Ray Optics and Optical Instruments — CBSE Pattern Test 1

Class 12 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 12 Physics · Ray Optics and Optical Instruments · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1 × 10), Section B (2 × 4), Section C (3 × 4) and Section D (5 × 2) — total 40 marks. Time allowed: 90 minutes.
(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
(3) For MCQ questions choose the single correct option; for VSA answers write a single line.
(4) Take g = 10 m/s^2. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA (10 × 1 = 10 marks)

1. Two plane mirrors are inclined at an angle of 70°. A ray incident on one mirror at an angle of incidence I, after reflection, falls on the second mirror and is reflected from there parallel to the first mirror. The value of I is

(A) 50°
(B) 45°
(C) 30°
(D) 55°

2. A man of height h is walking away from a street lamp of height 3h at a constant speed v. The rate at which the length of the man's shadow is increasing when he is at a distance 10h from the base of the lamp is

(A) v/2
(B) v/3
(C) v/6
(D) 2v

3. A boy of height 1.5 m with his eye level at 1.4 m stands before a plane mirror of length 0.75 m, whose lower edge is 0.8 m above the floor. Then

(A) the boy will see his full image
(B) the boy cannot see his hair
(C) the boy cannot see his feet
(D) the boy can see neither his hair nor his feet

4. A point source of light S is placed in front of two large mirrors M_1 and M_2 inclined at 30° as shown. The observer who sees only one image of S is

(A) only A
(B) only C
(C) both A and C
(D) both B and C

5. In the figure, if the object O moves toward the plane mirror, then the image I formed after successive reflections from mirrors M_1 and M_2 will move

(A) toward the right
(B) toward the left
(C) with zero velocity
(D) cannot be determined

6. A point source of light is 60 cm away from a screen and is kept at the focus of a concave mirror (f = 20 cm) that reflects light onto the screen. The ratio of the average intensities of illumination on the screen with and without the mirror is

(A) 36 : 1

(B) 37 : 1

(C) 49 : 1

(D) 10 : 1

7. State the new Cartesian sign convention for the focal length of a concave mirror.

8. Define the critical angle for a pair of media.

9. Define the power of a lens and give its SI unit.

10. Write the lens maker's formula, naming each symbol.

Section B — Short Answer I (4 × 2 = 8 marks)

11. A ray of light incident on an equilateral glass prism shows a minimum deviation of 30°. Calculate the speed of light through the glass prism.

12. A double convex lens of glass (n = 1.6) has both surfaces of equal radii of curvature 30 cm. An object of height 5 cm is placed at 12.5 cm from the lens. Find the size of the image.

13. Two lenses of power +6 D and −2 D are placed in contact. Find the power and focal length of the combination.

14. A beam of light converges to a point P. A concave lens of focal length 16 cm is placed in the path of the beam, 12 cm from P. Locate the final point of convergence.

Section C — Short Answer II (4 × 3 = 12 marks)

15. Derive, with the help of a ray diagram, an expression for the normal (apparent) shift of an object viewed through a glass slab of thickness t and refractive index n.

16. A boy of height 1.5 m has his eye level at 1.4 m and stands before a plane mirror of length 0.75 m, the lower edge of which is 0.8 m above the floor. Determine, with reasoning, whether he can see (i) his hair, (ii) his feet, (iii) his full image.

17. Two plane mirrors M_1 and M_2 are inclined to each other and a point object O moves toward the plane of the mirrors. Explain with a ray diagram the successive reflections and find the direction of motion of the image I.

18. A point source of light is placed at the focus of a concave mirror of focal length 20 cm, the screen being 60 cm from the source. The mirror-captured light falls on the screen. Find the ratio of intensities with and without the mirror.

Section D — Long Answers (2 × 5 = 10 marks)

19. (a) Draw a labelled ray diagram of an astronomical telescope in normal adjustment and derive an expression for its angular magnification. (b) A telescope has an objective of focal length 160 cm and an eyepiece of focal length 4 cm. Find its magnifying power and the separation between the two lenses.

20. (a) Derive the prism formula n = sin((A + δ_m)/2) / sin(A/2) using Snell's law at the two refracting faces. (b) An equilateral prism of refractive index √2 gives minimum deviation for a ray passing through it. Find the angle of minimum deviation.

Answer Key (Marking Scheme)

Q1 – (A) 50° (both reflections are at 40° and the ray emerges parallel to the first mirror). Q2 – (A) v/2 (shadow length s satisfies x/s = (3h − h)/h = 2, so ds/dt = v/2). Q3 – (C) cannot see his feet (lower edge 0.8 m > eye/2 = 0.7 m). Q4 – (B) only C. Q5 – (A) toward the right. Q6 – (D) 10 : 1.

Q7 – f is negative for a concave mirror (distances measured in the direction of incident light are positive; against it are negative). Q8 – The angle of incidence in the denser medium for which the refracted ray grazes the interface (r =

90°). Q9 – P = 1/f with f in metres; SI unit is the dioptre. Q10 – $1/f = (n - 1)(1/R_1 - 1/R_2)$; n = refractive index of the lens material, R_1 and R_2 are the signed radii of the two refracting surfaces in air.

Q11 – $n = \sin45°/\sin30° = \sqrt{2} \rightarrow v = c/n = 3 \times 10^8/1.414 \approx 2.12 \times 10^8$ m/s. Q12 – f = 25 cm; $1/v = 1/25 - 1/12.5 = -1/25 \rightarrow v = -25$ cm, $|m| = 2 \rightarrow$ image 10 cm, virtual and erect. Q13 – $P = +6 - 2 = +4$ D $\rightarrow f = 100/4 = 25$ cm. Q14 – For the concave lens $f = -16$ cm, $u = +12$ cm: $1/v = -1/16 + 1/12 = 1/48 \rightarrow v = +48$ cm.

Q15 – Real depth t, apparent depth t/n, so shift = $t - t/n = t(1 - 1/n)$, independent of the eye's distance. Q16 – Eye/2 = 0.7 m but lower edge is at 0.8 m → feet not seen; upper edge at 0.8 + 0.75 = 1.55 m > 1.4 m is not needed — hair is visible; full image not seen. Q17 – O's successive reflections shift the image; as O moves toward the mirror plane the multiple images move toward the right (the direction of the virtual image chain). Q18 – With the mirror the light is collimated onto the screen within the mirror aperture; ratio ≈ 10 : 1.

Q19 – (a) $M = f_o/f_e$ with the lenses separated by $f_o + f_e$ (parallel bundle condensed at the objective focus, magnified by the eyepiece). (b) M = 160/4 = 40; separation = 164 cm. Q20 – (a) At minimum deviation i = e and $r_1 = r_2 = A/2$; Snell's law at each face gives $n = \sin((A + \delta_m)/2)/\sin(A/2)$. (b) $\sin((60° + \delta_m)/2) = \sqrt{2} \sin30° = 0.707 \rightarrow \delta_m = 30°$.