis
3. Mark the optical center (O) at the center of the lens

4. Mark the principal focus (F) on the left side of the lens (same side as object)
5. Draw parallel rays coming from the left towards the lens
6. After passing through the lens, draw diverging rays
7. Extend these diverging rays backward (shown as dotted lines) to meet at F
8. Add arrows to show direction of light

Labels required:
- Principal axis
- Optical center (O)
- Principal focus (F)
- Incident parallel rays
- Refracted diverging rays
- Dotted lines showing backward extension

Observation: The diagram clearly shows that a concave lens diverges parallel rays of light, making them appear to come from the principal focus on the same side as the incident light.

SECTION D - Answer to Long Answer Question

18. Magnification and Numerical Problem

(a) Definition and Formula:
Magnification produced by a mirror is defined as the ratio of the height of the image to the height of the object.

Formula:
m = Height of image (h') / Height of object (h)
m = h'/h

Magnification can also be expressed as: m = -v/u
where v is image distance and u is object distance.

(b) Numerical Problem:
Given:
Object height, h = 3 cm
Object distance, u = -8 cm
Focal length, f = +5 cm (convex lens)

(i) Finding position of image:
Using lens formula: 1/v - 1/u = 1/f
1/v = 1/f + 1/u

$1/v = 1/5 + 1/(-8)$

$1/v = 1/5 - 1/8$

$1/v = (8 - 5)/40$

$1/v = 3/40$

$v = +40/3 = +13.33$ cm

The image is formed at 13.33 cm on the opposite side of the lens.

(ii) Finding height of image:

Using magnification formula: $m = v/u = h'/h$

$h'/3 = (40/3)/(-8)$

$h'/3 = 40/(3 \times (-8))$

$h'/3 = -40/24 = -5/3$

$h' = -5$ cm

The height of the image is 5 cm. The negative sign indicates it is inverted.

(iii) Nature of image:

- **Real** (formed by actual intersection of rays, positive v)
- **Inverted** (negative h')
- **Magnified/Enlarged** (image height 5 cm > object height 3 cm)
- Magnification $m = -5/3 \approx -1.67$ (enlarged 1.67 times)

SECTION E - Answers to Case Study Based Questions

19. Case Study 1: Headlights of Vehicles

(a) Why concave mirror instead of convex mirror:

A concave mirror is used in vehicle headlights because it can converge light rays into a powerful parallel beam. When the bulb (point source) is placed at the focus of a concave mirror, the reflected rays emerge parallel to the principal axis, creating a strong beam that can illuminate the road for a long distance. A convex mirror would diverge the light rays, making them spread out and reducing illumination.

(b) Position of bulb for parallel beam:

The bulb should be placed exactly at the principal focus (F) of the concave mirror. When a point source of light is placed at the focus of a concave mirror, all rays from it, after reflection, travel parallel to the principal axis, forming a parallel beam of light.

(c) If bulb is placed between pole and focus:

If the bulb is placed between the pole (P) and focus (F) of the concave mirror:

- The reflected rays would diverge (spread out)
- A virtual, enlarged image would be formed behind the mirror
- No parallel beam would be produced
- The headlight would not work effectively as light would scatter instead of forming a focused beam

(d) One more similar application:

Other similar applications of concave mirrors include:
- Searchlights (to produce powerful parallel beams)
- Torches/flashlights (to create focused beams)
- Spotlights in theaters and stadiums

(Any one correct answer is acceptable)

20. Case Study 2: Mirage in Deserts

(a) What causes a mirage:

A mirage is caused by the refraction of light through layers of air having different temperatures and hence different densities. When light passes through these layers of varying density, it bends continuously, and under certain conditions undergoes total internal reflection, creating an illusion of water on the ground.

(b) Phenomenon responsible for mirage:

The phenomenon of light responsible for mirage is:
1. **Refraction** - light bends as it passes through air layers of different densities
2. **Total Internal Reflection** - light rays undergo total internal reflection when moving from denser (cooler) to rarer (hotter) air layer at a critical angle

Both phenomena work together to create the mirage effect.

(c) Why air near hot road is less dense:

The air near the hot road surface is less dense because:
- The road surface gets extremely hot in sunlight
- It heats the air immediately above it by conduction
- Hot air expands and becomes less dense (molecules move farther apart)
- The cooler air above remains denser
- This creates layers of air with different densities - less dense near the ground, more dense higher up

(d) What we see in a mirage:

When we observe a mirage, we actually see an inverted image of the sky or distant objects. The light rays from the sky, after undergoing refraction and total internal reflection in the layers of air near the hot ground, reach our eyes. Our brain interprets these rays as coming from the ground, creating the illusion of water (since water also reflects the sky). We see a shimmering, inverted reflection of the sky that appears like a pool of water on the road.