Ray Optics and Optical Instruments

Standard difficulty · 20 questions · 40 marks · Time: 40 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. An object is 12 cm in front of a concave mirror of focal length 25 cm. The image distance v is:
(a) −8.11 cm **(b)** −23.1 cm **(c)** −37 cm **(d)** 23.1 cm

2. An object is 55 cm from a concave lens of focal length 40 cm. The image distance v is:
(a) 23.2 cm **(b)** −147 cm **(c)** −23.2 cm **(d)** −95 cm

3. A coin lies at the bottom of a tank of liquid 12 cm deep, of refractive index 2. Seen from directly above, it appears to be at a depth of:
(a) 12 cm **(b)** 7 cm **(c)** 24 cm **(d)** 6 cm

4. The critical angle for light going from a medium of refractive index 2.5 into air is:
(a) $\sin^{-1}(2/5)$ **(b)** 30° **(c)** 45° **(d)** 60°

5. The focal length of a spherical mirror of radius of curvature R is:
(a) R/2 **(b)** R **(c)** R/4 **(d)** 2R

6. Thin lenses of focal lengths −25 cm and −25 cm are placed in contact. The power of the combination is:
(a) 8 D **(b)** −0.5 D **(c)** −2 D **(d)** −8 D

7. An object is 39 cm from a concave mirror of focal length 20 cm; the image forms at v = −41.1 cm. The magnification is:
(a) −20/19 **(b)** −40/19 **(c)** −19/20 **(d)** 20/19

8. Assertion (A): Light inside a medium of refractive index 2, meeting the surface with air at 45°, is totally reflected.
Reason (R): Total internal reflection happens when light in the rarer medium meets the surface at more than the critical angle.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. An object 7 cm tall stands 28 cm in front of a concave mirror of focal length 40 cm. Find the position, size and nature of the image.

10. An object 7 cm tall is 42 cm from a concave lens of focal length 40 cm. Find the position, size and nature of the image.

11. A prism with apex angle 120° gives a minimum deviation of 60°. Find its refractive index and the angle of incidence at minimum deviation.

12. A double-convex lens of glass (n = 5/3) has radii of curvature 30 cm and 30 cm. Find its focal length and power.

13. An astronomical telescope has an objective of focal length 150 cm and an eyepiece of focal length 5 cm. Find its magnifying power in normal adjustment and the length of the tube.

14. A magnifying glass gives a magnifying power of 2 when the image is at the near point (25 cm). Find its focal length and its power.

15. The critical angle of a material with air is $\sin^{-1}(2/5)$. Find its refractive index, and say whether light in air meeting it can be totally reflected.

16. A convex lens of focal length 10 cm is in contact with a convex lens of focal length 50 cm. Find the focal length and power of the combination, and say whether it converges or diverges light.

Section C — Word problems — 4 × 4 = 16 marks

17. Two convex lenses of focal lengths 15 cm and 10 cm are 60 cm apart on the same axis. An object is 60 cm in front of the first. Find where the final image forms.

18. A compound microscope has an objective of focal length 1 cm and an eyepiece of focal length 5 cm, with a tube length of 15 cm. Find its approximate magnifying power when the final image is at infinity, and at the near point (25 cm).

19. A convex mirror has focal length 40 cm. A 3 cm tall candle stands 14 cm in front of it. Find the position, nature and height of the image. Where should the candle be to get an image half its size?

20. A telescope has an objective of focal length 200 cm and an eyepiece of 10 cm. (a) Find its magnifying power in normal adjustment. (b) A tower 200 m tall is 2 km away; find the height of its image formed by the objective.

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Answer key

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Q	Answer	Working
1	**(d) 23.1 cm**	1/v + 1/u = 1/f with u = −12 cm, f = −25 cm
2	**(c) −23.2 cm**	1/v − 1/u = 1/f with u = −55 cm, f = −40 cm
3	**(d) 6 cm**	apparent depth = real depth ÷ n
4	**(a) $\sin^{-1}(2/5)$**	sin C = 1/n
5	**(a) R/2**	—
6	**(d) −8 D**	P = 100/f(cm) for each lens; powers add
7	**(a) −20/19**	m = −v/u
8	**(c) A is true, but R is false.**	A is true: the critical angle is 30°, and 45° is larger. R is false.
9	**v = 93.3 cm (behind the mirror); height 23.3 cm; virtual and erect**	1/v = 1/f − 1/u; m = −v/u = 10/3
10	**v = −20.5 cm (on the same side as the object); height 3.41 cm; virtual and erect**	1/v = 1/f + 1/u; m = v/u = 20/41
11	**n = 2/√3; i = 90°**	n = sin((A + δm)/2)/sin(A/2) = sin 90°/sin 60°
12	**22.5 cm; 4.44 D**	1/f = (n − 1)(1/R_1 − 1/R_2) with R_1 = +30 cm, R_2 = −30 cm
13	**30; 155 cm**	m = f_o/f_e; L = f_o + f_e
14	**25 cm; 4 D**	1 + 25/f = 2
15	**n = 2.5; no, total internal reflection needs light travelling in the denser medium**	n = 1/sin C
16	**8.33 cm; 12 D; converging**	1/F = 1/f_1 + 1/f_2
17	**the first image is at 20 cm; the final image is 13.3 cm from the second lens (real, beyond it)**	the first image acts as the object for the second lens at u = −40 cm
18	**75; 90**	m ≈ (L/f_o)(D/f_e); with the image at D, m ≈ (L/f_o)(1 + D/f_e)
19	**v = 10.4 cm, virtual and erect, height 2.22 cm; 40 cm in front (u = −f gives m = ½)**	1/v + 1/u = 1/f; m = −v/u
20	**(a) 20; (b) 20 cm**	image height = f_o × (angle subtended) = f_o × h/distance

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