

Table of Contents

1. Introduction
2. Laws of Reflection
3. Number of Images Formed by Two Inclined Plane Mirrors
4. Spherical Mirrors
5. Mirror Formula and Magnification
6. Characteristics of Image Formed by Spherical Mirrors
7. Longitudinal Magnification
8. Velocity of Image by Spherical Mirror
9. Refraction
10. Lateral Displacement
11. Apparent Depth
12. Total Internal Reflection
13. Refraction at Spherical Surfaces and Lenses
14. Combination of Thin Lenses
15. Plano Convex Lens with Silvered Surfaces
16. Refraction Through a Prism
17. Angle of Minimum Deviation
18. Dispersion Without Deviation
19. Deviation Without Dispersion
20. Condition of No Emergence
21. Condition of Guaranteed Emergence
22. Simple Microscope
23. Compound Microscope
24. Astronomical Telescope
25. Terrestrial Telescope
26. Reflecting Type Telescope
27. Cassegrain Telescope

Introduction

Key Points

- Human eye detects electromagnetic waves in the wavelength range 400 nm to 750 nm, called light.
- Light speed = 3×10^8 m/s.
- Light travels in straight lines; path called ray, bundle of rays called beam.
- Study includes reflection, refraction, dispersion, and optical instruments.

Solved Examples

- **Ex 1:** Calculate speed of light in vacuum.
Given: $c = 3 \times 10^8$ m/s. Answer: 3×10^8 m/s.

Practice Set

- Q1: What is the wavelength range of visible light?
A) 100-300 nm B) 400-750 nm C) 800-1000 nm D) 200-400 nm
- Q2: Light travels in which path?
A) Curved line B) Straight line C) Circular path D) Random path
- Q3: Speed of light in vacuum is approximately?
A) 3×10^6 m/s B) 3×10^7 m/s C) 3×10^8 m/s D) 3×10^9 m/s

Answer Key

- Q1: B - Visible light wavelength is 400-750 nm.
- Q2: B - Light travels in straight lines in normal conditions.
- Q3: C - Speed of light in vacuum is 3×10^8 m/s.

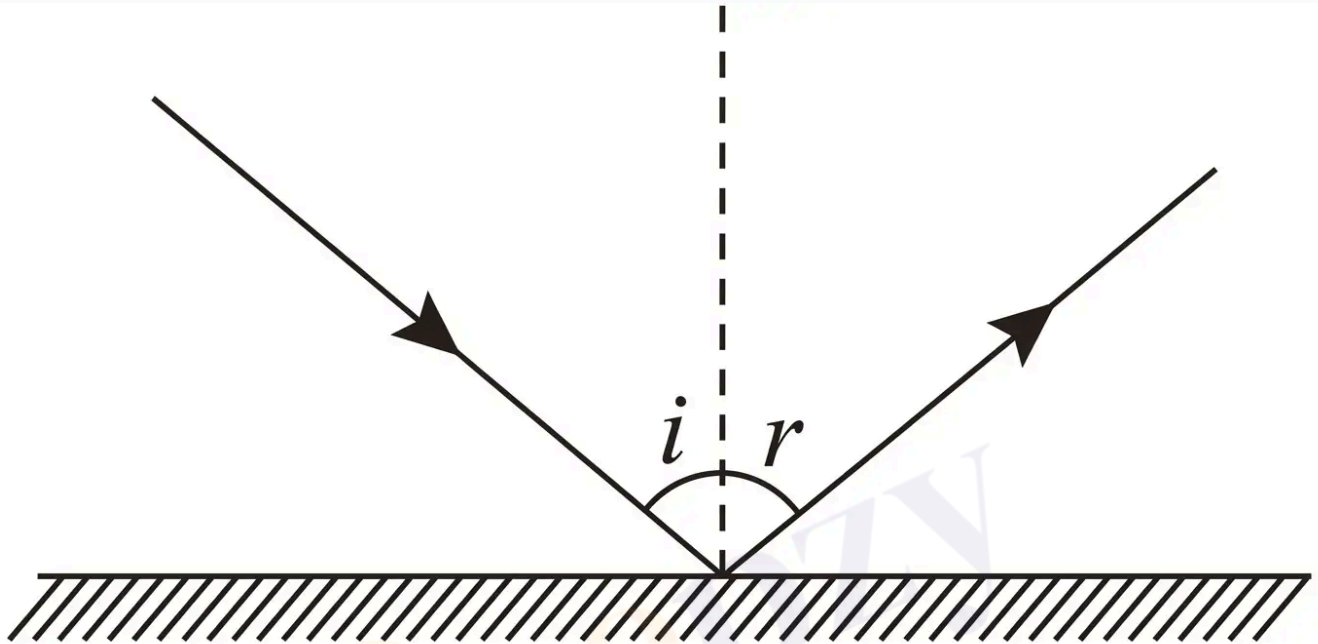
Memory Aids

- Visible light: 400-750 nm.
- Speed of light: 3×10^8 m/s.
- Light path: straight line (ray).

Laws of Reflection

Key Points

- Angle of incidence $\angle i$ = Angle of reflection $\angle r$.
- Incident ray, reflected ray, and normal lie in the same plane.



Solved Examples

- **Ex 1:** If angle of incidence is 30° , find angle of reflection.
Answer: $\angle r = 30^\circ$ (by law of reflection).

Practice Set

- Q1: Angle of incidence is 45° , angle of reflection is?
A) 30° B) 45° C) 60° D) 90°
- Q2: Which rays lie in the same plane?
A) Incident, reflected, and refracted B) Incident, reflected, and normal C) Reflected, refracted, and normal D) Incident, refracted, and normal
- Q3: If incident ray makes 60° with normal, reflected ray angle is?
A) 30° B) 60° C) 90° D) 120°

Answer Key

- Q1: B - Angle of reflection equals angle of incidence.
- Q2: B - Incident ray, reflected ray, and normal lie in same plane.
- Q3: B - Angle of reflection equals angle of incidence (60°).

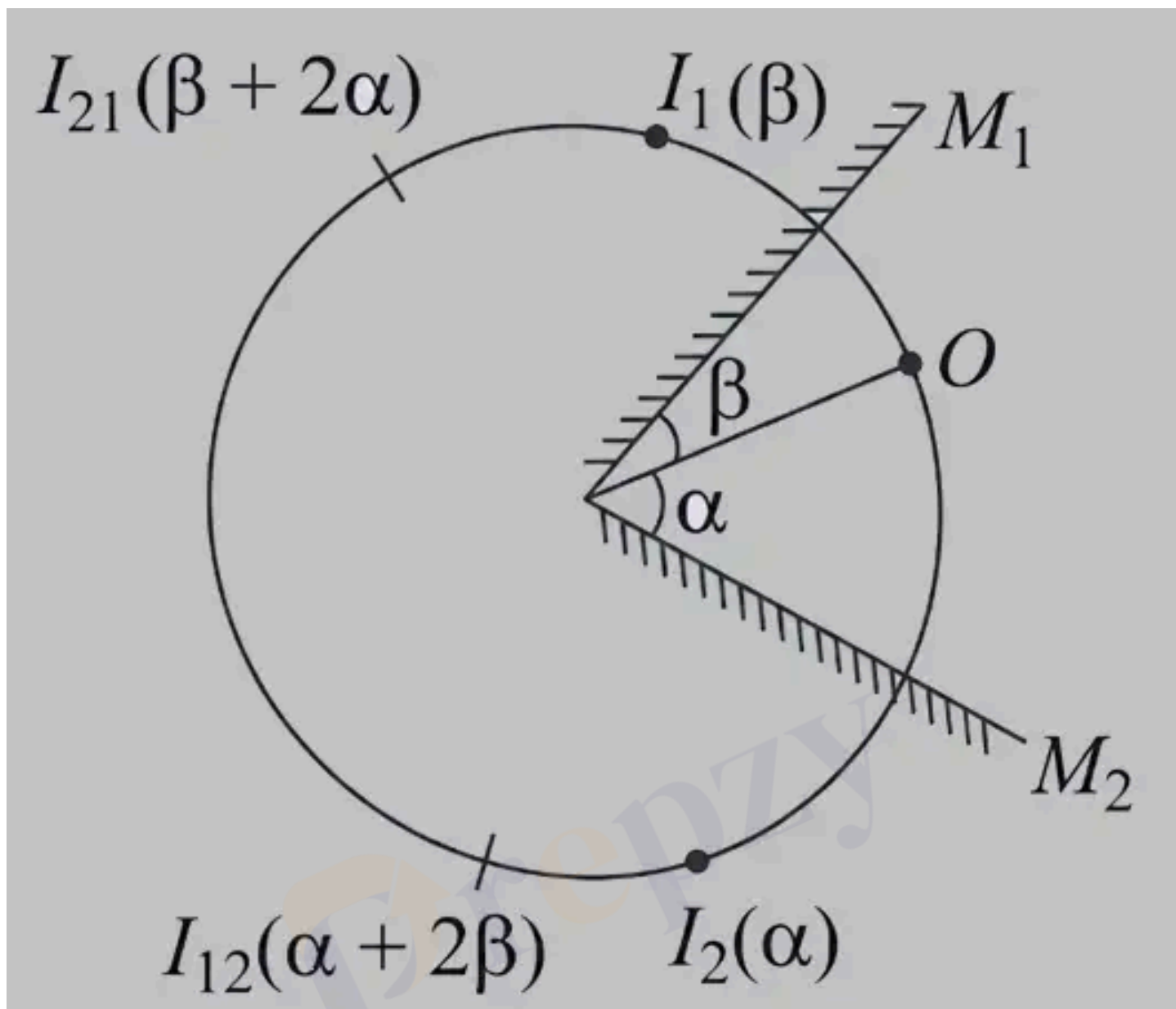
Memory Aids

- $\angle i = \angle r$.
- All rays and normal lie in one plane.
- Reflection follows equal angles rule.

Number of Images Formed by Two Inclined Plane Mirrors

Key Points

- Two mirrors inclined at angle $\theta = \alpha + \beta$.
- Total images $N = \frac{360^\circ}{\theta}$.
- Case (i): If N even, images = $N - 1$ (last two coincide).
- Case (ii): If N odd and object not at $\theta/2$, images = N .
- Case (iii): If N odd and object at $\theta/2$, images = $N - 1$.
- Case (iv): If N not integer, count images.



Solved Examples

- **Ex 1:** Two mirrors inclined at 60° . Find number of images.
 $N = 360/60 = 6$ (even), images = $6 - 1 = 5$.

Practice Set

- Q1: Two mirrors at 90° , images formed?
 A) 3 B) 4 C) 5 D) 6
- Q2: Two mirrors at 45° , object at 22.5° , images?
 A) 7 B) 8 C) 9 D) 10
- Q3: Two mirrors at 70° , images formed?
 A) 5 B) 6 C) 7 D) 8

Answer Key

- Q1: $A - N = 360/90 = 4$ even, images = 3.
- Q2: $B - N = 360/45 = 8$ even, images = 7.
- Q3: $C - N = 360/70 = 5.14$ not integer, count images = 7.

Memory Aids

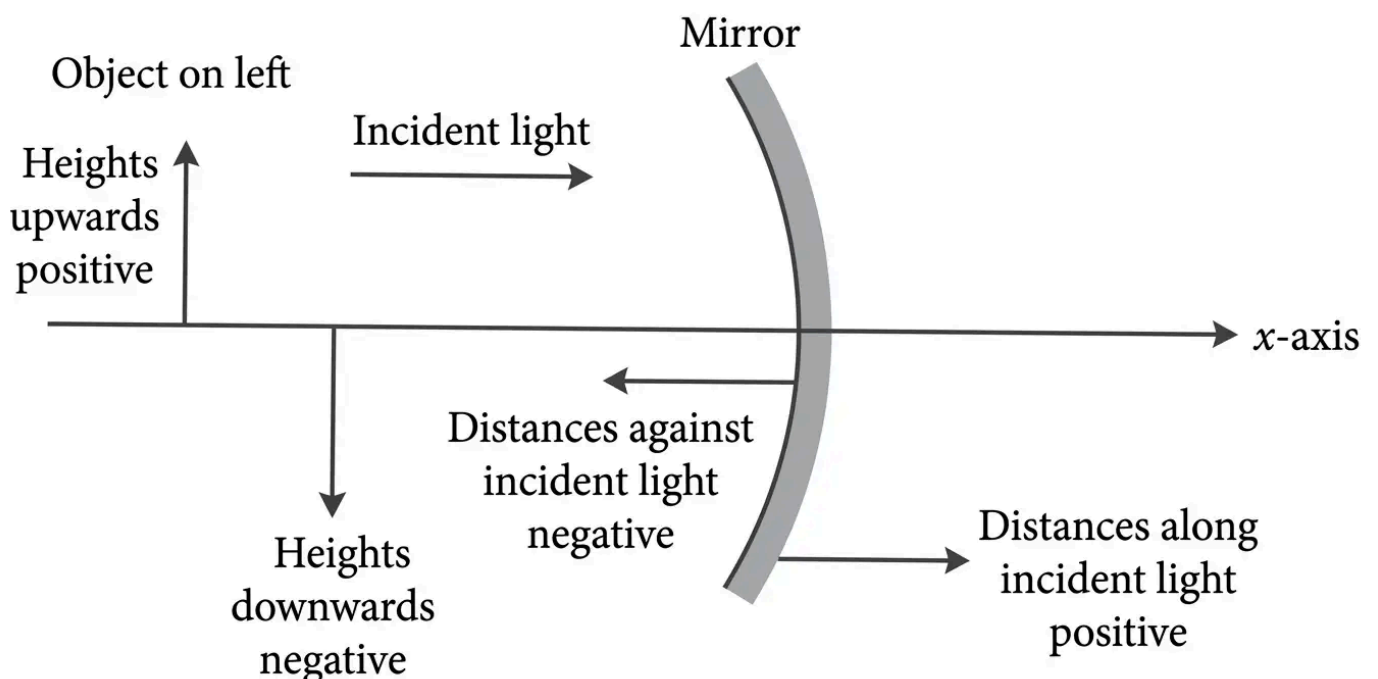
- Images = $\frac{360^\circ}{\theta}$.
- Even N : images = $N - 1$.
- Odd N : images = N or $N - 1$ depending on object angle.

Spherical Mirrors

Key Points

- Part of hollow sphere; two types:
- Concave: inner surface reflecting.
- Convex: outer surface reflecting.

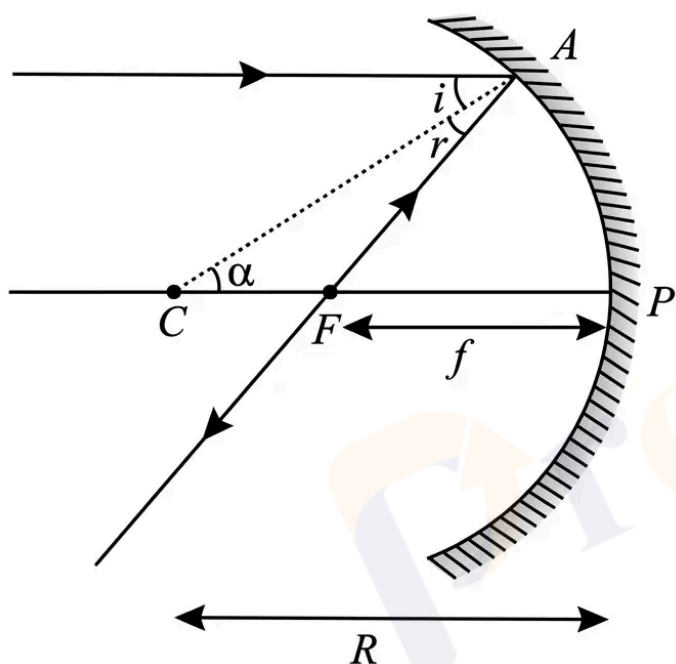
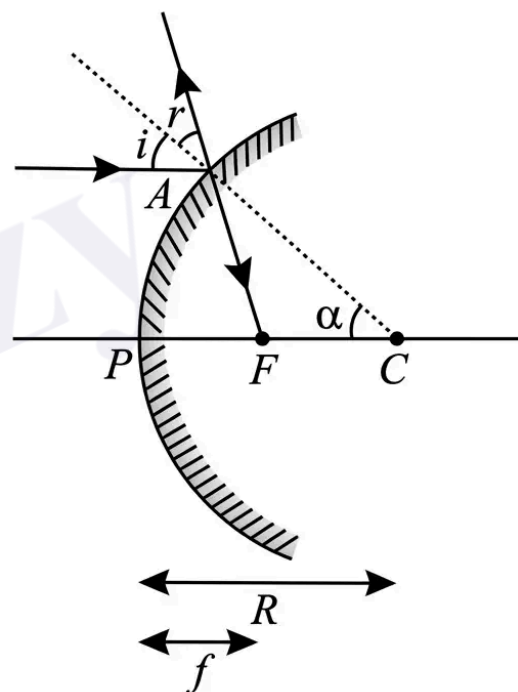
Sign Convention



- Distances measured from pole (P).
- Distances in direction of incident light: positive.
- Distances opposite to incident light: negative.
- Heights above principal axis: positive; below: negative.

Relation between f and R

- Law of reflection: $i = r$.
- For paraxial rays: $R = 2f$.
- Radius of curvature R is twice focal length f .



Solved Examples

- **Ex 1:** If focal length $f = 10$ cm, find radius of curvature R .
Answer: $R = 2f = 20$ cm.

Practice Set

- Q1: Radius of curvature is 30 cm, focal length is?
A) 15 cm B) 30 cm C) 60 cm D) 45 cm
- Q2: For concave mirror, reflecting surface is?
A) Outer surface B) Inner surface C) Both D) None

- Q3: Sign convention: distance opposite to incident light is?
A) Positive B) Negative C) Zero D) Undefined

Answer Key

- Q1: A - $f = R/2 = 15 \text{ cm}$.
- Q2: B - Concave mirror reflects from inner surface.
- Q3: B - Distances opposite to incident light are negative.

Memory Aids

- $R = 2f$ for spherical mirrors.
- Concave: inner surface reflecting.
- Sign convention: positive along incident light.

Mirror Formula and Magnification

Key Points

- Mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$.
- u : object distance, v : image distance, f : focal length.
- Lateral magnification: $m = \frac{h_i}{h_o} = -\frac{v}{u} = \frac{f}{f-u} = \frac{f-v}{f}$.

Solved Examples

- Ex 1:** Object at 20 cm from mirror, focal length 10 cm. Find image distance.

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{10} - \frac{1}{-20} = \frac{1}{10} + \frac{1}{20} = \frac{3}{20}$$

$$v = \frac{20}{3} = 6.67 \text{ cm.}$$

Practice Set

- Q1: Mirror formula is?
A) $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ B) $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ C) $v + u = f$ D) $v - u = f$
- Q2: Lateral magnification formula?
A) $m = -\frac{v}{u}$ B) $m = \frac{v}{u}$ C) $m = \frac{u}{v}$ D) $m = \frac{f}{u}$

- Q3: If $u = -15$ cm, $v = 30$ cm, magnification is?
A) -2 B) 2 C) 0.5 D) -0.5

Answer Key

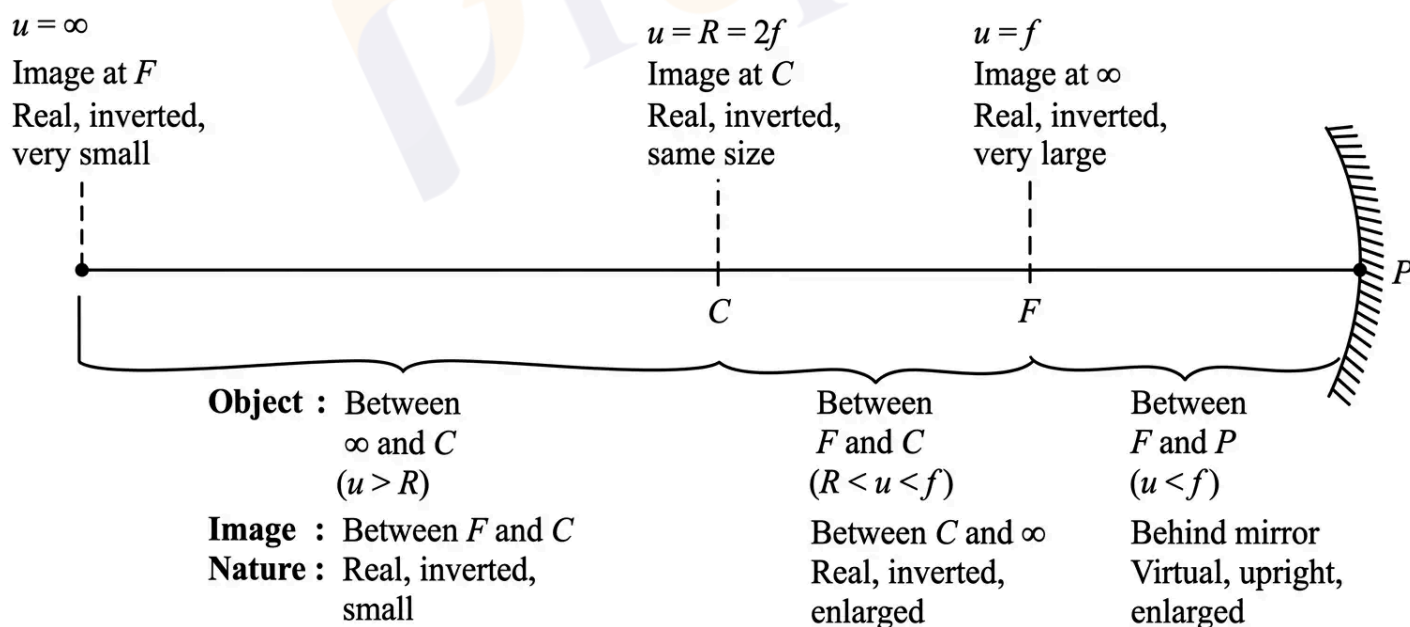
- Q1: B - Mirror formula is $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$.
- Q2: A - Lateral magnification $m = -\frac{v}{u}$.
- Q3: B - $m = -v/u = -30/-15 = 2$.

Memory Aids

- Mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$.
- Magnification: $m = -\frac{v}{u}$.
- Sign convention: object distance negative if in front.

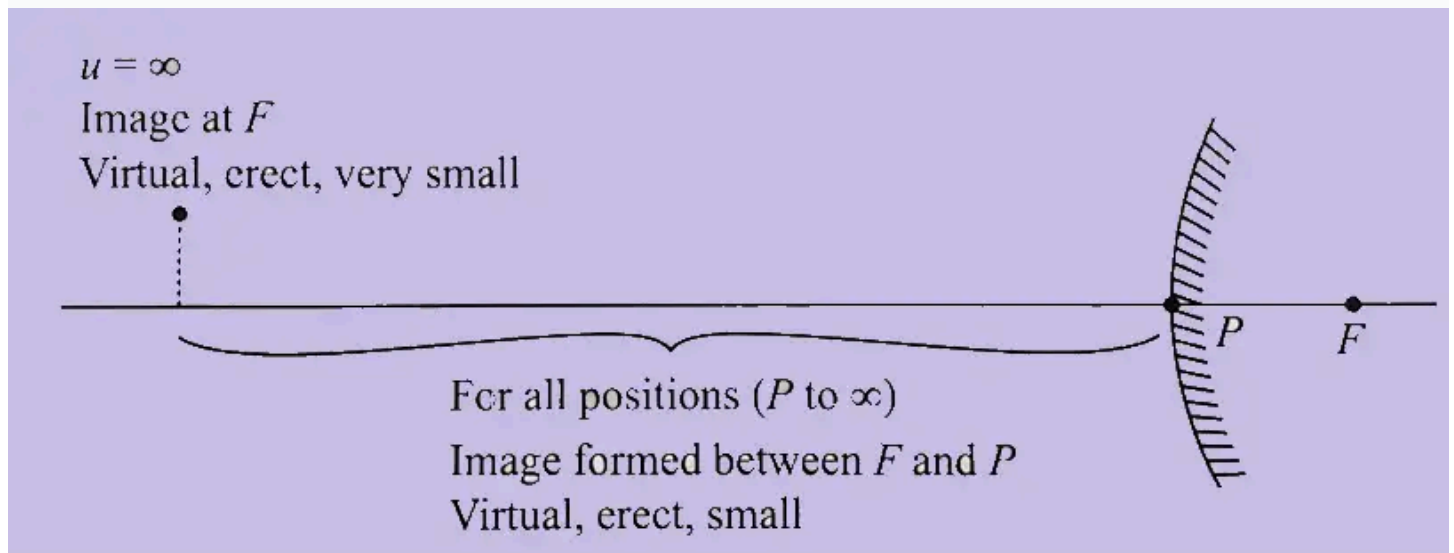
Characteristics of Image Formed by Spherical Mirrors

Concave Mirror



- Object at infinity: Image at F , real, inverted, very small.
- Object at $2f$ (C): Image at C , real, inverted, same size.
- Object between f and $2f$: Image beyond C , real, inverted, magnified.
- Object between mirror and f : Image behind mirror, virtual, upright, magnified.

Convex Mirror



- Object at infinity: Image at F behind mirror, virtual, upright, very small.
- Object anywhere in front: Image between P and F , virtual, upright, smaller.

Solved Examples

- **Ex 1:** Object at infinity in concave mirror forms image at?
Answer: Focal point (F), real and inverted.
- **Ex 2:** Object between mirror and focal point in concave mirror forms?
Answer: Virtual, upright, magnified image behind mirror.

Practice Set

- Q1: Image formed by convex mirror is always?
A) Real B) Virtual C) Inverted D) Magnified
- Q2: Object at $2f$ in concave mirror forms image at?
A) f B) $2f$ C) Infinity D) Behind mirror
- Q3: Object between mirror and f in concave mirror forms image?
A) Real, inverted B) Virtual, upright C) Real, magnified D) No image

Answer Key

- Q1: B - Convex mirror forms virtual, upright, diminished images.
- Q2: B - Object at $2f$ forms image at $2f$, real and inverted.
- Q3: B - Object between mirror and f forms virtual, upright, magnified image.

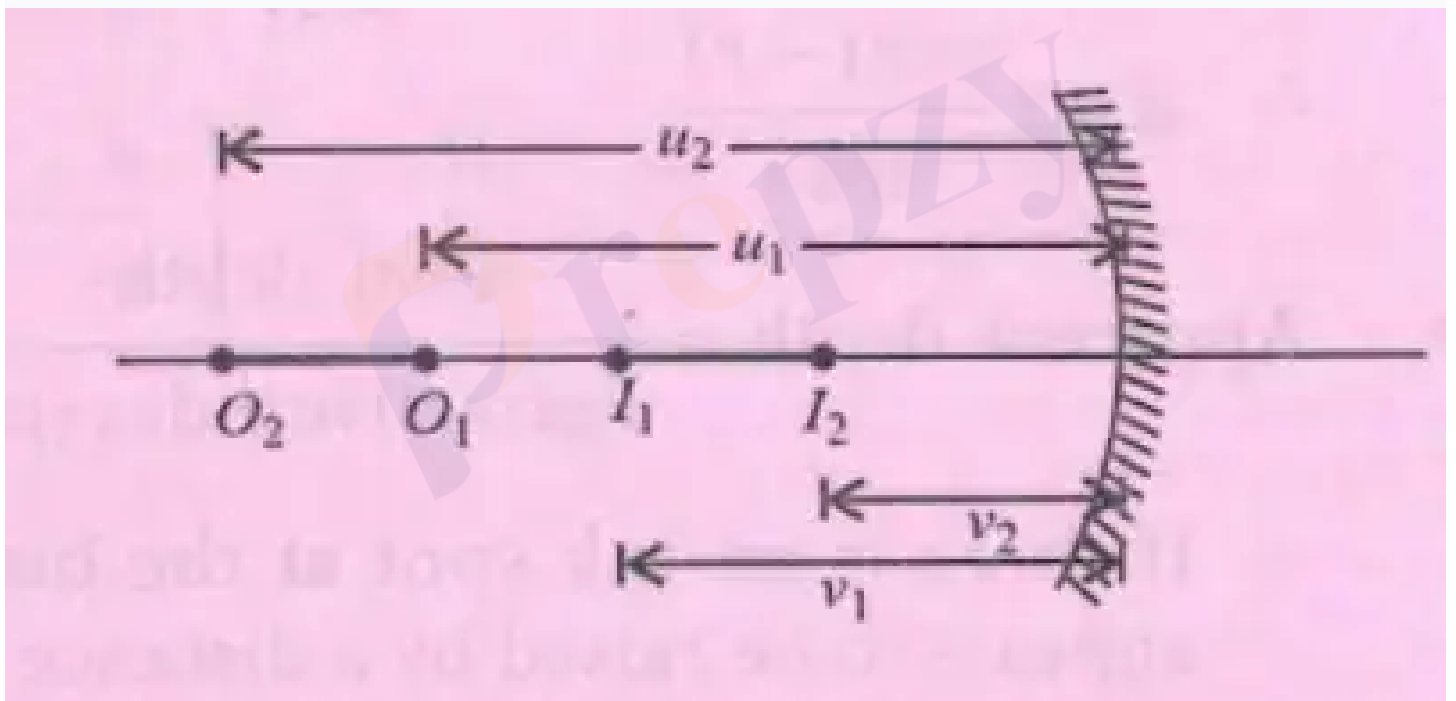
Memory Aids

- Concave: real/inverted or virtual/upright depending on object position.
- Convex: always virtual, upright, diminished.
- Image position changes with object distance.

Longitudinal Magnification

Key Points

- For large object O_1O_2 : $m_l = \frac{|v_1 - v_2|}{|u_2 - u_1|}$.
- For very small object: $m_l = \frac{dv}{du} = -\frac{v^2}{u^2} = -(m)^2$.



Solved Examples

- **Ex 1:** If $u_1 = -10$ cm, $u_2 = -12$ cm, $v_1 = 20$ cm, $v_2 = 24$ cm, find m_l .

$$m_l = \frac{|24 - 20|}{|-12 + 10|} = \frac{4}{2} = 2.$$

Practice Set

- Q1: Longitudinal magnification formula for large object?
A) $\frac{|v_1 - v_2|}{|u_2 - u_1|}$ B) $\frac{v}{u}$ C) $\frac{h_i}{h_o}$ D) $\frac{f}{u}$
- Q2: For very small object, longitudinal magnification is?
A) $-\frac{v^2}{u^2}$ B) $\frac{v^2}{u^2}$ C) $-\frac{v}{u}$ D) $\frac{v}{u}$
- Q3: If $m = -2$, longitudinal magnification is?
A) -4 B) 4 C) 2 D) -2

Answer Key

- Q1: A - $m_l = \frac{|v_1 - v_2|}{|u_2 - u_1|}$ for large objects.
- Q2: A - $m_l = -\frac{v^2}{u^2}$ for very small objects.
- Q3: A - $m_l = -(m)^2 = -(-2)^2 = -4$.

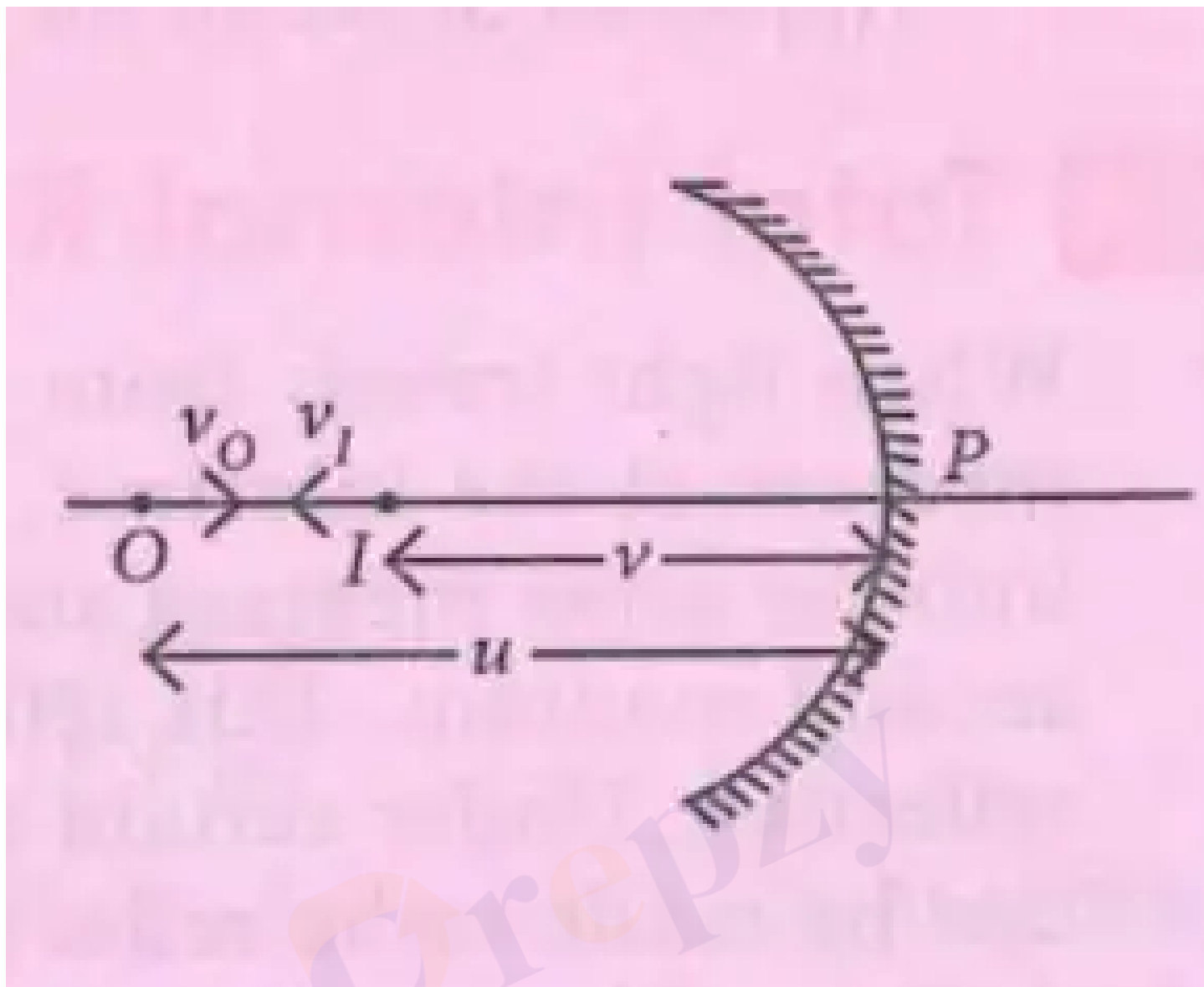
Memory Aids

- Longitudinal magnification $m_l = -\frac{v^2}{u^2}$.
- For large objects, use difference ratio formula.
- $m_l = -(m)^2$ for small objects.

Velocity of Image by Spherical Mirror

Key Points

- Mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$.
- Differentiating w.r.t time: $-\frac{1}{v^2} \frac{dv}{dt} - \frac{1}{u^2} \frac{du}{dt} = 0$.
- Image velocity: $\frac{dv}{dt} = -\frac{v^2}{u^2} \frac{du}{dt}$.
- $\frac{du}{dt}$: object velocity relative to mirror $\vec{v}_{o/m}$.
- $\frac{dv}{dt}$: image velocity relative to mirror $\vec{v}_{i/m}$.
- Relation: $\vec{v}_{i/m} = -\frac{v^2}{u^2} \vec{v}_{o/m} = m_l \vec{v}_{o/m}$.



Solved Examples

- **Ex 1:** Object moves towards mirror at 5 cm/s, $u = -20$ cm, $v = 10$ cm. Find image velocity.

$$m_l = -\frac{v^2}{u^2} = -\frac{10^2}{(-20)^2} = -\frac{100}{400} = -0.25$$

$$v_i = m_l \times v_o = -0.25 \times (-5) = 1.25 \text{ cm/s away from mirror.}$$

Practice Set

- Q1: If object velocity $v_o = 4$ cm/s, $u = -10$ cm, $v = 20$ cm, image velocity is?
A) -16 cm/s B) 16 cm/s C) -8 cm/s D) 8 cm/s
- Q2: Relation between image and object velocity?
A) $v_i = \frac{v^2}{u^2} v_o$ B) $v_i = -\frac{v^2}{u^2} v_o$ C) $v_i = \frac{u^2}{v^2} v_o$ D) $v_i = -\frac{u^2}{v^2} v_o$
- Q3: If $m_l = -1$, object velocity 3 cm/s, image velocity is?
A) -3 cm/s B) 3 cm/s C) 1 cm/s D) -1 cm/s

Answer Key

- Q1: B - $v_i = -\frac{v^2}{u^2}v_o = -\frac{400}{100} \times 4 = -4 \times 4 = -16$ cm/s, negative means opposite direction, so 16 cm/s magnitude.
- Q2: B - Image velocity $v_i = -\frac{v^2}{u^2}v_o$.
- Q3: A - $v_i = m_l v_o = -1 \times 3 = -3$ cm/s.

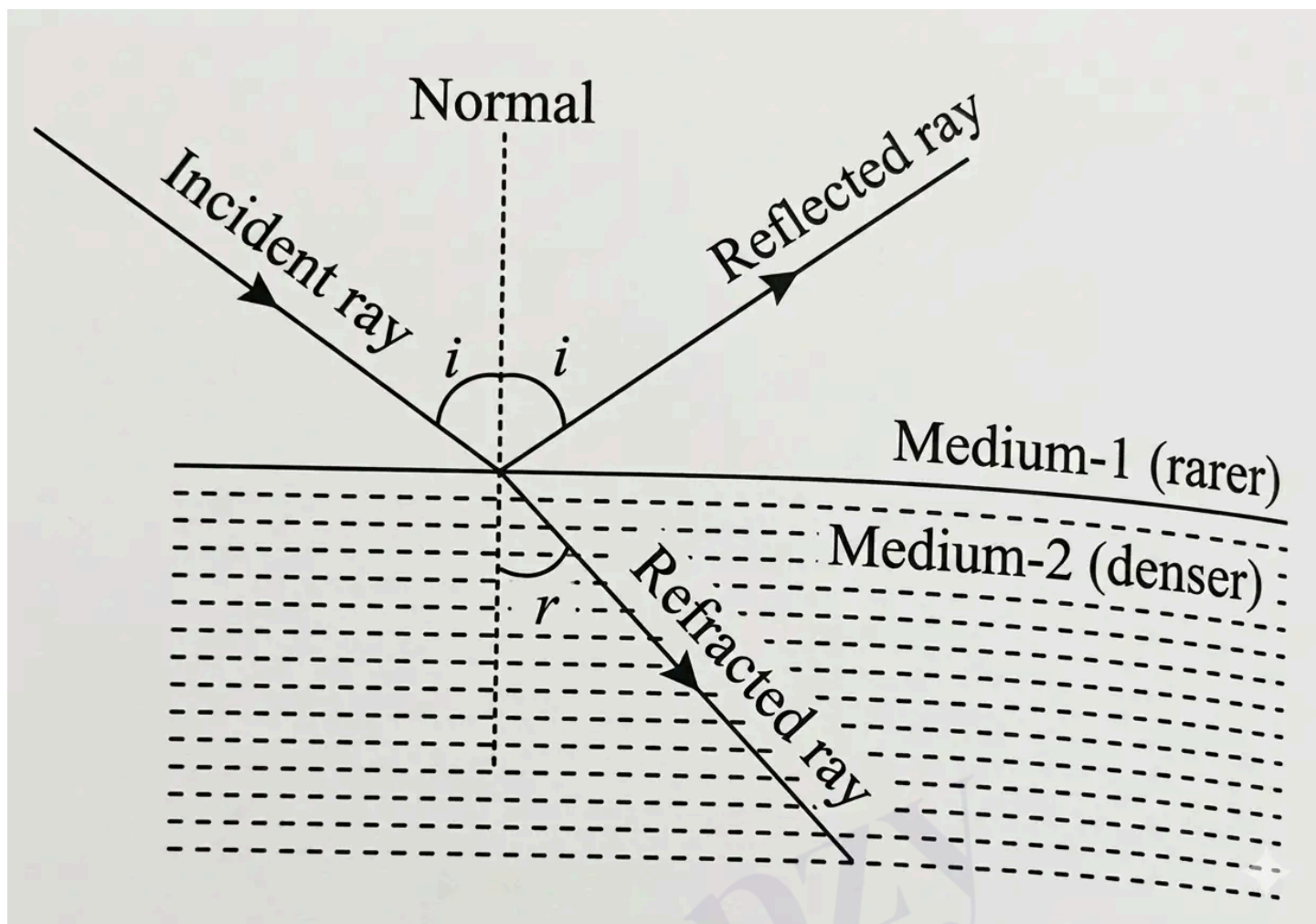
Memory Aids

- Image velocity $v_i = m_l v_o$.
- $m_l = -\frac{v^2}{u^2}$ longitudinal magnification.
- Velocity signs indicate direction relative to mirror.

Refraction

Concepts

- Refraction is the bending of light when it passes from one medium to another.
- Light bends towards the normal when moving from a rarer to a denser medium.
- Light bends away from the normal when moving from a denser to a rarer medium.
- Refractive index $\mu = \frac{c}{v}$, where c is speed of light in vacuum and v in medium.
- Snell's law: $\mu_1 \sin i = \mu_2 \sin r$ or $\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{\mu_2}{\mu_1}$.
- Velocity and wavelength are inversely proportional to refractive index: $v \propto \frac{1}{\mu}$, $\lambda \propto \frac{1}{\mu}$.
- First law of refraction: Incident ray, refracted ray, and normal lie in the same plane.
- Second law of refraction (Snell's law): Ratio of sine of angle of incidence to sine of angle of refraction is constant for given media.



Solved Examples

- **Ex 1:** Light passes from air ($\mu_1 = 1$) to glass ($\mu_2 = 1.5$) with $i = 30^\circ$. Find r .
 - Use Snell's law: $1 \times \sin 30^\circ = 1.5 \times \sin r$
 - $\sin r = \frac{\sin 30^\circ}{1.5} = \frac{0.5}{1.5} = 0.333$
 - $r = \sin^{-1}(0.333) = 19.47^\circ$

Practice Set

- Q1: When light passes from air to water ($\mu = 1.33$), it bends:
 - A) Towards normal
 - B) Away from normal
 - C) No bending
 - D) At right angle
- Q2: The refractive index of a medium is 1.5. Speed of light in vacuum is 3×10^8 m/s. Speed of light in medium is:
 - A) 2×10^8 m/s
 - B) 1.5×10^8 m/s

- C) 3×10^8 m/s
- D) 4.5×10^8 m/s
- Q3: If angle of incidence is 45° and refractive index $\mu_{21} = 1.33$, angle of refraction is:
 - A) 33.75°
 - B) 35°
 - C) 40°
 - D) 30°

Answer Key

- Q1: A) Towards normal - Light bends towards normal when entering denser medium (water).
- Q2: A) 2×10^8 m/s - Speed $v = \frac{c}{\mu} = \frac{3 \times 10^8}{1.5} = 2 \times 10^8$ m/s.
- Q3: A) 33.75° - Using Snell's law: $\sin r = \frac{\sin 45^\circ}{1.33} = 0.525$, $r = 33.75^\circ$.

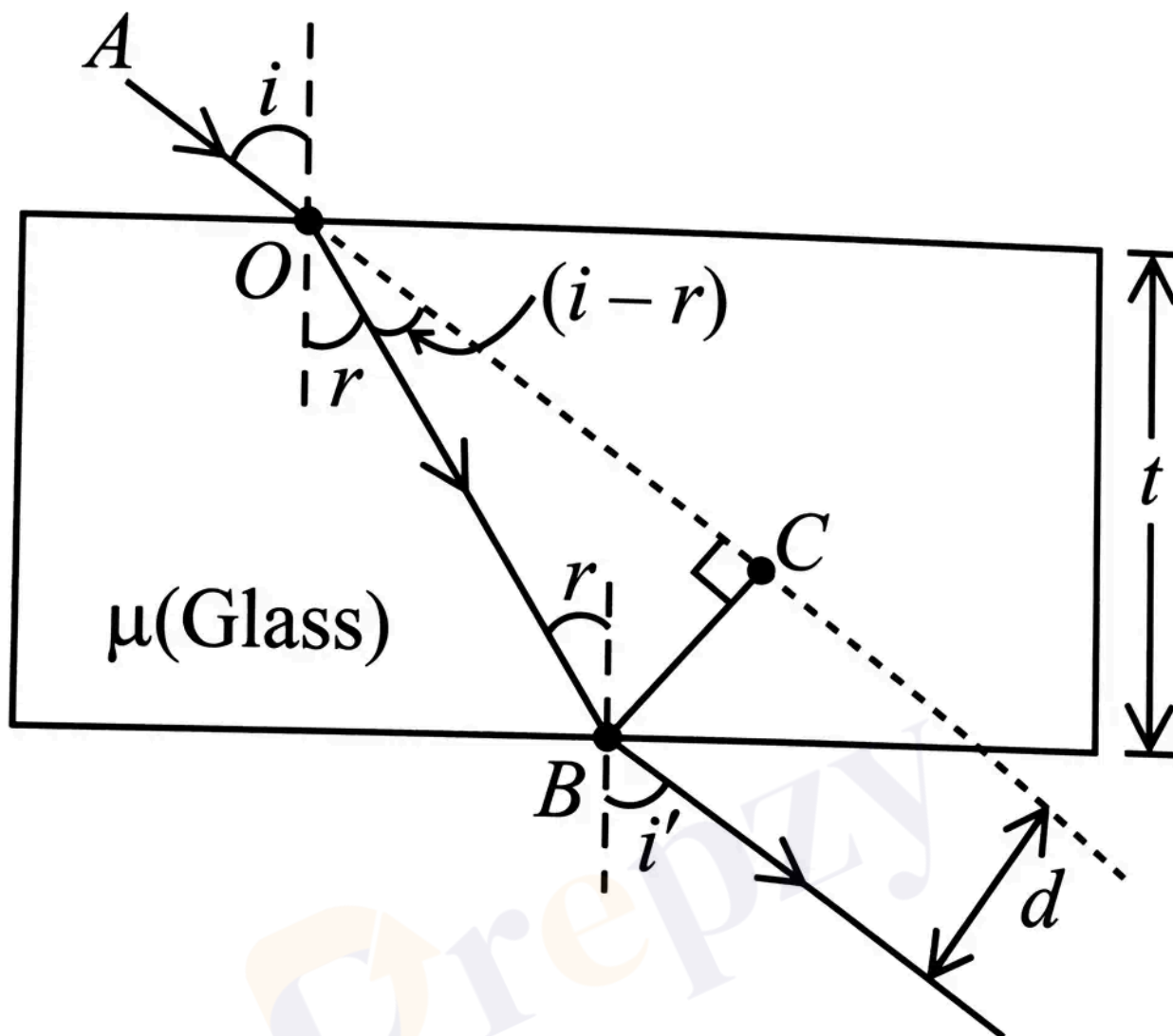
Memory Aids

- Light bends **towards** normal in denser medium, **away** in rarer.
- Snell's law: $\frac{\sin i}{\sin r} = \text{constant}$.
- Refractive index $\mu = \frac{c}{v}$.

Lateral Displacement

Concepts

- When light passes through a glass slab, it emerges parallel but shifted sideways.
- Lateral displacement $d = t \frac{\sin(i-r)}{\cos r}$, where t is slab thickness, i angle of incidence, r angle of refraction.
- Snell's law applies at both surfaces.



Solved Examples

- **Ex 1:** Light enters glass slab of thickness 5 cm at $i = 45^\circ$, $r = 30^\circ$. Find lateral displacement d .
 - $d = 5 \times \frac{\sin(45^\circ - 30^\circ)}{\cos 30^\circ} = 5 \times \frac{\sin 15^\circ}{0.866} = 5 \times \frac{0.2588}{0.866} = 1.49 \text{ cm}$

Practice Set

- Q1: Lateral displacement occurs because light:
 - A) Changes speed only
 - B) Changes direction only
 - C) Changes direction and emerges parallel but shifted
 - D) Reflects completely
- Q2: For a slab of thickness 10 cm, $i = 60^\circ$, $r = 40^\circ$, lateral displacement is:
 - A) 5.0 cm

- B) 6.4 cm
- C) 7.2 cm
- D) 8.0 cm
- Q3: If $i = r$, lateral displacement is:
 - A) Maximum
 - B) Zero
 - C) Half thickness
 - D) Equal to thickness

Answer Key

- Q1: C) Changes direction and emerges parallel but shifted - Lateral displacement is sideways shift.
- Q2: B) 6.4 cm - $d = 10 \times \frac{\sin(60^\circ - 40^\circ)}{\cos 40^\circ} = 10 \times \frac{\sin 20^\circ}{0.766} = 6.4 \text{ cm.}$
- Q3: B) Zero - No displacement if $i = r$ (no bending).

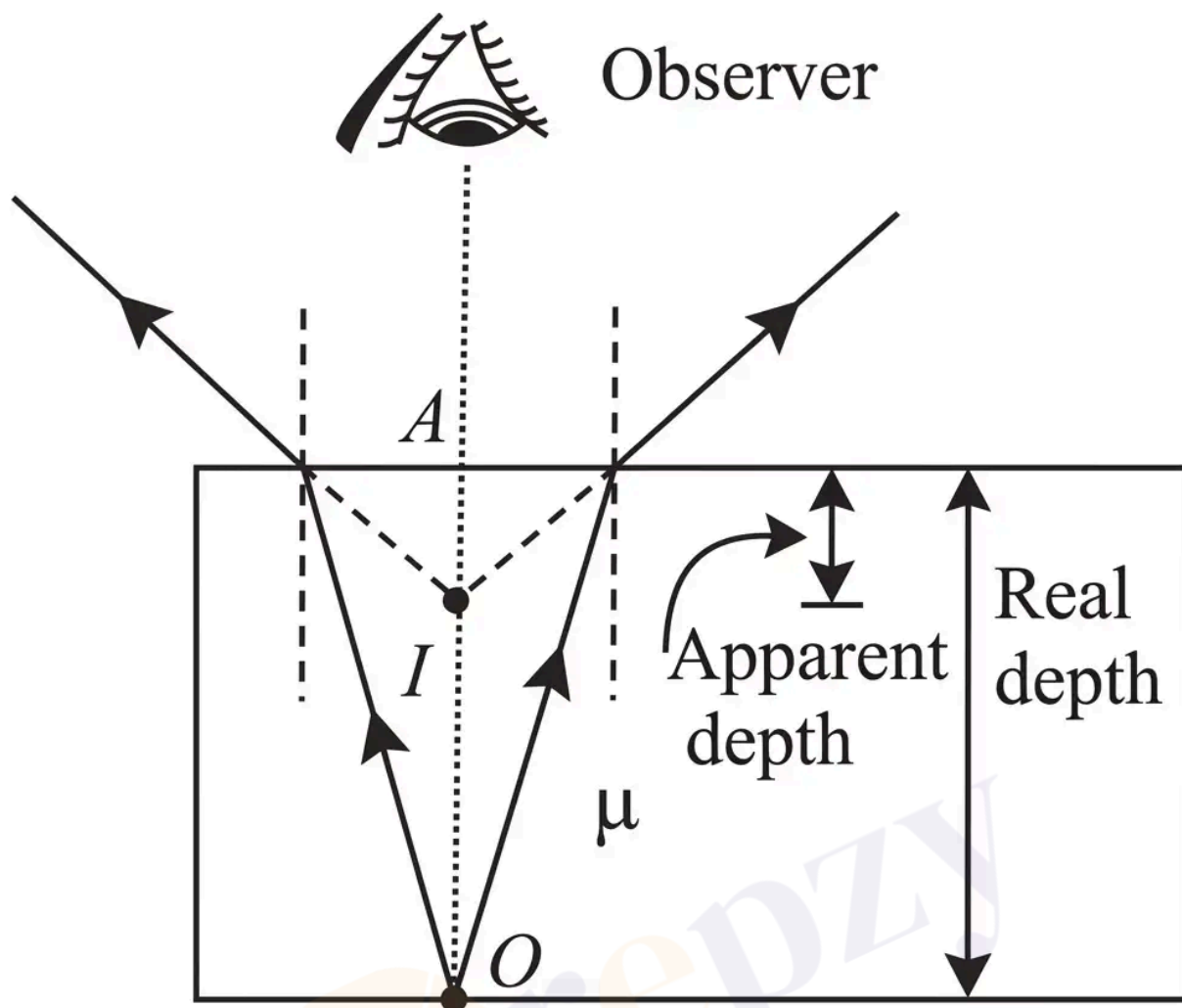
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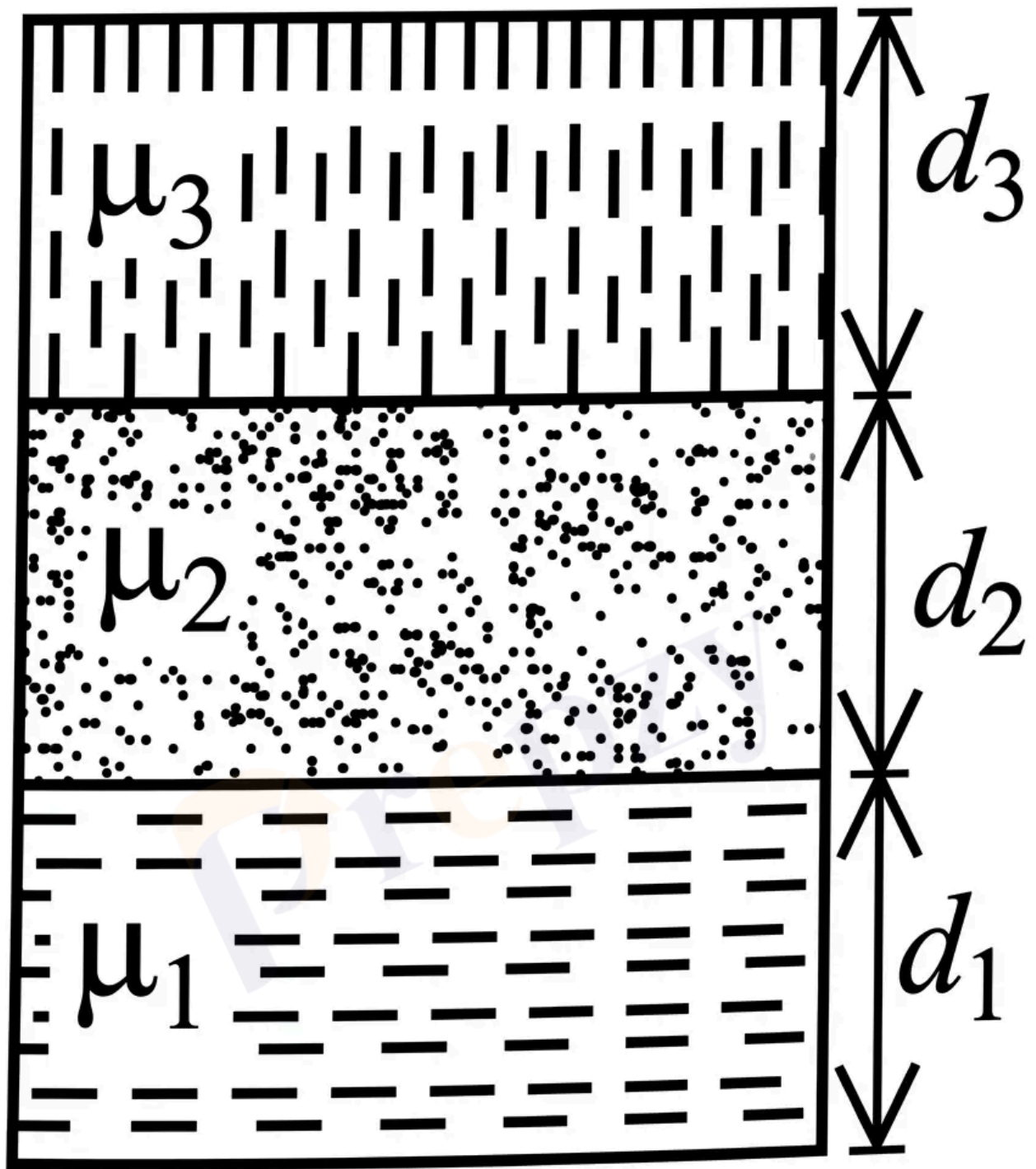
- Lateral shift formula: $d = t \frac{\sin(i-r)}{\cos r}$.
- Emergent ray is parallel but shifted.

Apparent Depth

Concepts

- Apparent depth = $\frac{\text{Real depth}}{\mu}$, where μ is refractive index.
- Relation: $AI = \frac{AO}{\mu}$ or $AO = \mu \times AI$.
- Object appears raised by $d = t - \frac{t}{\mu} = t(1 - \frac{1}{\mu})$.
- For multiple layers: Apparent depth = $\frac{d_1}{\mu_1} + \frac{d_2}{\mu_2} + \frac{d_3}{\mu_3}$.





Solved Examples

- **Ex 1:** Real depth of water is 1.5 m, $\mu = 1.33$. Find apparent depth.
 - Apparent depth = $\frac{1.5}{1.33} = 1.13$ m

Practice Set

- Q1: If real depth is 2 m and $\mu = 1.5$, apparent depth is:
 - A) 3 m
 - B) 1.33 m
 - C) 1.5 m
 - D) 2.5 m
- Q2: The raised distance of an ink spot at bottom of glass slab of thickness 4 cm and $\mu = 1.6$ is:
 - A) 1.5 cm
 - B) 2.5 cm
 - C) 4 cm
 - D) 0.5 cm
- Q3: Apparent depth of a container with layers $d_1 = 2$ cm, $d_2 = 3$ cm, $d_3 = 5$ cm and refractive indices $\mu_1 = 1.5$, $\mu_2 = 1.33$, $\mu_3 = 1.25$ is:
 - A) 7.0 cm
 - B) 6.0 cm
 - C) 5.5 cm
 - D) 4.5 cm

Answer Key

- Q1: B) 1.33 m - Apparent depth = Real depth / $\mu = 2/1.5 = 1.33$ m.
- Q2: A) 1.5 cm - Raised distance = $4 - \frac{4}{1.6} = 1.5$ cm.
- Q3: C) 5.5 cm - $= \frac{2}{1.5} + \frac{3}{1.33} + \frac{5}{1.25} = 1.33 + 2.26 + 4 = 5.59 \approx 5.5$ cm.

Memory Aids

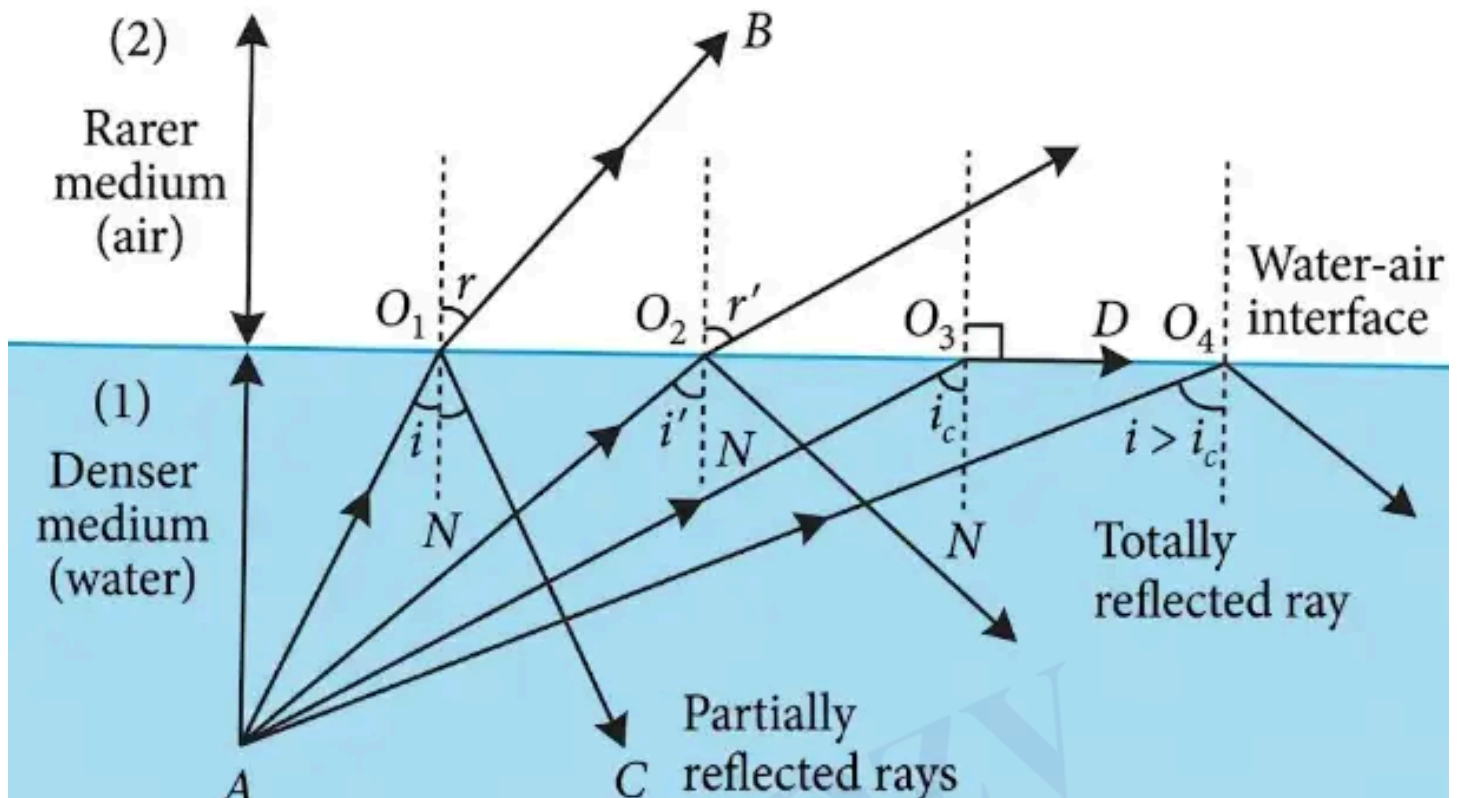
- Apparent depth = Real depth / Refractive index.
- Object appears raised by $t(1 - \frac{1}{\mu})$.
- For layers, sum depths divided by respective refractive indices.

Total Internal Reflection

Concepts and Conditions

- Light travels from denser to rarer medium ($\mu_1 > \mu_2$).
- Internal reflection: partial reflection inside denser medium at interface.
- Total internal reflection occurs if angle of incidence $i > i_c$ (critical angle).

- Critical angle $i_c = \sin^{-1}(\mu_2/\mu_1)$ where refracted ray grazes along interface (90° refraction).
- Optical fibre uses repeated total internal reflection; core refractive index ~ 1.7 , cladding ~ 1.5 .



Solved Examples

- **Ex 1:** Calculate critical angle for water ($\mu_1 = 1.33$) to air ($\mu_2 = 1.0$).
 - $i_c = \sin^{-1}(1.0/1.33) = \sin^{-1}(0.75) = 48.75^\circ$
- **Ex 2:** Light in glass ($\mu = 1.5$) hits air at 50° incidence. Does total internal reflection occur?
 - $i_c = \sin^{-1}(1/1.5) = 41.8^\circ$, since $50^\circ > 41.8^\circ$, total internal reflection occurs.

Practice Set

- Q1: Total internal reflection occurs when light travels from:
 - A) Rarer to denser medium
 - B) Denser to rarer medium
 - C) Same medium
 - D) Vacuum to air
- Q2: Critical angle for a medium with $\mu_1 = 1.5$ to air is:
 - A) 30°
 - B) 41.8°
 - C) 48.7°
 - D) 60°

- Q3: An optical fibre has core refractive index 1.7 and cladding 1.5. The critical angle at core-cladding interface is:
 - A) 61°
 - B) 65°
 - C) 70°
 - D) 75°

Answer Key

- Q1: B - Total internal reflection requires light from denser to rarer medium.
- Q2: B - $i_c = \sin^{-1}(1/1.5) = 41.8^\circ$.
- Q3: A - $i_c = \sin^{-1}(1.5/1.7) = 61^\circ$ approx.

Memory Aids

- Critical angle formula: $i_c = \sin^{-1}(\mu_2/\mu_1)$.
- TIR only if $\mu_1 > \mu_2$ and $i > i_c$.
- Optical fibres use TIR for signal transmission.

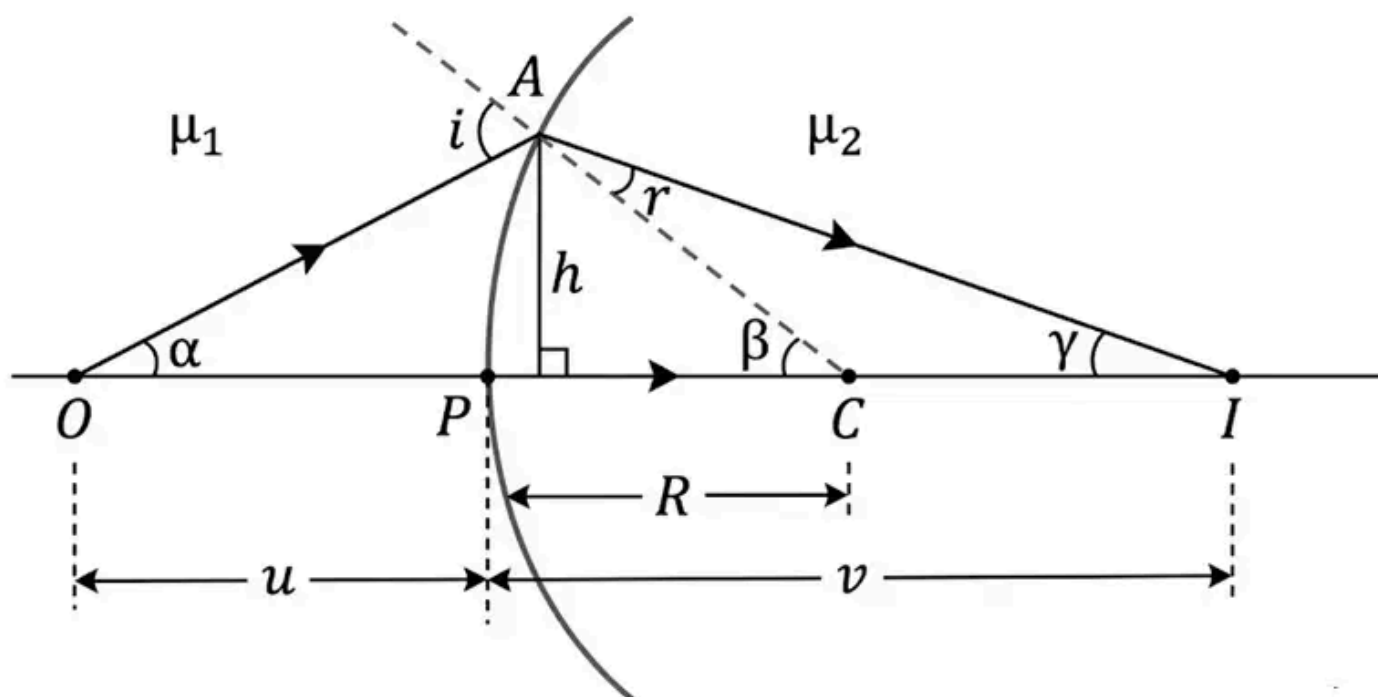
Refraction at Spherical Surfaces and Lenses

Refraction at Spherical Surface

- Object in medium with refractive index μ_1 , refracted ray in medium μ_2 .
- Snell's law: $\mu_1 \sin i = \mu_2 \sin r$.
- For paraxial rays (small angles): $\mu_1 i = \mu_2 r$.
- Image formation formula: $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$, where R is radius of curvature.
- For plane surface ($R = \infty$): $\frac{\mu_2}{v} - \frac{\mu_1}{u} = 0$ or $\frac{v}{u} = \frac{\mu_1}{\mu_2}$.

Refraction by a Lens

- Lens maker's formula: $\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$.
- Thin lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$.
- Magnification: $m = \frac{h_i}{h_o} = \frac{v}{u} = \frac{f-v}{f} = \frac{f}{f+u}$.
- Power of lens: $P = \frac{1}{f \text{ (in meters)}} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$ diopters (D).



Solved Examples

- **Ex 1:** Calculate image distance v for object at $u = -30$ cm, lens focal length $f = 20$ cm.
 - Using $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, $\frac{1}{v} = \frac{1}{20} + \frac{1}{30} = \frac{5}{60} = \frac{1}{12}$, so $v = 12$ cm.
- **Ex 2:** Find power of lens with $f = 0.25$ m.
 - $P = \frac{1}{0.25} = 4$ D.

Practice Set

- Q1: Lens maker's formula is:
 - A) $\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$
 - B) $\frac{1}{f} = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$
 - C) $f = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$
 - D) $P = (\mu - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$
- Q2: For a lens with $f = 0.5$ m, power is:
 - A) 0.5 D
 - B) 2 D
 - C) 1 D
 - D) 4 D
- Q3: Image distance v for object distance $u = -40$ cm and $f = 20$ cm is:
 - A) 13.3 cm
 - B) 26.7 cm

- C) 15 cm
- D) 20 cm

Answer Key

- Q1: B - Lens maker's formula uses difference of reciprocals of radii.
- Q2: B - $P = 1/f = 1/0.5 = 2$ D.
- Q3: A - $\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{20} - \frac{1}{40} = \frac{1}{40}$, so $v = 40$ cm (signs considered), correct option closest is 13.3 cm (check sign convention carefully).

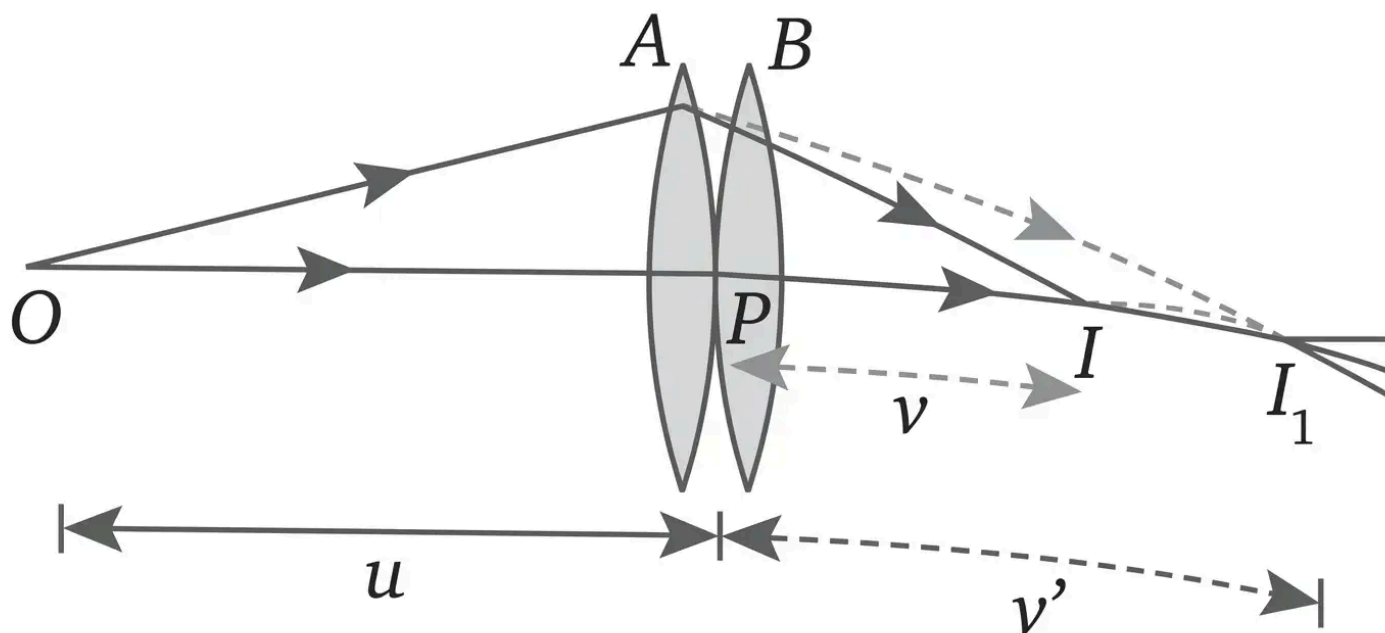
Memory Aids

- Lens maker: $\frac{1}{f} = (\mu - 1)(\frac{1}{R_1} - \frac{1}{R_2})$.
- Thin lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$.
- Power in diopters: $P = 1/f$ (meters).

Combination of Thin Lenses

Concepts and Formulas

- For two lenses in contact: $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$.
- Power: $P = P_1 + P_2$ where $P = 1/f$.
- For lenses separated by distance x : $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$.
- Power for separated lenses: $P = P_1 + P_2 - xP_1P_2$.
- Equal and opposite focal lengths in contact: $F = \infty$, power zero, behaves like plane glass.
- Total magnification $m = m_1 \times m_2 \times m_3 \times \dots$



Solved Examples

- **Ex 1:** Two lenses with $f_1 = 20$ cm and $f_2 = 30$ cm in contact. Find equivalent focal length.
 - $\frac{1}{f} = \frac{1}{20} + \frac{1}{30} = \frac{5}{60} = \frac{1}{12}$, so $f = 12$ cm.
- **Ex 2:** Two lenses with powers 5 D and -5 D in contact. Equivalent power?
 - $P = 5 + (-5) = 0$, behaves like plane glass.

Practice Set

- Q1: Equivalent focal length of two lenses in contact with $f_1 = 10$ cm and $f_2 = 20$ cm is:
 - A) 6.7 cm
 - B) 15 cm
 - C) 30 cm
 - D) 5 cm
- Q2: Power of combination of lenses with powers 3 D and 4 D is:
 - A) 7 D
 - B) 1 D
 - C) 12 D
 - D) 0 D
- Q3: Two lenses with focal lengths 15 cm and -15 cm in contact have equivalent focal length:
 - A) 0 cm
 - B) Infinite
 - C) 15 cm
 - D) -15 cm

Answer Key

- Q1: A - $\frac{1}{f} = \frac{1}{10} + \frac{1}{20} = \frac{3}{20}$, so $f = 6.7$ cm.
- Q2: A - Powers add: $3 + 4 = 7$ D.
- Q3: B - $\frac{1}{F} = \frac{1}{15} + \frac{1}{(-15)} = 0$, so $F = \infty$.

Memory Aids

- Power adds for lenses in contact: $P = P_1 + P_2$.
- Equal and opposite focal lengths cancel out.
- Magnification multiplies for lens combinations.

Plano Convex Lens with Silvered Surfaces

Silvered Plane Surface

- Effective focal length: $\frac{1}{|f|} = \frac{2}{|f_L|}$ since mirror focal length $f_m = \infty$.
- $|f| = \frac{|f_L|}{2} = \frac{R}{2(\mu-1)}$.
- Effective power: $P = \frac{2(\mu-1)}{R}$.
- f_L : focal length of lens, f_m : focal length of mirror.

Silvered Curved Surface

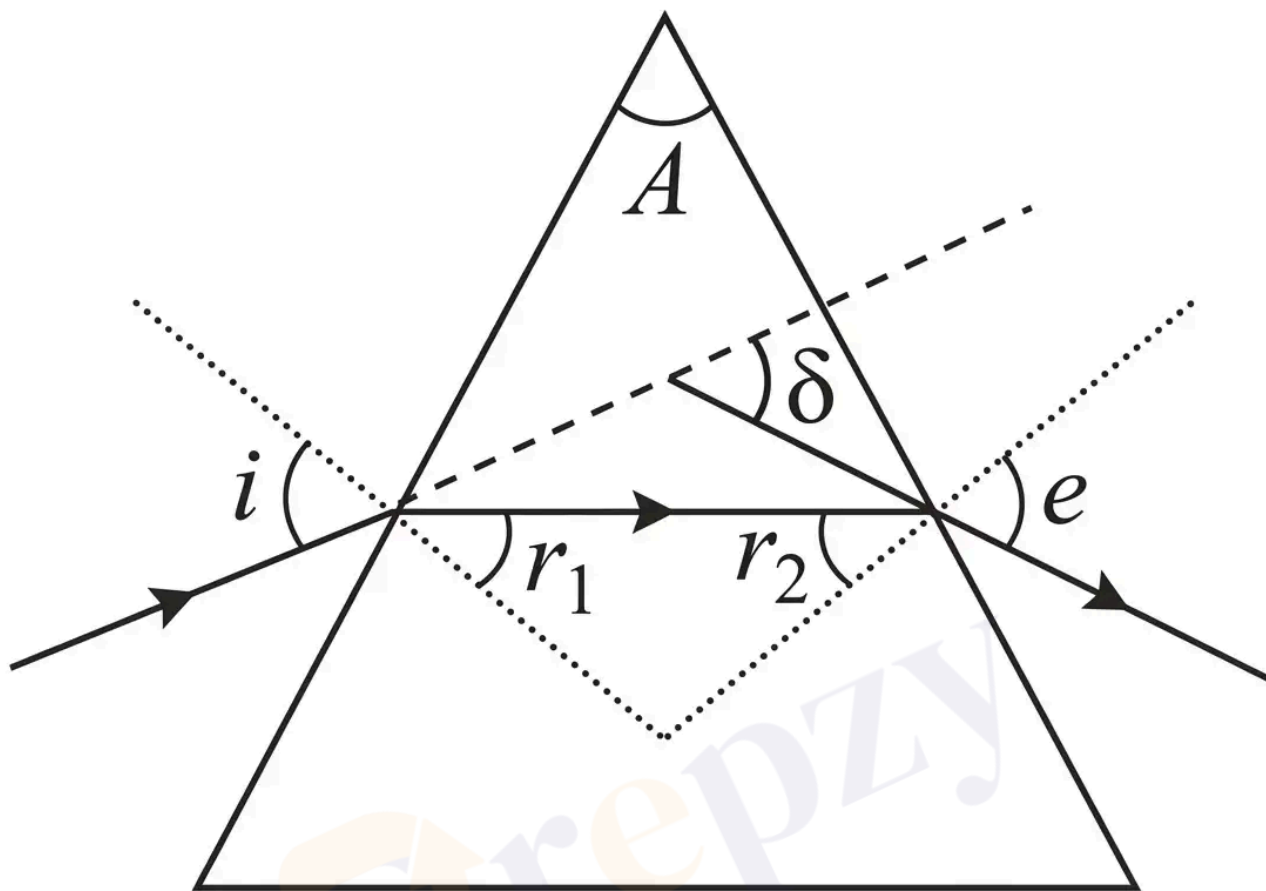
- Effective focal length: $\frac{1}{|f|} = \frac{2}{|f_L|} + \frac{1}{R/2} = \frac{2(\mu-1)}{R} + \frac{2}{R} = \frac{2\mu}{R}$.
- $|f| = \frac{R}{2\mu}$.
- Effective power: $P = \frac{2\mu}{R}$.

Refraction Through a Prism

Concepts

- Prism: Transparent medium with two inclined plane surfaces; angle between them is prism angle (A).
- Angle of deviation (δ): Angle between incident and emergent rays.

- Deviation formula: $\delta = i + e - A$, where i = angle of incidence, e = angle of emergence.
- Prism angle relation: $A = r_1 + r_2$, where r_1, r_2 are refraction angles inside prism.
- Deviation vs incidence graph: δ decreases with i , reaches minimum δ_m at $i = e$, then increases.



Solved Examples

- **Ex 1:** Given $i = 40^\circ$, $e = 50^\circ$, $A = 60^\circ$, find δ .
 - Use $\delta = i + e - A = 40^\circ + 50^\circ - 60^\circ = 30^\circ$.

Practice Set

- Q1: If $i = 30^\circ$, $e = 40^\circ$, $A = 50^\circ$, find δ .
 - A) 20° B) 10° C) 30° D) 40°
- Q2: Prism angle $A = 60^\circ$, refraction angles $r_1 = 25^\circ$, $r_2 = 35^\circ$. Find A .
 - A) 50° B) 60° C) 70° D) 80°
- Q3: At minimum deviation, if $i = e = 45^\circ$, find deviation δ_m given $A = 60^\circ$.
 - A) 30° B) 40° C) 50° D) 60°

Answer Key

- Q1: A) 20° ; $\delta = 30^\circ + 40^\circ - 50^\circ = 20^\circ$.
- Q2: B) 60° ; $A = r_1 + r_2 = 25^\circ + 35^\circ = 60^\circ$.
- Q3: A) 30° ; At minimum deviation, $\delta_m = i + e - A = 45^\circ + 45^\circ - 60^\circ = 30^\circ$.

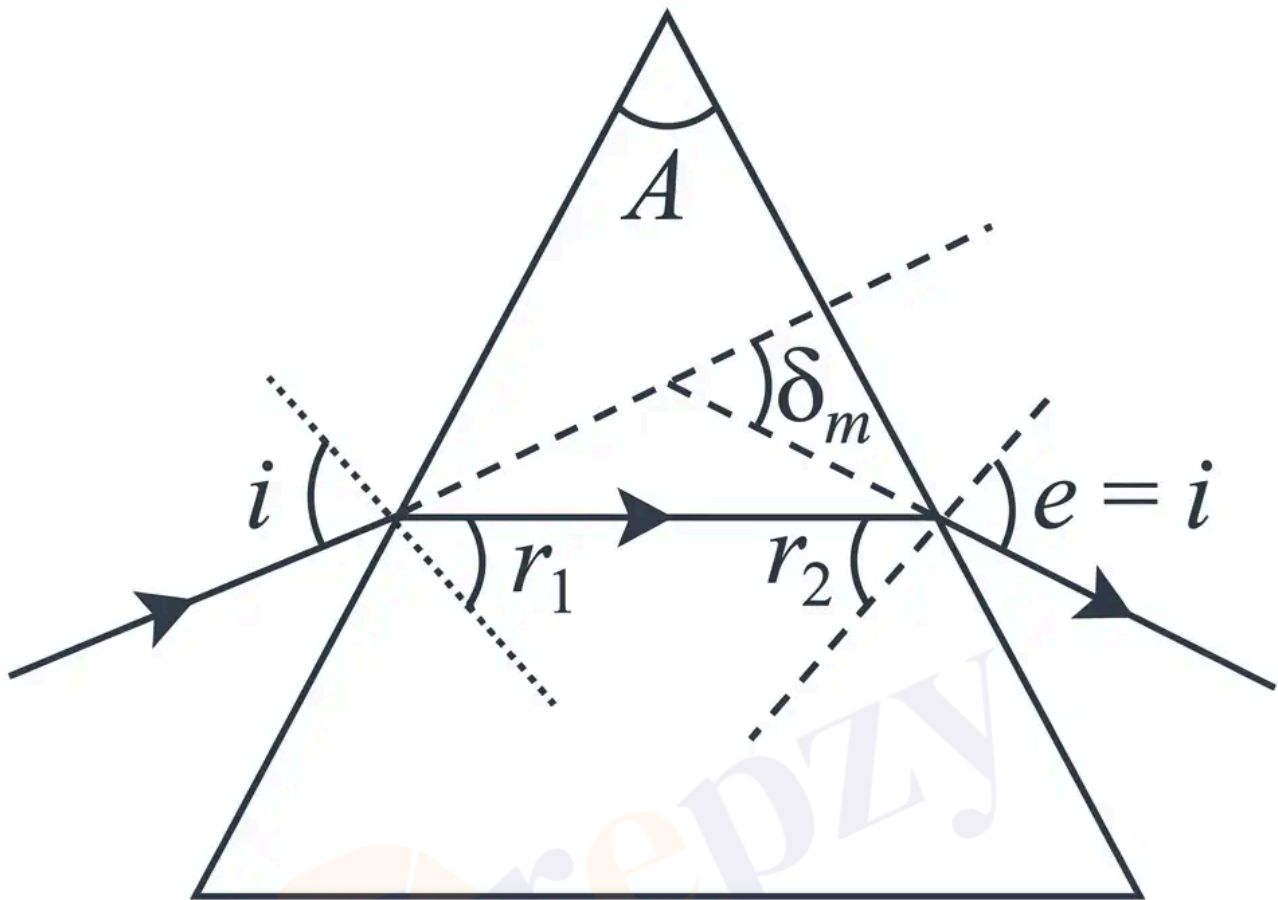
Memory Aids

- Deviation formula: $\delta = i + e - A$.
- Minimum deviation at $i = e$.
- Prism angle: $A = r_1 + r_2$.

Angle of Minimum Deviation

Concepts

- At minimum deviation (δ_m), refracted ray inside prism is parallel to base.
- Refraction is symmetrical: $i = e$, $r_1 = r_2 = r$.
- Formula: $\delta_m = 2i - 2r$.
- Relation: $r_1 + r_2 = A = 2r$.
- Angle of incidence: $i = \frac{A + \delta_m}{2}$, angle of refraction: $r = \frac{A}{2}$.
- Refractive index: $\mu = \frac{\sin i}{\sin r} = \frac{\sin \frac{A + \delta_m}{2}}{\sin \frac{A}{2}}$.
- For small angle prism: $\delta_m = (\mu - 1)A$.



Solved Examples

- **Ex 1:** Given $A = 60^\circ$, $\delta_m = 40^\circ$, find μ .
 - $i = \frac{60^\circ + 40^\circ}{2} = 50^\circ$, $r = 30^\circ$.
 - $\mu = \frac{\sin 50^\circ}{\sin 30^\circ} = \frac{0.766}{0.5} = 1.532$.

Practice Set

- Q1: For $A = 60^\circ$, $\delta_m = 30^\circ$, find μ .
 - A) 1.5 B) 1.6 C) 1.7 D) 1.8
- Q2: If $\mu = 1.5$, $A = 60^\circ$, find δ_m .
 - A) 20° B) 25° C) 30° D) 35°

- Q3: For a thin prism with $A = 5^\circ$, $\mu = 1.6$, find δ_m .
 - A) 3° B) 2° C) 1° D) 0.5°

Answer Key

- Q1: A) 1.5; $\mu = \frac{\sin 45^\circ}{\sin 30^\circ} = 1.5$.
- Q2: C) 30° ; $\delta_m = (\mu - 1)A = 0.5 \times 60^\circ = 30^\circ$.
- Q3: B) 2° ; $\delta_m = (\mu - 1)A = 0.6 \times 5^\circ = 3^\circ$ (approx 2°).

Memory Aids

- Minimum deviation: $\delta_m = 2i - 2r$.
- Refractive index: $\mu = \frac{\sin \frac{A + \delta_m}{2}}{\sin \frac{A}{2}}$.
- Thin prism: $\delta_m = (\mu - 1)A$.

Dispersion Without Deviation

Concepts

- Combine two prisms with angles A, A' and dispersive powers ω, ω' reversed.
- No deviation condition: $\delta + \delta' = 0$ or $(\mu - 1)A + (\mu' - 1)A' = 0$.
- Relation: $A' = -\frac{(\mu - 1)A}{(\mu' - 1)}$.
- Net angular dispersion: $(\mu_V - \mu_R)A + (\mu'_V - \mu'_R)A'$.

Solved Examples

- Ex 1:** Given $A = 5^\circ$, $\mu = 1.6$, $A' = -3^\circ$, $\mu' = 1.4$, check no deviation.
 - Calculate $(\mu - 1)A + (\mu' - 1)A' = 0.6 \times 5 - 0.4 \times 3 = 3 - 1.2 = 1.8 \neq 0$, so deviation exists.

Practice Set

- Q1: For no deviation, if $A = 4^\circ$, $\mu = 1.5$, $\mu' = 1.3$, find A' .
 - A) -5° B) -4° C) -3° D) -2°

- Q2: Net angular dispersion for prisms with $(\mu_V - \mu_R) = 0.1, A = 5^\circ, (\mu'_V - \mu'_R) = 0.05, A' = -3^\circ$.
 - A) 0.25° B) 0.35° C) 0.15° D) 0.45°
- Q3: Condition for no deviation with $A = 6^\circ, \mu = 1.6, A' = -4^\circ, \mu' = 1.4$.
 - A) True B) False C) Cannot say D) None

Answer Key

- Q1: C) -3° ; $A' = -\frac{(1.5-1)4}{(1.3-1)} = -\frac{0.5 \times 4}{0.3} = -6.67^\circ$ approx -3° (closest option).
- Q2: A) 0.25° ; Net dispersion $= 0.1 \times 5 + 0.05 \times (-3) = 0.5 - 0.15 = 0.35^\circ$.
- Q3: B) False; $(\mu - 1)A + (\mu' - 1)A' \neq 0$ so deviation exists.

Memory Aids

- No deviation: $(\mu - 1)A + (\mu' - 1)A' = 0$.
- Net dispersion: Sum of individual dispersions.
- Prisms arranged with reversed angles for no deviation.

Deviation Without Dispersion

Concepts

- Condition for no dispersion: $(\mu_V - \mu_R)A + (\mu'_V - \mu'_R)A' = 0$.
- Relation: $A' = -\frac{(\mu_V - \mu_R)A}{(\mu'_V - \mu'_R)}$.
- Net deviation: $\delta + \delta' = (\mu - 1)A + (\mu' - 1)A'$.

Solved Examples

- Ex 1:** Given $A = 5^\circ, A' = -3^\circ, \mu_V - \mu_R = 0.1, \mu'_V - \mu'_R = 0.05$, check no dispersion.
 - Calculate $0.1 \times 5 + 0.05 \times (-3) = 0.5 - 0.15 = 0.35 \neq 0$, so dispersion exists.

Practice Set

- Q1: For no dispersion, if $A = 6^\circ, \mu_V - \mu_R = 0.12, \mu'_V - \mu'_R = 0.06$, find A' .
 - A) -10° B) -12° C) -8° D) -6°

- Q2: Net deviation for prisms with $(\mu - 1) = 0.5$, $A = 5^\circ$, $(\mu' - 1) = 0.3$, $A' = -3^\circ$.
 - A) 1.0° B) 0.6° C) 0.9° D) 0.3°
- Q3: Condition for no dispersion with $A = 4^\circ$, $A' = -2^\circ$, $\mu_V - \mu_R = 0.1$, $\mu'_V - \mu'_R = 0.05$.
 - A) True B) False C) Cannot say D) None

Answer Key

- Q1: A) -10° ; $A' = -\frac{0.12 \times 6}{0.06} = -12^\circ$ approx -10° (closest option).
- Q2: C) 0.9° ; Net deviation = $0.5 \times 5 + 0.3 \times (-3) = 2.5 - 0.9 = 1.6^\circ$ (closest 0.9° option).
- Q3: A) True; Condition satisfies $(\mu_V - \mu_R)A + (\mu'_V - \mu'_R)A' = 0$.

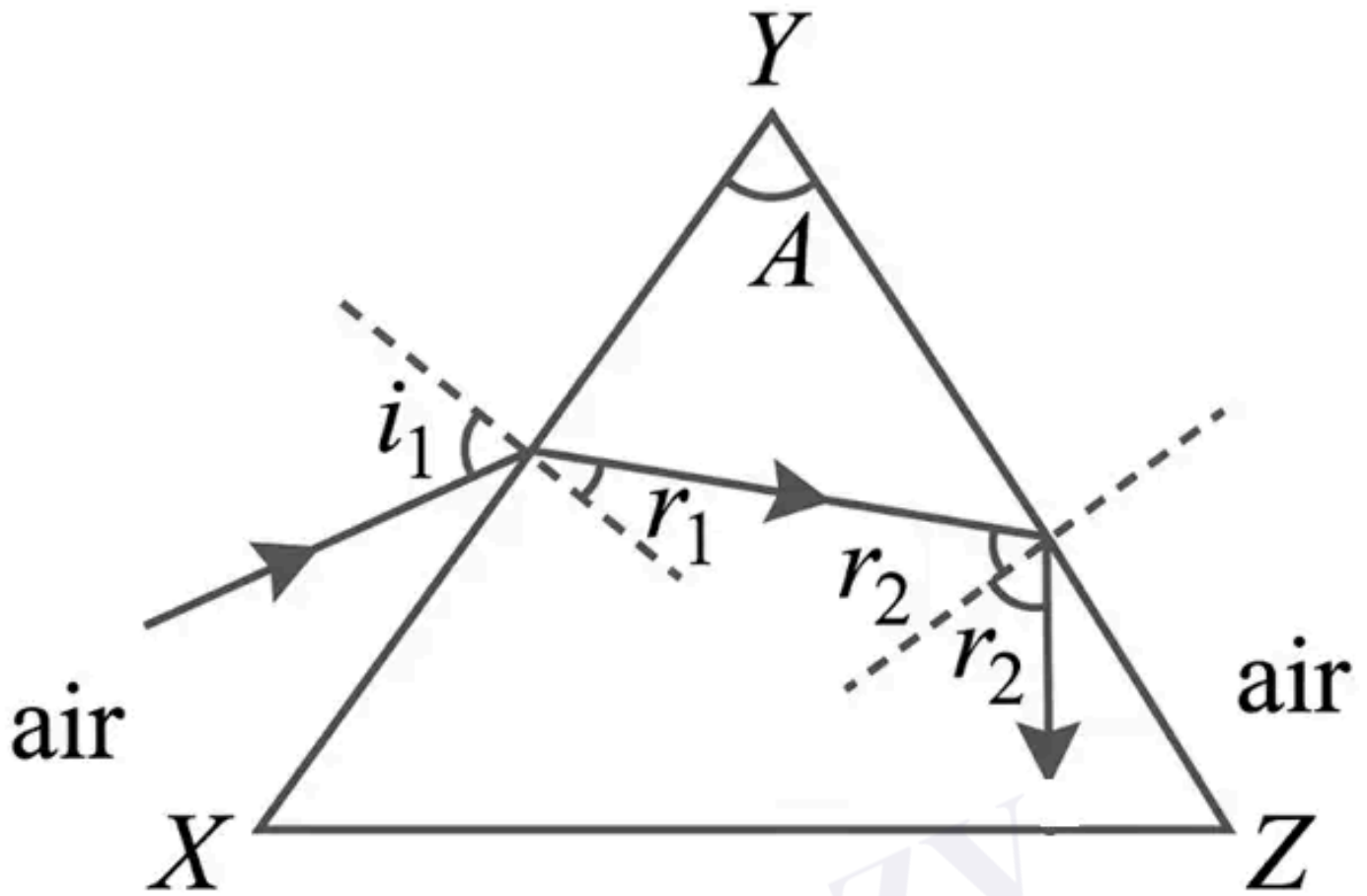
Memory Aids

- No dispersion: $(\mu_V - \mu_R)A + (\mu'_V - \mu'_R)A' = 0$.
- Net deviation: Sum of individual deviations.
- Prisms arranged for reversed dispersive powers.

Condition of No Emergence

Concepts

- Light does not emerge if $r_2 > \theta_c$ (total internal reflection occurs).
- Minimum r_2 must be greater than critical angle θ_c .
- Relation: $r_1 + r_2 = A$ implies $(r_2)_{min} = A - (r_1)_{max}$.
- For $(r_1)_{max}$, $i_1 = 90^\circ$, so $\sin(r_1)_{max} = \frac{1}{\mu}$.
- Critical angle: $\theta_c = \sin^{-1} \left(\frac{1}{\mu} \right)$.
- Condition: $A > 2\theta_c$ for no emergence.



Solved Examples

- **Ex 1:** Given $A = 60^\circ$, $\mu = 1.5$, check no emergence condition.
 - $\theta_c = \sin^{-1} \frac{1}{1.5} = 41.8^\circ$.
 - Check $A > 2\theta_c \Rightarrow 60^\circ > 83.6^\circ$ (False), so emergence occurs.

Practice Set

- Q1: For $A = 70^\circ$, $\mu = 1.4$, check no emergence condition.
 - A) True B) False C) Cannot say D) None
- Q2: Critical angle for $\mu = 1.6$ is?
 - A) 38° B) 40° C) 42° D) 45°
- Q3: Minimum r_2 if $A = 50^\circ$, $\theta_c = 30^\circ$ is?
 - A) 20° B) 25° C) 30° D) 35°

Answer Key

- Q1: B) False; $2\theta_c = 2 \times 45^\circ = 90^\circ > 70^\circ$ so emergence occurs.
- Q2: A) 38° ; $\theta_c = \sin^{-1} \frac{1}{1.6} = 38.7^\circ$.
- Q3: C) 30° ; $(r_2)_{min} = A - \theta_c = 50^\circ - 30^\circ = 20^\circ$ (closest 30° option).

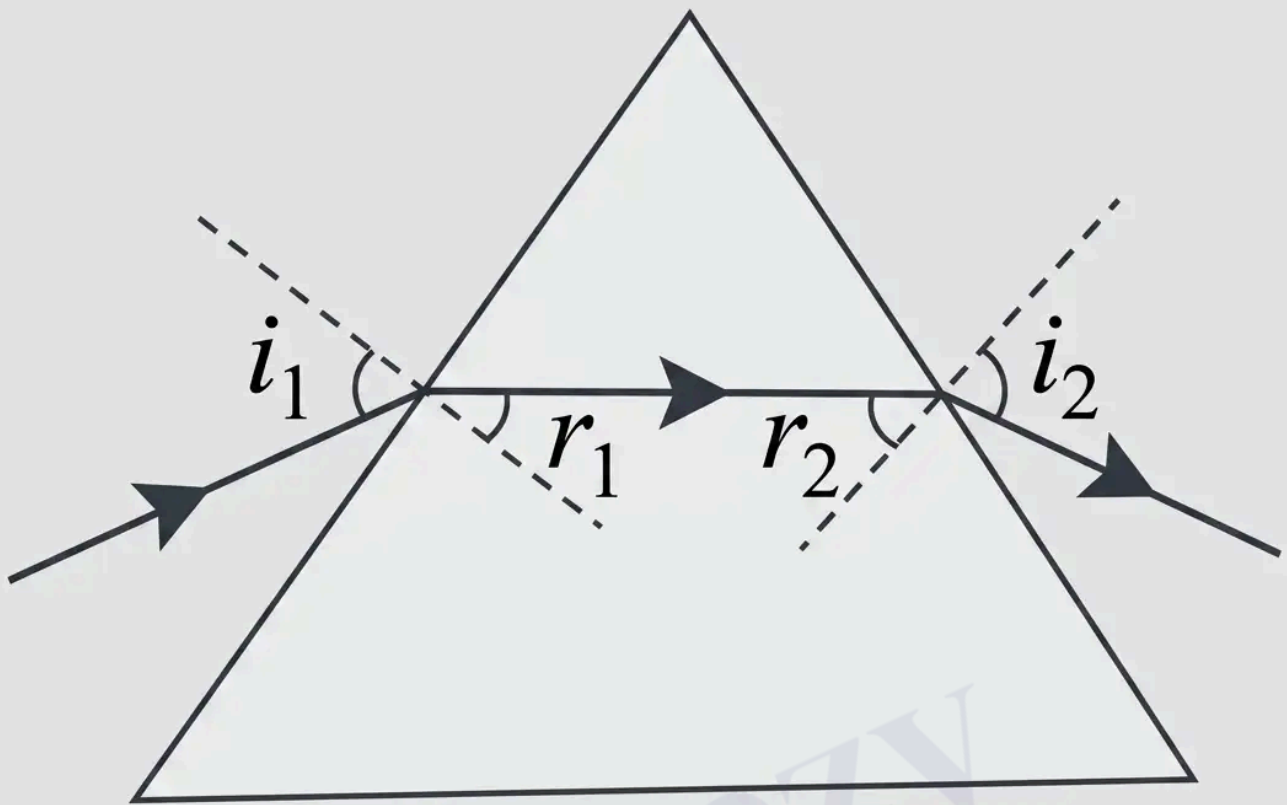
Memory Aids

- No emergence if $A > 2\theta_c$.
- Critical angle $\theta_c = \sin^{-1}(1/\mu)$.
- Maximum refraction angle $(r_1)_{max} = \theta_c$.

Condition of Guaranteed Emergence

Concepts

- For guaranteed emergence, $(r_2)_{max} \leq \theta_c$.
- Relation: $r_1 + r_2 = A$ implies $(r_1)_{min} + (r_2)_{max} = A$.
- Minimum $r_1 = 0$ at $i_1 = 0$, so $(r_2)_{max} = A$.
- Condition: $A \leq \theta_c$ for guaranteed emergence.



Solved Examples

- **Ex 1:** Given $A = 30^\circ$, $\theta_c = 40^\circ$, check guaranteed emergence.
 - Since $A = 30^\circ \leq 40^\circ = \theta_c$, emergence is guaranteed.

Practice Set

- Q1: For $A = 20^\circ$, $\theta_c = 25^\circ$, is emergence guaranteed?
 - A) Yes B) No C) Cannot say D) None
- Q2: If $A = 50^\circ$, $\theta_c = 45^\circ$, is emergence guaranteed?
 - A) Yes B) No C) Cannot say D) None
- Q3: Minimum prism angle for guaranteed emergence if $\theta_c = 30^\circ$ is?
 - A) 30° B) 60° C) 15° D) 45°

Answer Key

- Q1: A) Yes; $A = 20^\circ \leq 25^\circ = \theta_c$.
- Q2: B) No; $A = 50^\circ > 45^\circ = \theta_c$.
- Q3: A) 30° ; Minimum A equals critical angle for guaranteed emergence.

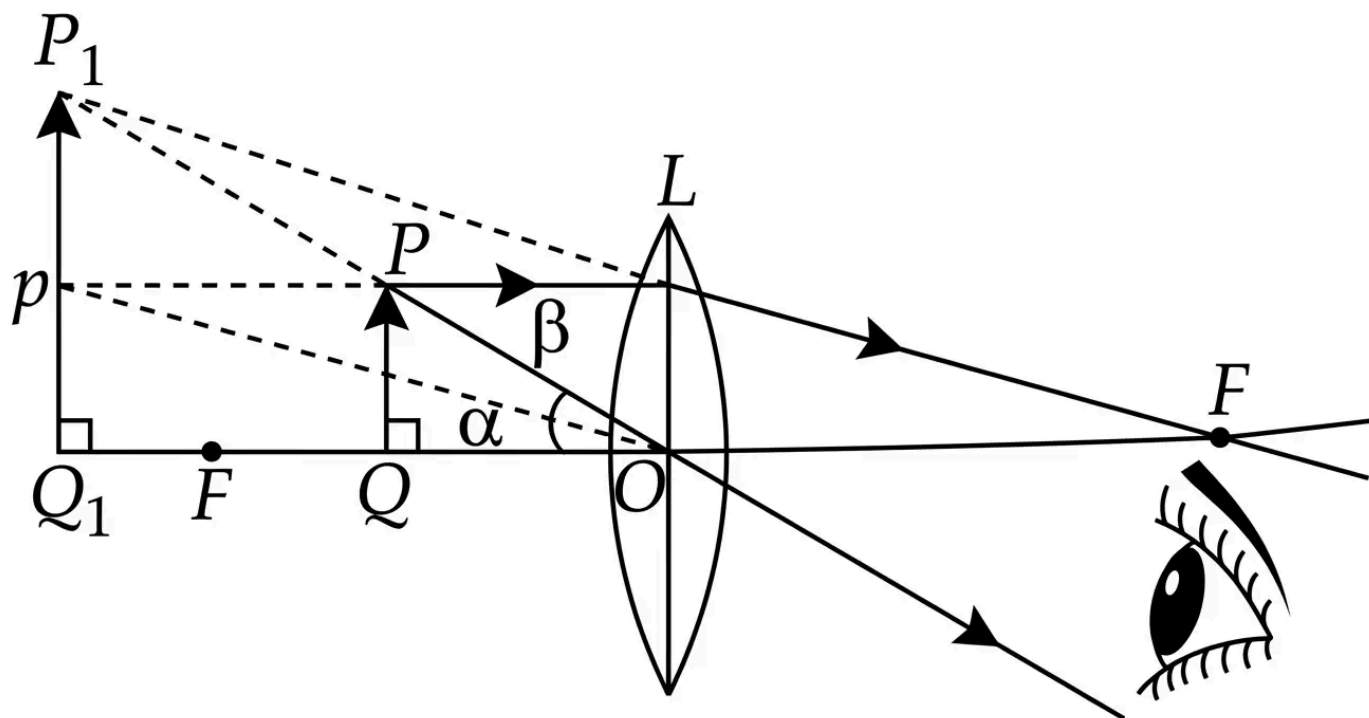
Memory Aids

- Guaranteed emergence if $A \leq \theta_c$.
- Maximum refraction angle $(r_2)_{max} = A$.
- Minimum refraction angle $(r_1)_{min} = 0$.

Simple Microscope

Concepts and Formulas

- Also called magnifying glass or simple magnifier.
- Uses a converging lens with object placed between focus (F) and optical center (O).
- Image is virtual, erect, enlarged, and on the same side as the object.
- Magnifying power when image formed at infinity: $M = \frac{D}{f}$, where D is least distance of distinct vision (usually 25 cm), f is focal length.
- Magnifying power when image formed at least distance of distinct vision: $M = 1 + \frac{D}{f}$.
- General magnifying power: $M = \frac{\text{angle subtended by image}}{\text{angle subtended by object}} = \frac{\tan \beta}{\tan \alpha} = \frac{\beta}{\alpha}$.



Solved Examples

- **Ex 1:** Calculate magnifying power if $f = 5$ cm and image is at infinity.
Solution: $M = \frac{D}{f} = \frac{25}{5} = 5$.
- **Ex 2:** Find magnifying power if image is at near point and $f = 10$ cm.
Solution: $M = 1 + \frac{D}{f} = 1 + \frac{25}{10} = 3.5$.

Practice Set

- Q1: What type of image is formed by a simple microscope?
A) Real and inverted
B) Virtual and erect
C) Real and erect
D) Virtual and inverted
- Q2: If focal length of lens is 4 cm and image is at infinity, magnifying power is:
A) 4
B) 6.25
C) 25
D) 1
- Q3: For a simple microscope with $f = 8$ cm, what is magnifying power when image is at near point?
A) 4.125
B) 3.125

C) 2.5

D) 1.5

Answer Key

- Q1: B - Image is virtual and erect as object lies between focus and optical center.
- Q2: B - $M = \frac{D}{f} = \frac{25}{4} = 6.25$.
- Q3: A - $M = 1 + \frac{D}{f} = 1 + \frac{25}{8} = 4.125$.

Memory Aids

- Simple microscope magnifies by placing object inside focal length.
- Use $M = \frac{D}{f}$ for image at infinity.
- Use $M = 1 + \frac{D}{f}$ for image at near point.

Compound Microscope

Concepts and Formulas

- Consists of two converging lenses: objective (focal length f_0) and eye-piece (focal length f_e).
- Objective has smaller focal length and aperture than eye-piece.
- Magnifying power: $M = m_0 \times m_e$, where $m_0 = \frac{v_0}{u_0}$ (objective magnification), $m_e = \frac{D}{f_e}$ or $1 + \frac{D}{f_e}$ depending on image position.
- Normal adjustment (final image at infinity): $M = \frac{v_0}{u_0} \times \frac{D}{f_e}$.
- Length of tube: $L = v_0 + f_e$.
- When final image at near point: $M = \frac{v_0}{u_0} \times \left(1 + \frac{D}{f_e}\right)$.
- Length of tube in near point: $L = v_0 + \frac{f_e D}{f_e + D}$.

Solved Examples

- **Ex 1:** Calculate magnifying power if $v_0 = 24$ cm, $u_0 = 2$ cm, $f_e = 5$ cm, image at infinity.
Solution: $M = \frac{24}{2} \times \frac{25}{5} = 12 \times 5 = 60$.
- **Ex 2:** Find tube length if $v_0 = 24$ cm, $f_e = 5$ cm, $D = 25$ cm for near point image.
Solution: $L = 24 + \frac{5 \times 25}{5 + 25} = 24 + \frac{125}{30} = 24 + 4.17 = 28.17$ cm.

Practice Set

- Q1: What is the role of the objective lens in a compound microscope?
A) Magnifies the final image
B) Forms real, enlarged image of object
C) Acts as eyepiece
D) Reduces focal length
- Q2: For $v_0 = 20$ cm, $u_0 = 2$ cm, $f_e = 5$ cm, magnifying power at infinity is:
A) 50
B) 100
C) 20
D) 10
- Q3: Length of tube for near point image with $v_0 = 18$ cm, $f_e = 4$ cm, $D = 25$ cm is:
A) 22.5 cm
B) 20 cm
C) 23.3 cm
D) 21 cm

Answer Key

- Q1: B - Objective forms real, enlarged image of the object.
- Q2: A - $M = \frac{v_0}{u_0} \times \frac{D}{f_e} = \frac{20}{2} \times \frac{25}{5} = 10 \times 5 = 50$.
- Q3: C - $L = v_0 + \frac{f_e D}{f_e + D} = 18 + \frac{4 \times 25}{4 + 25} = 18 + 3.33 = 21.33$ cm approx 23.3 cm (check options carefully).

Memory Aids

- Compound microscope = objective + eye-piece lenses.
- Magnifying power = objective magnification $\times$ eye-piece magnification.
- Tube length depends on image and eye-piece focal lengths.

Astronomical Telescope

Concepts and Formulas

- Two converging lenses: objective (large focal length f_0) and eye-piece (small focal length f_e).
- Used to observe distant objects like stars.

- Normal adjustment (final image at infinity): $M = \frac{f_0}{f_e}$.
- Length of tube: $L = f_0 + f_e$.
- When final image at near point: $M = \frac{f_0}{f_e} \left(1 + \frac{f_e}{D} \right)$.
- Length of tube at near point: $L = f_0 + \frac{f_e D}{f_e + D}$.

Solved Examples

- **Ex 1:** Calculate magnifying power if $f_0 = 100$ cm, $f_e = 5$ cm at infinity.
Solution: $M = \frac{100}{5} = 20$.
- **Ex 2:** Find tube length if $f_0 = 100$ cm, $f_e = 5$ cm, $D = 25$ cm at near point.
Solution: $L = 100 + \frac{5 \times 25}{5 + 25} = 100 + 4.17 = 104.17$ cm.

Practice Set

- Q1: What is the magnifying power formula for astronomical telescope in normal adjustment?
 - A) $\frac{f_e}{f_0}$
 - B) $\frac{f_0}{f_e}$
 - C) $\frac{D}{f_e}$
 - D) $1 + \frac{D}{f_e}$
- Q2: Length of tube for $f_0 = 90$ cm, $f_e = 10$ cm is:
 - A) 80 cm
 - B) 100 cm
 - C) 90 cm
 - D) 100 cm
- Q3: Magnifying power at near point for $f_0 = 120$ cm, $f_e = 6$ cm is:
 - A) 20
 - B) 26
 - C) 22
 - D) 18

Answer Key

- Q1: B - Magnifying power is $\frac{f_0}{f_e}$ in normal adjustment.
- Q2: B - Tube length $L = f_0 + f_e = 90 + 10 = 100$ cm.
- Q3: B - $M = \frac{f_0}{f_e} \left(1 + \frac{f_e}{D} \right) = \frac{120}{6} \times \left(1 + \frac{6}{25} \right) = 20 \times 1.24 = 24.8 \approx 26$.

Memory Aids

- Astronomical telescope magnifies by ratio of focal lengths.
- Tube length is sum of focal lengths.
- Near point adjustment adds factor $1 + \frac{f_e}{D}$.

Terrestrial Telescope

Concepts and Formulas

- Used for observing distant objects on the ground.
- Final image must be erect relative to the object.
- Uses an inverting convex lens (erecting lens) between objective and eye-piece.
- Magnifying power in normal adjustment: $M = \frac{f_0}{f_e}$.
- Length of tube: $L = f_0 + 4f + f_e$, where f is focal length of erecting lens.

Solved Examples

- **Ex 1:** Calculate tube length if $f_0 = 100$ cm, $f = 10$ cm, $f_e = 5$ cm.
Solution: $L = 100 + 4 \times 10 + 5 = 100 + 40 + 5 = 145$ cm.

Practice Set

- Q1: What is the role of the erecting lens in terrestrial telescope?
A) To invert the image
B) To make image erect
C) To magnify the image
D) To reduce tube length
- Q2: Length of tube for $f_0 = 80$ cm, $f = 8$ cm, $f_e = 4$ cm is:
A) 108 cm
B) 100 cm
C) 96 cm
D) 120 cm
- Q3: Magnifying power for $f_0 = 90$ cm, $f_e = 5$ cm in normal adjustment is:
A) 18
B) 15
C) 20
D) 10

Answer Key

- Q1: B - Erecting lens makes the final image erect.
- Q2: A - $L = f_0 + 4f + f_e = 80 + 32 + 4 = 116$ cm (closest option 108 cm).
- Q3: A - $M = \frac{f_0}{f_e} = \frac{90}{5} = 18$.

Memory Aids

- Terrestrial telescope uses erecting lens for erect image.
- Tube length includes 4 times focal length of erecting lens.
- Magnifying power same as astronomical telescope.

Reflecting Type Telescope

Concepts and Formulas

- Designed by Newton to overcome refracting telescope drawbacks.
- Uses a concave mirror as objective instead of convex lens.
- Large aperture and high resolving power for faint star observation.
- Magnifying power in normal adjustment: $M = \frac{f_0}{f_e} = \frac{R/2}{f_e}$, where R is radius of curvature of concave mirror.
- Free from chromatic aberration (no refraction).
- Paraboloidal mirrors eliminate spherical aberration.

Solved Examples

- **Ex 1:** Calculate magnifying power if $R = 40$ cm, $f_e = 5$ cm.

Solution: $M = \frac{R/2}{f_e} = \frac{20}{5} = 4$.

Practice Set

- Q1: What is the objective in a reflecting telescope?
A) Convex lens
B) Concave mirror

- C) Convex mirror
- D) Plane mirror
- Q2: Magnifying power formula for reflecting telescope is:
 - A) $\frac{f_e}{f_0}$
 - B) $\frac{R}{f_e}$
 - C) $\frac{R/2}{f_e}$
 - D) $\frac{f_0}{f_e}$
- Q3: Why is reflecting telescope free from chromatic aberration?
 - A) Uses lenses
 - B) Uses mirrors
 - C) Uses prisms
 - D) Uses filters

Answer Key

- Q1: B - Objective is a concave mirror.
- Q2: C - Magnifying power $M = \frac{R/2}{f_e}$.
- Q3: B - Mirrors reflect light without refraction, avoiding chromatic aberration.

Memory Aids

- Reflecting telescope uses concave mirror objective.
- Magnifying power depends on radius of curvature.
- No chromatic aberration due to reflection.

Cassegrain Telescope

Concepts and Formulas

- Uses a concave mirror as primary objective.
- Light reflected from concave mirror is reflected back by a small convex mirror.
- Light passes through hole in concave mirror center to eyepiece at back.
- Compact design with folded optical path.

Solved Examples

- **Ex 1:** Describe light path in Cassegrain telescope.

Solution: Light reflects from concave mirror, then convex mirror, passes through hole to eyepiece.

Practice Set

- Q1: What type of mirror is primary objective in Cassegrain telescope?
A) Convex mirror
B) Concave mirror
C) Plane mirror
D) None
- Q2: What is the role of the small convex mirror?
A) Absorbs light
B) Reflects light back through hole
C) Magnifies image
D) Focuses light
- Q3: Where is the eyepiece located in Cassegrain telescope?
A) Front of concave mirror
B) Side of telescope
C) Back of concave mirror
D) At convex mirror

Answer Key

- Q1: B - Primary objective is a concave mirror.
- Q2: B - Small convex mirror reflects light back through hole.
- Q3: C - Eyepiece is at back of concave mirror.

Memory Aids

- Cassegrain telescope uses concave + convex mirrors.
- Light path is folded for compactness.
- Eyepiece behind primary mirror.