Affiliated to CBSE, New Delhi (Affiliation No. 1030642)

GNPS

GOMTI NANDAN PUBLIC SCHOOL

Gandhi Ward, Bina (M.P.) 470113. | 9165 609 333. | info@mygnps.com | www.mygnps.com

CLASS X · SCIENCE (086) · PHYSICS · CBSE BOARD EXAMINATION 2027

CHAPTER 9

Light – Reflection and Refraction

1/v – 1/u = 1/f

Answer Booklet · CBSE marking-scheme answers with marks for every point

Every question of the chapter booklet | Marks shown point by point | MCQ keys with reasons

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HOW TO USE THE ANSWERS

1. Answer the question in your notebook **first**. Open this booklet only to check.
2. Each answer is written the way the CBSE marking scheme sets it out: **value points**, with the **mark for each point** in orange beside it.
3. Give yourself marks point by point. Use the same **key words** in your own answers.
4. Equations must be balanced; diagrams must be labelled; numericals need formula, substitution and unit.
5. Copy every wrong answer to the My Mistakes page of your booklet.

READ THIS FIRST

Marking Guide

Model answers to every question in the chapter booklet, set out the way a CBSE examiner marks them.

HOW MARKS ARE GIVEN IN SCIENCE ANSWERS

1. **MCQ and assertion–reason (1 mark):** only the correct option scores. The reason given here is for your understanding.
2. **2 and 3 marks:** one mark (or ½) for each correct **value point**. The examiner looks for the key word – a long answer without it scores less than a short answer with it.
3. **Equations:** a correct balanced equation earns its full mark; an unbalanced one, or one with wrong formulae, usually earns ½ or nothing.
4. **Numericals:** formula, substitution and the final answer **with unit** are marked separately.
5. **Diagrams:** marks for a correct drawing and for the labels asked for. An unlabelled diagram earns little.
6. **Case study (4 marks):** 1 + 1 + 2. **Long answer (5 marks):** the split is shown beside each point.

PART A · ANSWERS

A NCERT Practice – Answers

Marking-scheme answers for every question in Part A of the chapter booklet.

Spherical mirrors

A1. Define the principal focus of a concave mirror. [1]

The point on the principal axis at which rays parallel to the principal axis meet after reflection from a concave mirror. 1

A2. The radius of curvature of a spherical mirror is 32 cm. Find its focal length. [1]

f = R/2 = 32/2 = **16 cm**. 1

A3. Name the type of mirror that can give an erect and enlarged image of an object. Where must the object be? [1]

Concave mirror, with the object between its pole and principal focus. 1

A4. Why do we prefer a convex mirror as a rear-view mirror in vehicles? [2]

A convex mirror always gives an erect (though diminished) image. 1

Being curved outwards, it gives a much wider field of view, so the driver sees a large area behind. 1

A5. Name the mirror used in (i) the headlights of a car (ii) a shaving mirror (iii) a solar furnace. Give a reason for each. [3]

(i) Concave – the bulb at its focus gives a powerful parallel beam of light. 1

(ii) Concave – held close (face within F), it gives an erect, enlarged image of the face. 1

(iii) Concave – it focuses sunlight at its focus, producing a lot of heat. 1

A6. An object 3 cm tall is placed 30 cm in front of a concave mirror of focal length 20 cm. Where should a screen be placed to get a sharp image? Find the size and nature of the image. [3]

u = −30 cm, f = −20 cm. 1/v = 1/f − 1/u = −1/20 + 1/30 = −1/60, so **v = −60 cm**: screen 60 cm in front of the mirror. 1

m = −v/u = −(−60)/(−30) = −2; h′ = m × h = −2 × 3 = **−6 cm**. 1

Image is real, inverted and enlarged (twice the size). 1

A7. The rear-view convex mirror of a bus has a radius of curvature of 4 m. A car is 6 m behind the mirror. Find the position, nature and magnification of the image. [3]

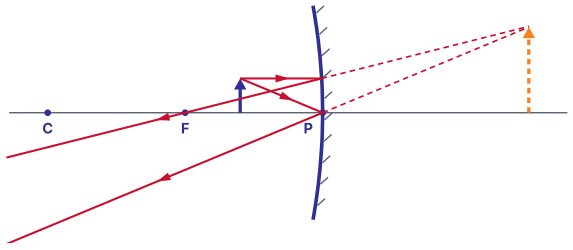
f = +R/2 = +2 m, u = −6 m. 1/v = 1/f − 1/u = 1/2 + 1/6 = 2/3, so **v = +1.5 m** (behind the mirror). 1½

m = −v/u = −(1.5)/(−6) = **+0.25**. 1

Image is virtual, erect and diminished (one-fourth the size). ½

A8. Draw a ray diagram to show the image formed by a concave mirror when the object is between its pole and principal focus. Give two uses of this. [3]

Correct diagram: one ray parallel to the axis reflected through F, one ray at P reflected at equal angle; reflected rays produced backwards (dotted) meet behind the mirror. 2



Uses: shaving/make-up mirror; dentist's mirror (½ each). 1

Refraction and refractive index

A9. A ray of light enters water from air at an angle. Does it bend towards or away from the normal? Why? [2]

It bends towards the normal. 1

Light travels slower in water (optically denser) than in air. 1

A10. The refractive index of glass is 1.5. Find the speed of light in glass. ($c = 3 \times 10^8$ m/s) [2]

n = c/v, so v = c/n = $(3 \times 10^8)/1.5$ 1

= **2×10^8 m/s**. 1

A11. Refractive indices: water 1.33, benzene 1.50, crown glass 1.52, diamond 2.42. Which is optically densest? In which does light travel fastest? [2]

Optically densest: diamond (highest refractive index). 1

Fastest: water (lowest refractive index). 1

A12. The refractive index of diamond is 2.42. What does this mean? [2]

The ratio of the speed of light in air (vacuum) to the speed of light in diamond is 2.42. 1

So light travels 2.42 times slower in diamond than in air. 1

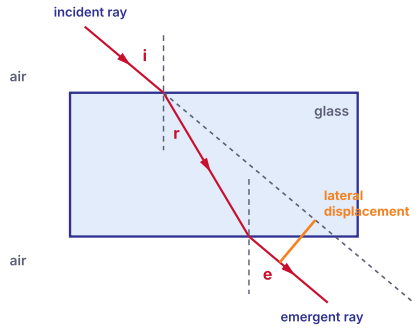
A13. State the two laws of refraction of light. [2]

The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane. 1

For a given colour and pair of media, sin i / sin r is constant (Snell's law); the constant is the refractive index. 1

A14. Draw the path of a ray of light passing obliquely through a rectangular glass slab. Mark the angles of incidence, refraction and emergence. Why is the emergent ray parallel to the incident ray? [3]

Correct diagram with normals, i, r, e and the lateral displacement. 2



The bending at the two parallel faces is equal and opposite (i = e), so the emergent ray is parallel to the incident ray. 1

Spherical lenses and power

A15. Where should an object be placed in front of a convex lens to get a real image of the same size? [1]

At $2F_1$ (twice the focal length from the lens). 1

A16. Which lens is used as a magnifying glass? Where is the object kept, and what kind of image is formed? [2]

A convex lens, with the object between F_1 and the optical centre. 1

The image is virtual, erect and enlarged, on the same side as the object. 1

A17. Define 1 dioptre of power. [1]

1 dioptre is the power of a lens whose focal length is 1 metre. 1

A18. A convex lens forms a real, inverted image of a pin 40 cm from the lens, of the same size as the pin. Where is the pin placed? Find the power of the lens. [3]

Same size real image: object at $2F_1$, so u = –40 cm and v = +40 cm. 1

$1/f = 1/v - 1/u = 1/40 + 1/40 = 1/20$, so f = 20 cm = 0.2 m. 1

$P = 1/f = 1/0.2 =$ **+5 D**. 1

A19. A concave lens of focal length 20 cm forms an image 12 cm from the lens. How far is the object from the lens? **[3]**

f = –20 cm, v = –12 cm (virtual image, same side). 1

1/u = 1/v – 1/f = –1/12 + 1/20 = –1/30 1

u = **–30 cm**: the object is 30 cm in front of the lens. 1

A20. An object 4 cm tall is 15 cm from a convex lens of focal length 10 cm. Find the position, size and nature of the image. **[3]**

u = –15 cm, f = +10 cm. 1/v = 1/f + 1/u = 1/10 – 1/15 = 1/30, so **v = +30 cm**. 1

m = v/u = 30/(–15) = –2; h′ = –2 × 4 = **–8 cm**. 1

Image is 30 cm on the other side of the lens, real, inverted and enlarged. 1

A21. Find the power of a concave lens of focal length 2 m. **[1]**

P = 1/f = 1/(–2) = **–0.5 D**. 1

A22. The power of a lens is –2.0 D. Find its focal length and name the lens. **[2]**

f = 1/P = 1/(–2) = –0.5 m = **–50 cm**. 1

Negative power: concave (diverging) lens. 1

A23. A doctor prescribes a lens of power +1.5 D. Find the focal length and the type of lens. **[2]**

f = 1/P = 1/1.5 m = 0.667 m ≈ **66.7 cm**. 1

Positive power: convex (converging) lens. 1

B

PART B · ANSWERS

Exemplar Practice – Answers

Marking-scheme answers for every question in Part B of the chapter booklet.

Multiple choice

Q	Answer	Working / reason
B1	**(d)** Concave mirror	Only a converging mirror or lens can form a real image.
B2	**(a)** both concave	Negative f: concave mirror and concave lens.
B3	**(c)** between P and F	Only for an object within F is the image virtual.
B4	**(b)** positive and less than 1	Image is erect (+) and diminished (less than 1).
B5	**(d)** Air	Air has the lowest refractive index.
B6	**(b)** A pencil looking bent in water	Light bends as it passes from water into air.
B7	**(c)** comes back along the same path	It falls along the normal, so it retraces its path.
B8	**(b)** 12 cm from the lens	Image of a very distant object forms at the focus.
B9	**(b)** –25 cm, concave	f = 1/P = –0.25 m = –25 cm; negative → concave.
B10	**(b)** convex mirror	A convex mirror gives a diminished image of a large field.

Short answer

B11. Why does a ray of light passing through the optical centre of a thin lens go undeviated? **[2]**

Near the optical centre the two faces of a thin lens are almost parallel, like a thin glass slab. 1

A thin slab shifts the ray only slightly sideways without changing its direction, so the ray goes straight on. 1

B12. The magnification produced by a mirror is –1/3. What is the nature of the image? Which type of mirror is it? **[2]**

Negative m: real and inverted; $|m| = 1/3$: diminished (one-third the size). 1

A concave mirror (a convex mirror always gives positive m). 1

B13. Two thin lenses of power +2 D and –1.5 D are placed in contact. Find the power and focal length of the combination. **[2]**

$P = P_1 + P_2 = +2 - 1.5 =$ **+0.5 D**. 1

$f = 1/P = 1/0.5 =$ **2 m** (converging). 1

B14. Why do dentists use concave mirrors? [2]

When a tooth is within the focus of a concave mirror, the mirror gives an erect and enlarged image. 1

So the dentist can see the tooth clearly in detail. 1

B15. The absolute refractive index of medium A is 1.6 and of medium B is 1.2. Find (i) the speed of light in A (ii) the refractive index of A with respect to B. (iii) In which medium does light travel faster? ($c = 3 \times 10^8$ m/s) [3]

(i) $v = c/n = 3 \times 10^8 / 1.6 =$ **1.875×10^8 m/s**. 1

(ii) n(A w.r.t. B) = n(A)/n(B) = 1.6/1.2 = **1.33**. 1

(iii) In B, as it has the lower refractive index. 1

B16. Where is the image formed when an object is placed at the principal focus of a convex lens? Describe it. [2]

At infinity (the refracted rays come out parallel). 1

Highly enlarged, real and inverted. 1

PART C · ANSWERS

C Board Pattern Practice – Answers

Marking-scheme answers for every question in Part C of the chapter booklet.

Spherical mirrors

Q	Answer	Working / reason
C1	**(b)** comes back along the same path	Angle of incidence 0° means angle of reflection 0°: the ray retraces its path.
C2	**(a)** passes through the principal focus	Rays parallel to the axis converge at F.
C3	**(a)**	Both true; R gives the reason for A.
C4	**(a)** at infinity	f = 20 cm, so the object is at F: image at infinity.

C5. A concave mirror of focal length 12 cm forms a virtual image three times the size of the object. Find the object distance and the image distance. [3]

Virtual, erect image: m = +3 = −v/u, so v = −3u. 1

1/v + 1/u = 1/f: 1/(−3u) + 1/u = 2/(3u) = −1/12, so **u = −8 cm**. 1

v = −3u = **+24 cm** (behind the mirror). 1

C6. Draw a ray diagram for an object placed between F and C of a concave mirror. State the position and nature of the image. **[3]**

Correct diagram with two rays, arrows and the image marked. **2**

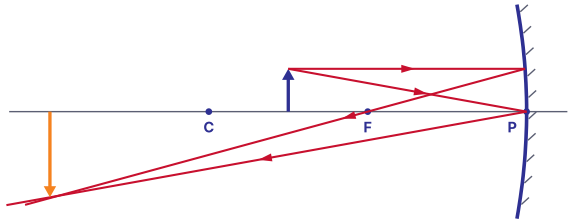


Image beyond C; real, inverted and enlarged. **1**

C7. Name the type of mirror that gives (i) an erect, diminished image for every object position (ii) a real image of the same size. Where is the object in (ii)? **[2]**

(i) Convex mirror. **1**

(ii) Concave mirror, with the object at C (centre of curvature). **1**

Refraction and refractive index

Q	Answer	Working / reason
C8	**(b)** its speed decreases and it bends towards the normal	Glass is optically denser.
C9	**(a)**	Both true; R explains A.
C10	**(a)** parallel to the incident ray but shifted sideways	Equal and opposite bending at two parallel faces.

C11. A ray of light falls on a glass surface at an angle of incidence of 45° and is refracted at 28°. Find the refractive index of glass. (sin 45° = 0.707, sin 28° = 0.47) **[2]**

$n = \sin i / \sin r = 0.707 / 0.47$ **1**

$= \mathbf{1.5}$ (approx.). **1**

C12. The speed of light is 2×10^8 m/s in medium A and 2.25×10^8 m/s in medium B. Which medium is optically denser? Find the refractive index of A with respect to B. **[2]**

A is optically denser (light is slower in it). **1**

$n(A \text{ w.r.t. } B) = v(B)/v(A) = 2.25/2 = \mathbf{1.125}$. **1**

C13. The refractive index of water is 1.33 and of glass is 1.5. Find (i) the speed of light in water (ii) the refractive index of glass with respect to water. (iii) Which way does a ray bend going from water into glass? ($c = 3 \times 10^8$ m/s) **[3]**

(i) $v = c/n = 3 \times 10^8 / 1.33 = \mathbf{2.26 \times 10^8\ m/s}$. **1**

(ii) $n(\text{glass w.r.t. water}) = 1.5/1.33 = \mathbf{1.13}$. **1**

(iii) Towards the normal, as glass is optically denser than water. **1**

Lenses: ray diagrams and images

Q	Answer	Working / reason
C14	**(b)** 24 cm	Same size real image: object at 2F = 24 cm.
C15	**(b)** convex, object at 2F	m = −1: real, inverted, same size – convex lens with the object at $2F_1$.
C16	**(b)** 18 cm	Sun's rays are parallel; they meet at the focus.
C17	**(a)**	Both true; the rays never meet, so the image is virtual – R explains A.

C18. Draw a ray diagram for an object placed between F_1 and $2F_1$ of a convex lens. State the position, size and nature of the image. [3]

Correct diagram: ray parallel to the axis refracted through F_2; ray through O undeviated; image marked. 2

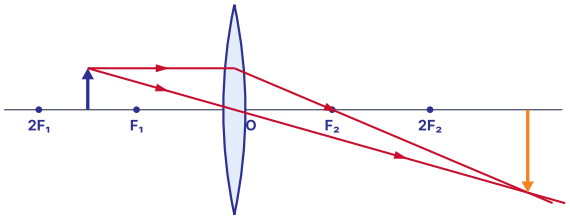


Image beyond $2F_2$; enlarged, real and inverted. 1

C19. Draw a ray diagram to show the formation of an image by a concave lens. State the nature of the image. [2]

Correct diagram: parallel ray diverges as if from F_1 (dotted back to F_1); ray through O undeviated; image between F_1 and O. 1½

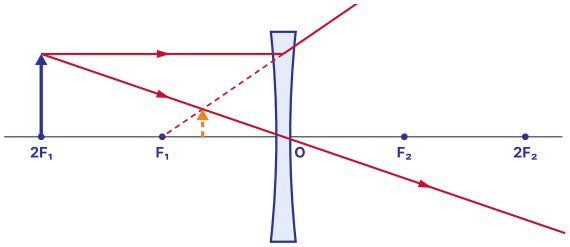


Image is virtual, erect and diminished. ½

C20. A lens gives an erect, enlarged image on the same side as the object. Name the lens and state where the object is placed. Can this image be caught on a screen? [2]

Convex lens; object between F_1 and the optical centre O. 1

No – the image is virtual. 1

Lens formula, magnification and power

C21. A convex lens forms a real image three times the size of the object on a screen 60 cm from the lens. Find the object distance and the focal length. [3]

Real image: m = –3 = v/u, with v = +60 cm, so **u = –20 cm**. 1

1/f = 1/v – 1/u = 1/60 + 1/20 = 4/60 1

f = 15 cm. 1

C22. An object 6 cm tall is placed 30 cm from a convex lens of focal length 10 cm. Find the position and size of the image, and describe it. [3]

1/v = 1/f + 1/u = 1/10 – 1/30 = 2/30, so **v = +15 cm**. 1

m = v/u = 15/(–30) = –0.5; h′ = –0.5 × 6 = **–3 cm**. 1

Real, inverted, diminished, between F_2 and $2F_2$. 1

C23. An object is 30 cm from a concave lens and its image forms 15 cm from the lens on the same side. Find the focal length, power and magnification. [3]

u = –30 cm, v = –15 cm. 1/f = 1/v – 1/u = –1/15 + 1/30 = –1/30, so **f = –30 cm**. 1

P = 1/f = 1/(–0.3 m) = **–3.3 D**. 1

m = v/u = (–15)/(–30) = **+0.5** (erect, half the size). 1

C24. A convex lens of focal length 20 cm and a concave lens of focal length 40 cm are placed in contact. Find the power of the combination and say whether it converges or diverges light. [2]

P_1 = 1/0.2 = +5 D; P_2 = 1/(–0.4) = –2.5 D. 1

P = +5 – 2.5 = **+2.5 D**; positive, so the combination converges light (f = 40 cm). 1

C25. A student recorded these object and image distances (in cm) for a convex lens: (–60, +30), (–40, +40), (–30, +60), (–25, +80). (i) Find the focal length from the second reading. (ii) Which reading is wrong? What should it be? (iii) Which reading gives an image of the same size? [3]

(i) 1/f = 1/v – 1/u = 1/40 + 1/40 = 1/20, so **f = 20 cm**. 1

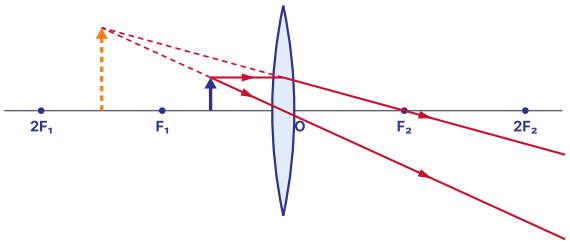
(ii) Fourth reading: for u = –25 cm, 1/v = 1/20 – 1/25 = 1/100, so v should be **+100 cm**, not 80 cm. 1

(iii) The second reading (u = –40 cm = $2F_1$). 1

Long answer

C26. (a) Draw a ray diagram to show how a convex lens works as a magnifying glass. (b) An object 2 cm high is 15 cm from a convex lens of focal length 10 cm. Find the position and size of the image. (c) Find the power of the lens. **[5]**

(a) Object between F_1 and O; image virtual, erect, enlarged on the same side. **2**



(b) $1/v = 1/10 - 1/15 = 1/30$, so $v = +30$ cm (real, on the other side). **1**

$m = v/u = 30/(-15) = -2$; $h' = \mathbf{-4\ cm}$ (inverted, enlarged). **1**

(c) $P = 1/0.1\ m = \mathbf{+10\ D}$. **1**

C27. (a) State the position, size and nature of the image formed by a concave mirror when the object is (i) beyond C (ii) at C (iii) between P and F. (b) An object is 12 cm in front of a concave mirror of focal length 18 cm. Find the image distance and magnification. (c) Give one use of a convex mirror. **[5]**

(a) (i) Between F and C, diminished, real, inverted (ii) at C, same size, real, inverted (iii) behind the mirror, enlarged, virtual, erect. **2**

(b) $u = -12$, $f = -18$: $1/v = 1/f - 1/u = -1/18 + 1/12 = 1/36$, so $\mathbf{v = +36\ cm}$ (behind). **1**

$m = -v/u = -36/(-12) = \mathbf{+3}$: virtual, erect, three times enlarged. **1**

(c) Rear-view mirror in vehicles (or at blind road turns). **1**

C28. (a) What is refraction? State its laws. (b) Define absolute refractive index. (c) Light enters glass ($n = 1.5$) from air. Find its speed in glass. (d) Why does a stick partly dipped in water look bent? **[5]**

(a) Bending of light as it passes obliquely from one medium to another. Laws: incident ray, refracted ray and normal in one plane; $\sin i/\sin r$ = constant. **2**

(b) Ratio of the speed of light in vacuum to its speed in the medium: $n = c/v$. **1**

(c) $v = 3 \times 10^8 / 1.5 = \mathbf{2 \times 10^8\ m/s}$. **1**

(d) Light from the dipped part bends away from the normal on leaving water, so that part appears raised. **1**

PART D · ANSWERS

D Case-Based Questions – Answers

Marking-scheme answers for every question in Part D of the chapter booklet.

D1. Case Study · The Reflecting Telescope [4]

(i) Which type of mirror is the main mirror? **[1]**

Concave mirror. 1

(ii) Where is the image of the star formed? **[1]**

At the principal focus of the mirror (rays from a distant star are parallel). 1

(iii) Find the focal length of the main mirror. Describe the image of the star formed by it. **[2]**

f = R/2 = 2.4/2 = **1.2 m**. 1

Real, inverted, highly diminished (point-sized), 1.2 m in front of the mirror. 1

OR

(iii) Why could a convex mirror not be used as the main mirror? Give one other use of the type of mirror used. **[2]**

A convex mirror spreads light out; it cannot bring the parallel rays together to a point (no real image). 1

Concave mirrors are also used in headlights, solar furnaces or shaving mirrors (any one). 1

D2. Case Study · The Watch Repairer's Lens [4]

(i) Which type of lens is he using? **[1]**

Convex (converging) lens. 1

(ii) State the nature of the image he sees. **[1]**

Virtual, erect and enlarged. 1

(iii) Find the image distance and the magnification. **[2]**

u = −4, f = +5: 1/v = 1/5 − 1/4 = −1/20, so **v = −20 cm** (same side). 1

m = v/u = (−20)/(−4) = **+5**. 1

OR

(iii) Find the power of the lens. What happens to the image if he moves the lens until the screw is 10 cm away? **[2]**

P = 1/0.05 m = **+20 D**. 1

At 10 cm the screw is at $2F_1$: the image becomes real, inverted and of the same size, on the other side (he can no longer see an upright magnified image). 1

D3. Case Study · The Coin in the Pool [4]

(i) Name the phenomenon that makes the coin appear raised. **[1]**

Refraction of light. 1

(ii) Find the speed of light in water. **[1]**

v = c/n = $3 \times 10^8 \times 3/4$ = **2.25×10^8 m/s**. 1

(iii) Explain, with the direction of bending, why the pool looks shallower than it is. **[2]**

Light from the coin goes from water (denser) into air (rarer) and bends away from the normal. 1

When produced backwards, the refracted rays appear to come from a point above the coin, so the coin (and the bottom) appears raised. 1

OR

(iii) A ray goes from air into water with sin i = 0.8. Find sin r. Does the ray bend towards or away from the normal? **[2]**

sin r = sin i / n = 0.8 / (4/3) = **0.6**. 1

r is smaller than i: the ray bends towards the normal. 1