

# Ray Optics

## Question1

Three immiscible transparent liquids with refractive indices  $3/2$ ,  $4/3$  and  $6/5$  are arranged one above the other in a container. The depths of the liquids are 3 cm, 4 cm and 6 cm respectively. The apparent depth of the vessel is

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Options:

A.

4 cm

B.

6 cm

C.

8 cm

D.

10 cm

**Answer: D**

**Solution:**

$$\mu = \frac{\text{Real depth (R)}}{\text{Apparent depth}} \Rightarrow \text{Apparent depth} = \frac{R}{\mu}$$

For vessel,

$$\text{Apparent depth} = \frac{R_1}{\mu_1} + \frac{R_2}{\mu_2} + \frac{R_3}{\mu_3}$$



$$= \frac{3}{3/2} + \frac{4}{4/3} + \frac{6}{6/5}$$
$$= 2 + 3 + 5$$

Apparent depth = 10 cm

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## Question2

**Refractive index of a glass convex lens is 1.5 . The radius of curvature of each of the two surfaces of the lens is 40 cm . The ratio of the power of the lens when immersed in a liquid of refractive index 1.25 to that when placed in air is**

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**Options:**

A.

2 : 3

B.

3 : 2

C.

2 : 5

D.

5 : 2

**Answer: C**

**Solution:**

Given data:  $\mu_g = 1.5$ ,  $R_1 = R_2 = 40$  cm,  $\mu_l = 1.25$

$$P_1 = \left( \frac{\mu_g}{\mu_a} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = (1.5 - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$\therefore P_2 = \left( \frac{\mu_g}{\mu_l} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = \left( \frac{1.5}{1.25} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$



$$= (1.2 - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

Taking ratio,

$$\frac{P_2}{P_1} = \frac{1.2 - 1}{1.5 - 1} = \frac{2}{5}$$

### Question3

A monochromatic ray of light is incident normally on a thin prism of refracting angle  $A$ . The ray is deviated through an angle  $(1.15)^\circ$  in passing through the prism. The ray reflected internally from the second face emerges from the first face making an angle of  $(6.3)^\circ$  with the incident ray. The refractive index of the prism is

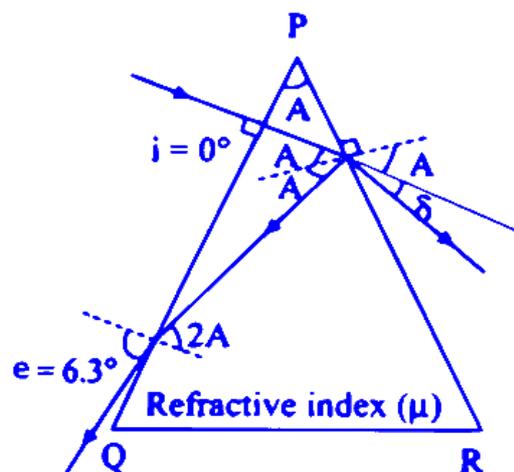
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Options:

- A. 1.625
- B. 1.575
- C. 1.525
- D. 1.515

Answer: B

Solution:



According to given condition, the incident ray undergoes partial reflection and partial refraction at the face PR. Hence, applying Snell's law at face PR,

$$\mu \times \sin(A) = 1 \times \sin(A + \delta)$$

$$\therefore \mu = \frac{\sin(A + \delta)}{\sin(A)} \quad \dots (i)$$

Similarly, at face PQ ,

$$\mu \times \sin(2A) = 1 \times \sin(e)$$

$$\therefore \mu = \frac{\sin(e)}{\sin(2A)} \quad \dots (ii)$$

Equating equations (i) and (ii),

$$\frac{\sin(A + \delta)}{\sin(A)} = \frac{\sin(e)}{\sin(2A)}$$

However, for small angles,  $\sin \theta \approx \theta$

$$\therefore \frac{A + \delta}{A} = \frac{e}{2A}$$

$$\therefore 2A + 2\delta = e$$

$$\therefore A = \frac{e - 2\delta}{2}$$

Given that,  $e = 6.3^\circ$  and  $\delta = 1.15^\circ$

$$\therefore A = \frac{6.3 - 2(1.15)}{2} = 2^\circ$$

Substituting the value in equation (i),

$$\mu = \frac{2 + 1.15}{2} = 1.575$$

## Question4

**A glass cube of length 21 cm has a small air bubble trapped inside. When viewed normally from the opposite face, its apparent distance is 6 cm . The refractive index of glass and the actual distance of the air bubble from the first surface respectively are**

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### Options:

- A. 1.5, 12 cm
- B. 1.55, 14 cm
- C. 1.6, 11 cm
- D. 1.5, 9 cm

**Answer: A**

### Solution:

✔ Correct Answer: A. 1.5, 12 cm

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#### ✔ Explanation (Easy & Exam-Oriented)

##### 📌 Given:

- Glass cube thickness: 21 cm
  - Apparent distance of air bubble (when viewed normally from opposite face): 6 cm
  - We need:
    - Refractive index of glass ( $\mu$ )
    - Actual distance of bubble from first surface (real depth)
- 

#### ✔ Step 1: Apply the formula for apparent depth

When looking from a rarer medium (air) into a denser medium (glass):

$$\text{Apparent depth} = \frac{\text{Real depth}}{\mu}$$

Here, bubble is viewed from opposite face, so:

$$\frac{21 - x}{\mu} = 6$$

Where

- $x$  = distance of bubble from the first surface
  - $21 - x$  = real depth from the observing side
- 

#### ✔ Step 2: Rearranging

$$21 - x = 6\mu$$



Also we know the bubble is inside the cube, and glass typically has  $\mu \approx 1.5$  (common exam value).

Try  $\mu = 1.5$ :

$$21 - x = 6 \times 1.5 = 9$$

$$x = 21 - 9 = 12$$

This matches one of the options.

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✔ **Final Values:**

- Refractive index = 1.5
- Actual distance from first face = 12 cm

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## Question5

The image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from  $\frac{25}{3}$  m to  $\frac{50}{7}$  m in 30 second. The speed of the object in km/hr is

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**Options:**

- A. 5
- B. 2.5
- C. 4
- D. 3

**Answer: D**

**Solution:**

Focal length of convex mirror :

$$f = \frac{R}{2} \Rightarrow f = \frac{20}{2}$$

$$\therefore f = 10m$$



By mirror Formula ,

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{4} \Rightarrow \frac{1}{4} = \frac{1}{v} - \frac{1}{f}$$

For first position,

$$\frac{1}{u_1} = \frac{1}{\frac{25}{3}} - \frac{1}{10} = \frac{3}{25} - \frac{2.5}{25}$$

$$\therefore u_1 = 50 \text{ m}$$

For second position,

$$\frac{1}{u_2} = \frac{1}{\frac{50}{7}} - \frac{1}{10} = \frac{7}{50} - \frac{5}{50}$$

$$\therefore u_2 = 25 \text{ m}$$

$$\therefore \text{Speed} = \frac{\Delta u}{t} = \frac{50-25}{30} = \frac{5}{6} \text{ m/s} = 3 \text{ km/hr}$$

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## Question6

**A convex lens of refractive index 1.5 has power 3D. It is placed in a liquid of refractive index 2. The new power of the lens is**

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**Options:**

A. 3 D

B. 0.75 D

C. 1.5 D

D. 2 D

**Answer: C**

**Solution:**

Using Lens maker's formula,

$$\frac{1}{f} = P = (\mu - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$



When placed in liquid the power is given by

$$P' = (\mu' - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

Where refractive index of lens in the liquid,

$$\mu' = \frac{\mu}{\mu_l} = \frac{1.5}{2} = \frac{3}{4}$$

$$\therefore \frac{P'}{P} = \frac{\mu' - 1}{\mu - 1} = \frac{\frac{3}{4} - 1}{1.5 - 1} = \frac{-\frac{1}{4}}{0.5} = -\frac{1}{2}$$

$$P' = -\frac{1}{2} \times P = -\frac{1}{2} \times 3 = -1.5D$$

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## Question 7

Select the correct statement.

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Options:

A.

If the Brewster's angle for the light propagation from air to glass is ' $\theta$ ', then Brewster's angle for the light propagating from glass to air is  $(\frac{\pi}{2} - \theta)$ .

B.

The Brewster's angle for the light propagating from the glass to air is  $\tan^{-1}(\mu)$  where  $\mu$  is the refractive index of glass.

C.

The Brewster's angle for light propagating from air to glass is ' $\theta$ ' then Brewster's angle for the light propagating from glass to air is  $(\pi + \theta)$ .

D.

The Brewster's angle for light propagating from glass to air is  $\tan(\mu)$  where is  $\mu$  the refractive index of glass.

**Answer: A**



## Solution:

As the Since  $n_{\theta_B} = \mu$  and refractive index becomes  $1/\mu$  when going from glass to air  $\tan \theta'_B = 1/\mu$ .

Given that  $\theta_B = \theta$  and  $\mu = \tan \theta$ , we get;  $\tan \theta'_B = 1/\tan \theta = \cot \theta \therefore \theta'_B = \pi/2 - \theta$

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## Question8

A ray of light is incident on first face of an equilateral glass prism at an angle of incidence ' I '. The emergent ray just grazes along the adjacent face. The refractive index of the the prism is  $\sqrt{2}$ . The value of angle of incidence at first face is  $\left( \sin 45^\circ = \frac{1}{\sqrt{2}}, \sin 90^\circ = 1 \right)$

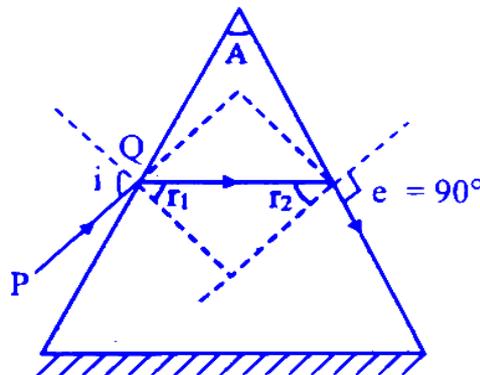
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Options:

- A.  $\sin^{-1} \left( \sqrt{2} \sin 15^\circ \right)$
- B.  $\sin^{-1} \left( \frac{\sin 30^\circ}{\sqrt{2}} \right)$
- C.  $\cos^{-1} \left( \sqrt{2} \sin 20^\circ \right)$
- D.  $\tan^{-1} \sqrt{2} \sin 15^\circ$

Answer: A

Solution:



The emergent ray just grazes the second face. Hence angle of emergence  $e = 90^\circ$

$$\therefore \mu = \frac{\sin e}{\sin r_2} = \frac{\sin 90^\circ}{\sin r_2} = \frac{1}{\sin r_2}$$

$$\therefore \frac{1}{\sin r_2} = \sqrt{2} \text{ or } \sin r_2 = \frac{1}{\sqrt{2}}$$

$$\therefore r_2 = 45^\circ; \quad A = r_1 + r_2$$

$$\therefore r_1 = A - r_2 = 60 - 45 = 15^\circ$$

Also,  $\frac{\sin i}{\sin r_1} = \mu$

$$\therefore \sin i = \mu \sin r_1 = \sqrt{2} \sin 15^\circ$$

$$\therefore i = \sin^{-1}(\sqrt{2} \sin 15^\circ)$$

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## Question9

Let the speed of light and the polarising angle for a given medium be ' $V$ ' and ' $i_p$ ' respectively. The relation between them is : ( $C$  = speed of light in vacuum)

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Options:

A.  $V = C \cos(i_p)$

B.  $V \cos(i_p) = C \sin(i_p)$

C.  $C = V \cot(i_p)$

D.  $V \sin(i_p) = C \cos(i_p)$

**Answer: D**

### Solution:

The polarising angle,  $i_p$ , is related to the refractive index  $n$  of the medium by:

$$n = \tan(i_p)$$

The refractive index  $n$  is also equal to the speed of light in vacuum  $C$  divided by the speed of light in the medium  $V$ :



$$n = \frac{C}{V}$$

So, we set these equal:

$$\tan(i_p) = \frac{C}{V}$$

We can write tangent as sine divided by cosine:

$$\frac{\sin(i_p)}{\cos(i_p)} = \frac{C}{V}$$

Now, multiply both sides by  $V$  and  $\cos(i_p)$ :

$$V \sin(i_p) = C \cos(i_p)$$

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## Question10

**A concave lens (refractive index = 1.5 ) has both surfaces of same radius of curvature R . If it is immersed in a liquid of refractive index 1.75 it will act as a**

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**Options:**

- A. concave lens of focal length  $(3.5) R$
- B. concave lens of focal length  $2 R .$
- C. convex lens of focal length  $(3.5) R$
- D. convex lens of focal length  $2R$

**Answer: C**

**Solution:**

Using Lens Maker's Formula (in a medium)

$$\frac{1}{f} = \left( \frac{n_{\text{lens}}}{n_{\text{medium}}} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

For a biconcave lens with equal radii of curvature:

$$R_1 = -R; R_2 = +R$$

$$\therefore \frac{1}{f} = \left( \frac{n_{\text{lens}}}{n_{\text{medium}}} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = \left( \frac{1.5}{1.75} - 1 \right) \left( -\frac{2}{R} \right) = \frac{2}{7R}$$

$$\therefore f = 3.5R$$

$\therefore$  The focal length is positive, so it acts as a convex lens of focal length  $(3.5) R$ .

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## Question11

Two thin lenses having  $R_1, R_2$  as the radii of curved surfaces are kept coaxially together. Their power is proportional to

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**Options:**

A.  $R_1 + R_2$

B.  $R_1 - R_2$

C.  $\frac{R_1 R_2}{R_1 + R_2}$

D.  $\frac{R_1 + R_2}{R_1 R_2}$

**Answer: D**

**Solution:**

Two thin lenses are in contact, so the resultant focal length will be:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$f = \frac{f_1 f_2}{f_1 + f_2}$$

$$\therefore \text{Power of lens: } P = \frac{1}{f} = \frac{f_1 + f_2}{f_1 f_2}$$

Since  $2f = R$ , we have:

$$\text{Power of the lens, } P = \frac{\frac{R_1}{2} + \frac{R_2}{2}}{\frac{R_1 R_2}{2}} = 2 \frac{R_1 + R_2}{R_1 R_2}$$

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## Question12

A ray of light travelling through rarer medium is incident at a very small angle '  $i$  ' on a glass slab and after refraction its velocity is reduced by 20%. The angle of deviation is

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**Options:**

- A.  $\frac{i}{5}$
- B.  $\frac{i}{8}$
- C.  $\frac{i}{4}$
- D.  $\frac{i}{2}$

**Answer: A**

**Solution:**

**Step 1. Relation between velocity and refractive index**

Velocity in medium:

$$v = \frac{c}{\mu}$$

where  $\mu$  is the refractive index.

In rarer medium (say air):  $v_1 = c$ .

In glass slab:  $v_2 = 0.8c$  (since reduced by 20%).

So

$$\mu = \frac{v_1}{v_2} = \frac{c}{0.8c} = \frac{1}{0.8} = 1.25$$



## Step 2. Use Snell's Law

Snell's law:

$$n_1 \sin i = n_2 \sin r$$

For air,  $n_1 = 1$ ,  $n_2 = \mu = 1.25$ .

So

$$\sin r = \frac{\sin i}{1.25}$$

For small angles (since given  $i$  is small),

$$\sin \theta \approx \theta \text{ (in radians).}$$

Therefore

$$r \approx \frac{i}{1.25} = 0.8i$$

## Step 3. Find angle of deviation

Deviation  $\delta = i - r$ .

$$\delta = i - 0.8i = 0.2i = \frac{i}{5}$$

 **Final Answer**

$$\boxed{\frac{i}{5}}$$

So, the correct option is **A**.  $\frac{i}{5}$ .

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## Question13

**A plano convex lens fits exactly in to a plano concave lens. Their plane surfaces are parallel to each other. Lenses are made up of different materials of refractive indices ' $n_1$ ' ' $n_2$ ' and ' $R$ ' is the radius of curvature of the curved surface of lenses. Focal length of the combination is**

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### Options:

A.  $\frac{R}{n_1+n_2}$

B.  $\frac{2R}{n_1-n_2}$

C.  $\frac{R}{2(n_1-n_2)}$

D.  $\frac{R}{n_1-n_2}$

**Answer: D**

### Solution:

#### Step 1: Focal length of the first lens (plano-convex)

The formula for the focal length of a lens is:

$$\frac{1}{f} = (n - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

For the first lens (plano-convex):

-  $n_1$  is its refractive index.

- Its first surface is flat, so  $R_1 = \infty$  (infinity), and its second surface is curved with radius  $-R$  (negative because it's outward).

So,

$$\frac{1}{f_1} = (n_1 - 1) \left( \frac{1}{\infty} - \frac{1}{-R} \right) = \frac{n_1 - 1}{R}$$

#### Step 2: Focal length of the second lens (plano-concave)

For the second lens (plano-concave):

-  $n_2$  is its refractive index.

- Its first surface has radius  $-R$ , and its second surface is flat ( $\infty$ ).

So,

$$\frac{1}{f_2} = (n_2 - 1) \left( \frac{1}{-R} - \frac{1}{\infty} \right) = -\frac{n_2 - 1}{R}$$

#### Step 3: Combined focal length of the two lenses

When lenses are put together, the combined power is the sum of their individual powers:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$



Substitute the values found above:

$$\frac{1}{f} = \frac{n_1-1}{R} - \frac{n_2-1}{R}$$

$$\frac{1}{f} = \frac{n_1-n_2}{R}$$

So, the final answer for focal length is:

$$f = \frac{R}{n_1-n_2}$$

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## Question14

The phenomenon, which is not due to total internal reflection is

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**Options:**

- A. mirage on hot summer days.
- B. brilliance of diamond
- C. difference between apparent real depth of a pond
- D. working of optical fibre.

**Answer: C**

**Solution:**

Option C: **difference between apparent and real depth of a pond**

This phenomenon is **not** due to total internal reflection. It is caused by **refraction of light** when it passes from water (denser medium) to air (rarer medium). The apparent depth appears less than the real depth due to bending of light at the water-air interface.

The other options (mirage, brilliance of diamond, and working of optical fibre) are all due to **total internal reflection**.

**Final Answer:**

**Option C: difference between apparent and real depth of a pond**

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## Question15

**An achromatic convergent doublet of two lenses in contact has a power +2 D . The convex lens has power +5 D . The ratio of the dispersive powers of the convergent and divergent lenses is (in magnitude)**

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**Options:**

A. 3 : 5

B. 2 : 5

C. 4 : 5

D. 5 : 6

**Answer: A**

**Solution:**

Power of an achromatic convergent doublet given as,

$$P = P_{\text{convex}} + P_{\text{concave}}$$

$$P_{\text{concave}} = P - P_{\text{convex}}$$

Given that,

$$P = +2D \text{ and } P_{\text{convex}} = +5D$$

$$P_{\text{concave}} = 2 - 5$$

$$P_{\text{concave}} = -3D$$

$$\therefore \frac{f_{\text{convex}}}{f_{\text{concave}}} = \frac{P_{\text{concave}}}{P_{\text{convex}}} = -\frac{3}{5}$$

Ratio of dispersive power of convergent lens to that of divergent lens is given by,

$$\therefore \frac{f_{\text{convex}}}{f_{\text{concave}}} = -\frac{\omega_{\text{convex}}}{\omega_{\text{concave}}} \Rightarrow \frac{\omega_{\text{convex}}}{\omega_{\text{concave}}} = \frac{3}{5}$$

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## Question16

**The length of the compound microscope is 15 cm . The magnifying power for relaxed eye is 25 . If the focal length of eye lens is 6 cm then the object distance for objective lens will be**



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**Options:**

A. 1.3 cm

B. 1.5 cm

C. 1.7 cm

D. 1.9 cm

**Answer: B**

**Solution:**

**Step 1: Understand the symbols.** Let  $L$  be the total length of the microscope,  $v_0$  be the distance where the image forms from the objective lens, and  $f_e$  be the focal length of the eye lens.

**Step 2: Find  $v_0$  (the image distance for the objective lens).**

The total length of the microscope is the sum of  $v_0$  and  $f_e$ . So,  $L = v_0 + f_e$

We know  $L = 15$  cm and  $f_e = 6$  cm:  $15 = v_0 + 6$

Subtract 6 from 15:  $v_0 = 15 - 6 = 9$  cm

**Step 3: Write the formula for magnifying power.**

The magnifying power ( $m$ ) of a microscope for a relaxed eye is:  $m = \frac{v_0}{u_0} \times \frac{D}{f_e}$  where  $u_0$  is the object distance from the objective lens,  $D$  (the least distance of distinct vision) is 25 cm, and  $f_e$  is given.

We are told  $m = 25$ ,  $v_0 = 9$  cm,  $D = 25$  cm, and  $f_e = 6$  cm.

Put in the numbers:  $25 = \frac{9}{u_0} \times \frac{25}{6}$

**Step 4: Solve for  $u_0$  (the object distance).**

First, multiply both sides by 6:  $150 = \frac{9}{u_0} \times 25$

Now, divide both sides by 25:  $6 = \frac{9}{u_0}$

Switch the sides and solve for  $u_0$ :  $u_0 = \frac{9}{6} = 1.5$  cm

**Final Answer:** The object distance for the objective lens will be 1.5 cm.

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## Question 17



**A convex lens of focal length  $\frac{1}{3}$  m forms a real, inverted image twice the size of the object. The distance of the object from the lens is**

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**Options:**

A. 0.5 m

B. 0.166 m

C. 0.33 m

D. 1 m

**Answer: A**

### **Solution:**

Given:

Focal length of convex lens,  $f = \frac{1}{3}$  m

Magnification,  $m = -2$  (negative because the image is real and inverted)

**Step 1: Magnification formula for lens:**

$$m = \frac{h'}{h} = \frac{v}{u}$$

So,

$$m = \frac{v}{u}$$

Given  $m = -2$ , so

$$\frac{v}{u} = -2 \implies v = -2u$$

**Step 2: Lens formula:**

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Put  $v = -2u$  and  $f = \frac{1}{3}$  m

$$\frac{1}{1/3} = \frac{1}{-2u} - \frac{1}{u}$$

$$3 = -\frac{1}{2u} - \frac{1}{u}$$

Get common denominator:

$$3 = -\frac{1+2}{2u}$$

$$3 = -\frac{3}{2u}$$

Step 3: Solve for  $u$ :

$$3 = -\frac{3}{2u}$$

Multiply both sides by  $2u$ :

$$6u = -3$$

$$u = -\frac{1}{2} \text{ m}$$

Step 4: Take the magnitude (distance is always positive):

Distance of the object from the lens is 0.5 m

Correct option: A

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## Question18

For a thin prism,  $\delta_1$  is the angle of deviation produced, when prism is placed in air. When the prism is immersed in water, the angle of deviation produced is  $\delta_2$ . Given  ${}_a\mu_g = \frac{3}{2}$  and  ${}_a\mu_w = \frac{4}{3}$ . The ratio  $\delta_2 : \delta_1$  is

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Options:

A. 1 : 2

B. 1 : 4

C. 1 : 8

D. 4 : 1

**Answer: B**

**Solution:**

For a thin prism, the angle of deviation  $\delta$  is given by:

$$\delta = (\mu_{\text{rel}} - 1)A$$

where  $\mu_{\text{rel}}$  is the refractive index of prism material with respect to the surrounding medium and  $A$  is the prism angle.

Step 1: Deviations in air and in water



**1. In air:**

The refractive index of glass with respect to air is  ${}_a\mu_g = \frac{3}{2}$ .

$$\delta_1 = ({}_a\mu_g - 1)A = \left(\frac{3}{2} - 1\right)A = \left(\frac{1}{2}\right)A$$

**2. In water:**

The refractive index of glass with respect to water is:

$${}_w\mu_g = \frac{{}_a\mu_g}{{}_a\mu_w}$$

Given  ${}_a\mu_g = \frac{3}{2}$  and  ${}_a\mu_w = \frac{4}{3}$ :

$${}_w\mu_g = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{3}{2} \times \frac{3}{4} = \frac{9}{8}$$

So,

$$\delta_2 = ({}_w\mu_g - 1)A = \left(\frac{9}{8} - 1\right)A = \left(\frac{1}{8}\right)A$$

**Step 2: Find the ratio  $\frac{\delta_2}{\delta_1}$**

$$\frac{\delta_2}{\delta_1} = \frac{\frac{1}{8}A}{\frac{1}{2}A} = \frac{1}{8} \times \frac{2}{1} = \frac{1}{4}$$

So,

$$\delta_2 : \delta_1 = 1 : 4$$

**Final Answer:**

**Option B:**

$$1 : 4$$

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## Question19

**An optician makes spectacles having a combination of a convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm . The power of this combination of lenses in dioptr is**

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**Options:**

A.  $-6.67$

B.  $-1.5$



C. +6.67

D. +1.5

**Answer: B**

### Solution:

To determine the power of the combination of two lenses in dioptres, we use the formula for the total power  $P$  of lenses in contact:

$$P = P_1 + P_2$$

Where:

$P_1$  is the power of the convex lens.

$P_2$  is the power of the concave lens.

The power  $P$  of a lens is given by:

$$P = \frac{1}{f}$$

where  $f$  is the focal length in meters.

Given:

The focal length of the convex lens,  $f_1 = 40 \text{ cm} = 0.4 \text{ m}$ .

The focal length of the concave lens,  $f_2 = 25 \text{ cm} = 0.25 \text{ m}$ .

Calculate  $P_1$  and  $P_2$ :

$$P_1 = \frac{1}{f_1} = \frac{1}{0.4} = 2.5 \text{ D}$$

$$P_2 = \frac{1}{f_2} = \frac{1}{0.25} = -4 \text{ D}$$

(Note: The concave lens has a negative power since a concave lens is diverging.)

Add the powers to find the total power  $P$ :

$$P = P_1 + P_2 = 2.5 + (-4) = -1.5 \text{ D}$$

Thus, the power of the lens combination is  $-1.5$  dioptres.

---

## Question20

**A ray of light travelling through a rarer medium is incident at very small angle '  $i$  ' on a glass slab and after refraction its velocity is reduced by 25%. The angle of deviation is**



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**Options:**

A.  $\frac{3i}{4}$

B.  $\frac{i}{4}$

C.  $\frac{i}{3}$

D.  $\frac{4i}{3}$

**Answer: B**

**Solution:**

When a ray of light travels through a less dense medium and enters a glass slab at a very small angle, denoted as 'i', its velocity decreases by 25%. We want to determine the angle of deviation.

First, apply Snell's Law for small angles:

$$n = \frac{\sin i}{\sin r} \approx \frac{i}{r}$$

Here,  $n$  represents the refractive index, and given the problem conditions,  $n$  is calculated based on the change in velocity:

$$n = \frac{c}{v} = \frac{c}{0.75c} \approx \frac{4}{3}$$

So, applying Snell's Law:

$$\frac{4}{3} = \frac{i}{r}$$

Solving for  $r$ :

$$r = \frac{3}{4}i$$

The angle of deviation,  $\delta$ , is calculated as:

$$\delta = i - r = i - \frac{3}{4}i = \frac{i}{4}$$

Thus, the angle of deviation is  $\frac{i}{4}$ .

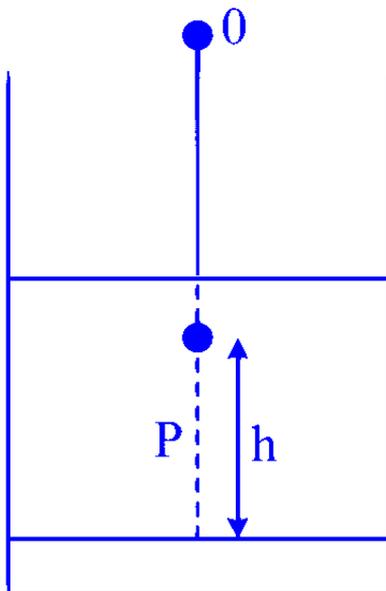
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## Question21

A plane mirror is placed at the bottom of a tank containing a liquid of refractive index ' $\mu$ ', ' $p$ ' is a small object at a height ' $h$ ' above the



mirror. An observer 'O' vertically above 'p' outside the liquid sees 'p' and the image in a mirror. The apparent distance between these two will be



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Options:

A.  $2\mu h$

B.  $\frac{2h}{\mu}$

C.  $\frac{2h}{(\mu-1)}$

D.  $h \left(1 + \frac{1}{\mu}\right)$

**Answer: B**

**Solution:**

Let the apparent depth of P be  $x_1$  and the apparent depth of the image of P be  $x_2$ .

$$\therefore x_1 = \frac{d-h}{\mu} \text{ and } x_2 = \frac{d+h}{\mu}$$



∴ Apparent distance between  $P$  and its image is

$$\begin{aligned}x_2 - x_1 &= \frac{d+h}{\mu} - \frac{(d-h)}{\mu} \\ &= \frac{d+h-d+h}{\mu} = \frac{2h}{\mu}\end{aligned}$$

---

## Question22

Optical path of a particular ray of light has travelled a distance of 3 cm in flint glass is same as that on travelling a distance '  $x$  ' cm through another medium. The value of '  $x$  ' is [refractive index of flint glass = 1.6, refractive index of another medium = 1.25]

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Options:

- A. 3.84 cm
- B. 2.84 cm
- C. 1.84 cm
- D. 4.84 cm

**Answer: A**

**Solution:**

To determine the equivalent optical path in another medium, we can use the concept that the optical paths are equal when the product of the refractive index and the distance traveled in both media are the same.

Given:

Refractive index of flint glass,  $\mu_g = 1.6$

Distance traveled in flint glass,  $x_g = 3$  cm

Refractive index of the other medium,  $\mu_m = 1.25$

Distance traveled in the other medium,  $x_m = x$  cm



The relationship for equal optical paths is given by:

$$\mu_g \cdot x_g = \mu_m \cdot x_m$$

Solving for  $x_m$ :

$$x_m = \frac{\mu_g \cdot x_g}{\mu_m} = \frac{1.6 \times 3}{1.25} = 3.84 \text{ cm}$$

Therefore, the distance 'x' that the light travels in the other medium is 3.84 cm.

---

## Question23

The angle of incidence is found to be twice the angle of refraction when ray of light passes from vacuum into a medium of refractive index ' $\mu$ '. The angle of incidence will be

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Options:

- A.  $\cos^{-1} \left( \frac{\mu}{2} \right)$
- B.  $2 \cos^{-1} \left( \frac{\mu}{2} \right)$
- C.  $\sin^{-1} \left( \frac{\mu}{2} \right)$
- D.  $2 \sin^{-1} \left( \frac{\mu}{2} \right)$

**Answer: B**

**Solution:**

Snell's law states that:

$$\mu = \frac{\sin i}{\sin r}$$

where  $i$  is the angle of incidence and  $r$  is the angle of refraction.

Given that the angle of incidence  $i$  is twice the angle of refraction  $r$ , or  $i = 2r$ , we can express  $r$  as:

$$r = \frac{i}{2}$$

Substituting this into Snell's law gives:

$$\mu = \frac{\sin i}{\sin\left(\frac{i}{2}\right)}$$

Using the trigonometric identity  $\sin 2A = 2 \sin A \cos A$ , we can express  $\sin i$  as  $2 \sin\left(\frac{i}{2}\right) \cos\left(\frac{i}{2}\right)$ . Thus:

$$\mu = \frac{2 \sin\left(\frac{i}{2}\right) \cos\left(\frac{i}{2}\right)}{\sin\left(\frac{i}{2}\right)}$$

Simplifying, we find:

$$\mu = 2 \cos\left(\frac{i}{2}\right)$$

This implies:

$$i = 2 \cos^{-1}\left(\frac{\mu}{2}\right)$$

---

## Question24

**A glass slab of thickness 4.8 cm is placed on the piece of paper on which an ink dot is marked. By how much distance would an ink dot appear to be raised?(The refractive index of glass = 1.5 )**

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**Options:**

A. 1.6 cm

B. 2.4 cm

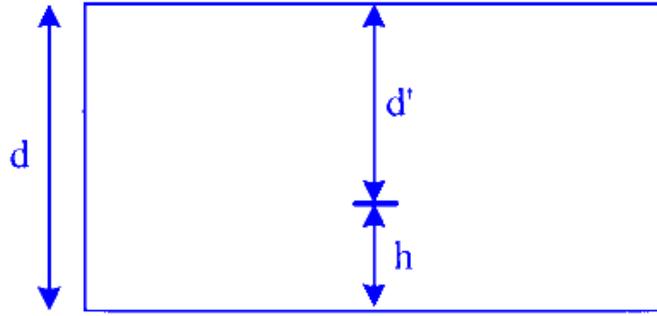
C. 3.2 cm

D. 4.8 cm

**Answer: A**

**Solution:**





$$n = \frac{\text{Real depth}}{\text{Apparent depth}}$$

$$1.5 = \frac{4.8}{d'}$$

$$\therefore d' = 3.2 \text{ cm}$$

$$\therefore h = d - d' = 4.8 - 3.2 = 1.6 \text{ cm}$$

## Question25

A glass prism ' A ' deviates the red and blue rays through  $10^\circ$  and  $12^\circ$  respectively. A second prism ' B ' deviates them through  $8^\circ$  and  $10^\circ$  respectively. The ratio of their dispersive powers is (A to B)

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**Options:**

A. 9 : 13

B. 4 : 5

C. 9 : 11

D. 8 : 9

**Answer: C**

**Solution:**

**Dispersive Power Calculation**

To calculate the dispersive power, we use the formula:

$$\omega = \frac{\delta_v - \delta_R}{\delta_y}$$

$$\text{where } \delta_y = \frac{\delta_v + \delta_R}{2}.$$

Let's apply this to prisms A and B:

**For Prism A:**

Blue ray deviation ( $\delta_v$ ):  $12^\circ$

Red ray deviation ( $\delta_R$ ):  $10^\circ$

Calculate  $\delta_y$  for prism A:

$$\delta_y = \frac{12+10}{2} = 11$$

Calculate the dispersive power  $\omega_A$ :

$$\omega_A = \frac{12-10}{11} = \frac{2}{11}$$

**For Prism B:**

Blue ray deviation ( $\delta_v$ ):  $10^\circ$

Red ray deviation ( $\delta_R$ ):  $8^\circ$

Calculate  $\delta_y$  for prism B:

$$\delta_y = \frac{10+8}{2} = 9$$

Calculate the dispersive power  $\omega_B$ :

$$\omega_B = \frac{10-8}{9} = \frac{2}{9}$$

**Ratio of Dispersive Powers (A to B):**

$$\frac{\omega_A}{\omega_B} = \frac{\frac{2}{11}}{\frac{2}{9}} = \frac{9}{11}$$

Thus, the ratio of the dispersive powers of prism A to prism B is  $\frac{9}{11}$ .

---

## Question26

**The angle of minimum deviation produced by a thin prism in air is  $\delta_1$ .  
If it is immersed in water the angle of minimum deviation is**

$$\left[ a_g = \frac{3}{2}, a_w = \frac{4}{3} \right]$$

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## Options:

A.  $2\delta_1$

B.  $\frac{\delta_1}{2}$

C.  $\frac{\delta_1}{3}$

D.  $\frac{\delta_1}{4}$

**Answer: D**

## Solution:

For a thin prism, the angle of minimum deviation  $\delta$  is given by the formula:

$$\delta = (\mu - 1) \cdot A$$

where  $\mu$  is the refractive index of the prism material relative to the surrounding medium, and  $A$  is the prism's angle.

### Given:

$$\mu_{\text{glass, air}} = \frac{3}{2}$$

$$\mu_{\text{water, air}} = \frac{4}{3}$$

### When the prism is in air:

$$\text{Refractive index, } \mu_1 = \frac{\mu_{\text{glass}}}{\mu_{\text{air}}} = \frac{3}{2}$$

### When the prism is immersed in water:

$$\text{Refractive index, } \mu_2 = \frac{\mu_{\text{glass}}}{\mu_{\text{water}}} = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{9}{8}$$

Now, the ratio of the angles of minimum deviation when the prism is in air ( $\delta_1$ ) and in water ( $\delta_2$ ) is:

$$\frac{\delta_1}{\delta_2} = \frac{\mu_1 - 1}{\mu_2 - 1} = \frac{\frac{3}{2} - 1}{\frac{9}{8} - 1}$$

Calculating the expression gives:

$$\frac{\delta_1}{\delta_2} = \frac{\frac{1}{2}}{\frac{1}{8}} = 4$$

Therefore:

$$\delta_2 = \frac{\delta_1}{4}$$

This shows that the angle of minimum deviation when the prism is immersed in water is  $\frac{\delta_1}{4}$ .

-----



## Question27

For a symmetric (equilateral) prism, the prism formula can be written as

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**Options:**

A.  $2 \sin \left( 30 + \frac{\delta_m}{2} \right)$

B.  $\frac{2}{\sqrt{3}} \sin \left( 30 + \frac{\delta_m}{2} \right)$

C.  $2 \sin \left( 60 + \frac{\delta_m}{2} \right)$

D.  $\frac{2}{\sqrt{3}} \sin \left( 60 + \frac{\delta_m}{2} \right)$

**Answer: A**

**Solution:**

For a symmetric (equilateral) prism, the prism formula is derived using the relationship:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Where:

$\mu$  is the refractive index of the material of the prism,

$A$  is the angle of the prism, and

$\delta_m$  is the minimum angle of deviation.

For a symmetric prism, the angle  $A$  is  $60^\circ$ . Thus, the formula simplifies as follows:

$$\begin{aligned} \mu &= \frac{\sin\left(30 + \frac{\delta_m}{2}\right)}{\sin 30} \\ &= 2 \sin\left(30 + \frac{\delta_m}{2}\right) \quad \left(\text{since } \sin 30^\circ = \frac{1}{2}\right) \end{aligned}$$

This shows how the formula becomes  $2 \sin\left(30 + \frac{\delta_m}{2}\right)$  for a symmetric prism.

---



## Question28

For a ray of light, the critical angle is minimum, when it travels from

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Options:

- A. glass to air
- B. air to glass
- C. glass to water
- D. water to glass

Answer: A

Solution:

The **critical angle**  $c$  for total internal reflection (TIR) when light travels from a medium of refractive index  $n_1$  to a medium of lower refractive index  $n_2$  is given by

$$\sin c = \frac{n_2}{n_1},$$

where  $n_1 > n_2$ .

The **smaller** the ratio  $\frac{n_2}{n_1}$ , the **smaller**  $\sin c$ , and hence the **smaller** the critical angle  $c$ .

From the options, the valid scenarios for TIR are only those in which the first medium has a higher index than the second. That is:

**Glass to air** ( $n_{\text{glass}} \approx 1.5$ ,  $n_{\text{air}} \approx 1.0$ )

$$\sin c = \frac{1.0}{1.5} = \frac{2}{3} \implies c \approx 42^\circ.$$

**Glass to water** ( $n_{\text{glass}} \approx 1.5$ ,  $n_{\text{water}} \approx 1.33$ )

$$\sin c = \frac{1.33}{1.5} \approx 0.887 \implies c \approx 62^\circ.$$

Clearly, the critical angle is **smaller** for glass-to-air than for glass-to-water.

Hence, the critical angle is **minimum** when light travels from **glass to air**.

Answer: (A) glass to air.

---

## Question29



## Critical angle of light passing from glass to air is minimum for wavelength of

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#### Options:

- A. red colour
- B. yellow colour
- C. green colour
- D. blue colour

**Answer: D**

#### Solution:

The critical angle is the angle of incidence above which total internal reflection occurs when light travels from a denser medium to a rarer medium, such as from glass to air. The critical angle,  $\theta_c$ , is given by the equation:

$$\theta_c = \sin^{-1} \left( \frac{n_2}{n_1} \right)$$

where  $n_1$  is the refractive index of the denser medium (glass) and  $n_2$  is the refractive index of the less dense medium (air). The refractive index of glass varies with the wavelength of light due to dispersion; it generally increases with decreasing wavelength.

Among the visible spectrum, the refractive index is higher for blue light and lower for red light. Since the critical angle is inversely related to the refractive index of the denser medium (when  $n_2$  is constant), the critical angle is smallest for the shortest wavelength, which corresponds to blue light.

Therefore, the critical angle is minimum for the wavelength of:

Option D: blue colour.

---

## Question30

**A vessel is filled with two different liquids which do not mix. One is 40 cm deep and has refractive index 1.6 and other is 30 cm deep and has refractive index 1.5. The apparent depth of vessel when viewed normally is**

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### Options:

A. 37.5 cm

B. 50 cm

C. 45 cm

D. 40 cm

**Answer: C**

### Solution:

To determine the apparent depth of the vessel when viewed normally, we use the formula for apparent depth involving two layers of liquids with different refractive indices:

$$\text{Apparent depth} = \frac{d_1}{n_1} + \frac{d_2}{n_2}$$

where:

$d_1 = 40$  cm, the depth of the first liquid,

$n_1 = 1.6$ , the refractive index of the first liquid,

$d_2 = 30$  cm, the depth of the second liquid,

$n_2 = 1.5$ , the refractive index of the second liquid.

Substituting the values into the formula gives:

$$\text{Apparent depth} = \frac{40}{1.6} + \frac{30}{1.5}$$

Calculating these values:

$$\frac{40}{1.6} = 25 \text{ cm}$$

$$\frac{30}{1.5} = 20 \text{ cm}$$

Thus, the total apparent depth is:

$$25 \text{ cm} + 20 \text{ cm} = 45 \text{ cm}$$

Therefore, the apparent depth of the vessel when viewed normally is 45 cm.

---

## Question31

An ink mark is made on a piece of paper. A glass slab of thickness '  $t$  ' is placed on it. The ink mark appears to be raised up through a distance '  $x$  ' when viewed at nearly normal incidence. If the refractive index of material of glass slab is '  $\mu$  ' then thickness of glass slab '  $t$  ' is given by

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Options:

A.  $\frac{(\mu-1)}{\mu x}$ .

B.  $\frac{\mu x}{(\mu-1)}$

C.  $\frac{(\mu-1)x}{\mu}$

D.  $\frac{\mu}{(\mu-1)x}$

**Answer: B**

**Solution:**

When light passes through a medium, it bends due to refraction. In this case, when a glass slab is placed over an ink mark, the ink mark appears to be closer than it actually is. This apparent shift can be described through the concept of apparent and real depth, where the apparent depth  $x$  is related to the real depth  $t$  by the formula:

$$x = \frac{t}{\mu}$$

where  $x$  is the apparent shift,  $t$  is the real thickness of the glass slab, and  $\mu$  is the refractive index of the glass slab. Rearranging this equation to solve for the actual thickness  $t$  gives:

$$t = \mu x$$

However, the apparent shift  $x$  is given as the distance the ink mark appears to be raised. To find the relationship where  $t$  is expressed in terms of  $x$ , we consider:

$$x = t - \frac{t}{\mu}$$

Simplifying:

$$x = t \left(1 - \frac{1}{\mu}\right)$$

$$x = t \frac{\mu-1}{\mu}$$

Solving for  $t$ :

$$t = \frac{\mu x}{\mu-1}$$



Thus, the actual thickness of the glass slab  $t$  in terms of  $x$ ,  $\mu$ , and the shift is given by:

Option B:

$$\frac{\mu x}{\mu - 1}$$

---

## Question32

For a light ray to undergo total internal reflection ( $i =$  angle of incidence,  $i_c =$  critical angle)

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Options:

- A. light travels from denser to rarer medium and  $i < i_c$ .
- B. light travels from rarer to denser medium and  $i < i_c$ .
- C. light travels from denser to rarer medium and  $i > i_c$ .
- D. light travels from rarer to denser medium and  $i > i_c$ .

Answer: C

Solution:

Total internal reflection (TIR) takes place only when:

Light travels **from a denser medium to a rarer medium** (i.e.,  $n_{\text{denser}} > n_{\text{rarer}}$ ).

The angle of incidence  $i$  is **greater than** the critical angle  $i_c$ .

Thus, among the options :

(C) light travels from denser to rarer medium and  $i > i_c$ .

---

## Question33

When the same monochromatic ray of light travels through glass slab and through water, the number of waves in glass slab of thickness 5



cm is same as in water column of height 6 cm . If refractive index of glass is 1.56 , then refractive index of water is

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**Options:**

A. 1.28

B. 1.29

C. 1.30

D. 1.32

**Answer: C**

**Solution:**

When light travels through different mediums, the wavelength of the light changes, although its frequency remains the same. The number of wavelengths of light ( $N$ ) within a medium can be described by the relation:

$$N = \frac{\text{thickness of the medium}}{\text{wavelength in the medium}}$$

For two mediums, glass slab and water, with thicknesses  $d_g$  and  $d_w$ , and refractive indices  $n_g$  and  $n_w$ , respectively, the condition given is:

$$N_{\text{glass}} = N_{\text{water}}$$

This can be expressed as:

$$\frac{d_g}{\lambda_g} = \frac{d_w}{\lambda_w}$$

Where  $\lambda_g$  and  $\lambda_w$  are the wavelengths in the glass and water, respectively. The wavelength in a medium is related to the refractive index by:

$$\lambda_m = \frac{\lambda_0}{n_m}$$

Where  $\lambda_0$  is the wavelength in vacuum, and  $n_m$  is the refractive index of the medium. Substitute these into the expression for  $N$ , we get:

$$\frac{d_g \cdot n_g}{\lambda_0} = \frac{d_w \cdot n_w}{\lambda_0}$$

Canceling out  $\lambda_0$  from both sides:

$$d_g \cdot n_g = d_w \cdot n_w$$

Given:



Glass thickness  $d_g = 5$  cm

Water thickness  $d_w = 6$  cm

Refractive index of glass  $n_g = 1.56$

Now, solving for  $n_w$  (refractive index of water):

$$5 \cdot 1.56 = 6 \cdot n_w$$

$$7.8 = 6 \cdot n_w$$

$$n_w = \frac{7.8}{6}$$

$$n_w = 1.3$$

Therefore, the refractive index of water is:

**Option C: 1.30**

---

## Question34

**A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. The power of combination is**

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**Options:**

A.  $-1.5D$

B.  $-6.5D$

C.  $+6.5D$

D.  $+1.5D$

**Answer: A**

**Solution:**

To find the power of a combination of lenses, you can use the formula:

$$P = \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

Here,  $f_1 = 0.4$  m (the focal length of the convex lens) and  $f_2 = -0.25$  m (the focal length of the concave lens, which is negative because it's concave).



Let's calculate the power:

$$P = \frac{1}{0.4} + \frac{1}{-0.25}$$

Convert the focal lengths to have a common denominator:

$$\text{For the convex lens: } \frac{1}{0.4} = \frac{10}{4} = 2.5$$

$$\text{For the concave lens: } \frac{1}{-0.25} = \frac{-4}{1} = -4$$

Now, add these values:

$$P = 2.5 - 4 = -1.5 \text{ D}$$

Therefore, the power of the lens combination is  $-1.5 \text{ D}$ .

---

## Question35

**In compound microscope, the focal length and the aperture of the objective used is respectively**

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**Options:**

- A. large and large
- B. large and small.
- C. small and large.
- D. small and small.

**Answer: C**

**Solution:**

In a compound microscope:

The objective lens is designed to have a **short (small) focal length**, because high magnification requires a short focal length.

To gather more light (improving brightness and resolution), the aperture of this short-focal-length lens is typically **large**.

Hence, the correct option is:

**(C) small and large.**

---

## Question36

A ray of light is incident on a medium of refractive index ' $\mu$ ' at an angle of incidence ' $i$ '. On refraction in the medium ' $\delta$ ' is the angle of deviation. Then

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**Options:**

A.  $\frac{1}{\mu} = \cos \delta - \frac{\sin \delta}{\tan i}$

B.  $\frac{1}{\mu} = \sin \delta - \frac{\cos \delta}{\tan i}$

C.  $\frac{1}{\mu} = \cos \delta - \sin \delta \cdot \tan i.$

D.  $\frac{1}{\mu} = \sin \delta - \cos \delta \cdot \tan i$

**Answer: A**

**Solution:**

To understand the relationship between the angle of incidence, the refractive index, and the angle of deviation for a ray of light passing through a medium, we start with the following equations:

$\delta = i + r$ : The angle of deviation ( $\delta$ ) is the sum of the angle of incidence ( $i$ ) and the angle of refraction ( $r$ ).

$\mu = \frac{\sin i}{\sin r}$ : Snell's Law, where  $\mu$  is the refractive index of the medium.

To express  $\mu$  in terms of the angle of deviation, we derive that:

$$\mu = \frac{\sin i}{\sin(i-\delta)}$$

We then rearrange to find:

$$\frac{1}{\mu} = \frac{\sin(i-\delta)}{\sin i}$$

Using the trigonometric identity for  $\sin(i - \delta)$ , which is  $\sin i \cos \delta - \cos i \sin \delta$ , we can write:

$$\frac{1}{\mu} = \frac{\sin i \cos \delta - \cos i \sin \delta}{\sin i}$$

Simplifying further, we get:

$$\frac{1}{\mu} = \cos \delta - \frac{\sin \delta}{\tan i}$$



This equation reveals how the inverse of the refractive index is related to the angles involved through cosine and sine functions, as well as the tangent of the angle of incidence.

---

## Question37

**Simple microscope is used to see the object first in blue light and then a red light. Due to the change from blue to red light, its magnifying power**

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**Options:**

- A. decreases
- B. increases
- C. remains same
- D. first increases and then decreases

**Answer: A**

**Solution:**

Magnifying power of a simple microscope

$$= 1 + \frac{D}{f}$$

Focal length of red light is greater than the focal length of blue light. Hence, the magnifying power will decrease.

---

## Question38

**Concave and convex lenses are placed touching each other. The ratio of magnitudes of their power is 2 : 3. The focal length of the system is 30 cm . The focal lengths of individual lens are**

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### Options:

- A. 5 cm,  $-10$  cm
- B. 10 cm,  $-15$  cm
- C. 10 cm,  $-20$  cm
- D. 20 cm,  $-30$  cm

**Answer: B**

### Solution:

To solve the problem of finding the focal lengths of individual lenses when concave and convex lenses are placed together, we use the following steps:

#### Power Definition:

The power  $P$  of a lens is given by:

$$P = \frac{1}{f}$$

where  $f$  is the focal length of the lens.

#### Power Ratio:

It is given that the ratio of the magnitudes of their powers is  $\frac{2}{3}$ :

$$\frac{P_{\text{concave}}}{P_{\text{convex}}} = \frac{2}{3}$$

#### Focal Lengths:

Let the focal length of the convex lens be  $f_{\text{convex}} = f$ .

#### Relationship Between Focal Lengths:

From the power ratio, the focal length of the concave lens  $f_{\text{concave}}$  can be expressed as:

$$f_{\text{concave}} = -\frac{3}{2}f$$

(negative because the lens is concave).

#### System Focal Length:

When lenses are in contact, the equivalent focal length  $f_{eq}$  is given by:

$$\frac{1}{f_{eq}} = \frac{1}{f_{\text{convex}}} + \frac{1}{f_{\text{concave}}}$$

Substituting the expressions for the focal lengths:

$$\frac{1}{30} = \frac{1}{f} + \frac{1}{-\frac{3}{2}f}$$



### Solve the Equation:

Simplify the right side:

$$\frac{1}{f} - \frac{2}{3f} = \frac{3f-2f}{3f^2} = \frac{1}{3f}$$

Set up the equation:

$$\frac{1}{30} = \frac{1}{3f}$$

Solve for  $f$ :

$$f = 10 \text{ cm}$$

### Determine Individual Focal Lengths:

For the convex lens:

$$f_{\text{convex}} = 10 \text{ cm}$$

For the concave lens:

$$f_{\text{concave}} = \frac{-3}{2} \times 10 = -15 \text{ cm}$$

Thus, the focal lengths of the individual lenses are 10 cm for the convex lens and -15 cm for the concave lens.

---

## Question39

**An astronomical telescope has a large aperture to**

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**Options:**

- A. have high resolution.
- B. have low dispersion.
- C. increase the span of observation.
- D. have large wavelength.

**Answer: A**

**Solution:**

An astronomical telescope has a large aperture to :

**Option A : have high resolution.**

A larger aperture allows the telescope to collect more light, which is essential for observing fainter objects and increasing the resolution. The resolution of a telescope is its ability to distinguish between two close objects. According to the Rayleigh criterion, the angular resolution  $\theta$  is given by:

$$\theta = 1.22 \frac{\lambda}{D}$$

where  $\lambda$  is the wavelength of light, and  $D$  is the diameter of the aperture. A larger aperture (larger  $D$ ) results in a smaller  $\theta$ , meaning the telescope can resolve finer details and closely spaced objects more effectively.

---

## Question40

**Three immiscible transparent liquids with uniform refractive indices  $\frac{3}{2}$ ,  $\frac{4}{3}$  and  $\frac{6}{5}$  are arranged one on top of another. The depths of the liquids are 3 cm 4 cm and 6 cm respectively. The apparent depth of the vessel is**

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**Options:**

A. 10 cm

B. 9 cm

C. 8 cm

D. 7 cm

**Answer: A**

**Solution:**

To find the apparent depth of a vessel containing three immiscible transparent liquids with refractive indices of  $\frac{3}{2}$ ,  $\frac{4}{3}$ , and  $\frac{6}{5}$ , and depths of 3 cm, 4 cm, and 6 cm respectively, we can use the formula for apparent depth.

The formula relating real depth (R) to apparent depth with refractive index ( $\mu$ ) is given by:

$$\mu = \frac{\text{Real depth (R)}}{\text{Apparent depth}}$$

Thus, the apparent depth for each liquid can be calculated as:

$$\text{Apparent depth} = \frac{R}{\mu}$$

For the entire vessel, the total apparent depth is the sum of the apparent depths of each layer of liquid:



$$\text{Apparent depth} = \frac{R_1}{\mu_1} + \frac{R_2}{\mu_2} + \frac{R_3}{\mu_3}$$

Plugging in the values:

$$\text{Apparent depth} = \frac{3}{2} + \frac{4}{3} + \frac{6}{5}$$

Calculating each term:

For the first liquid:

$$\frac{3}{\frac{3}{2}} = 2$$

For the second liquid:

$$\frac{4}{\frac{4}{3}} = 3$$

For the third liquid:

$$\frac{6}{\frac{6}{5}} = 5$$

Adding these gives:

$$\text{Total apparent depth} = 2 + 3 + 5 = 10 \text{ cm}$$

Therefore, the apparent depth of the vessel is 10 cm.

---

## Question41

**Velocity of light in diamond is  $\left(\frac{5}{12}\right)^{\text{th}}$  times that in air. Velocity of light in water is  $\left(\frac{3}{4}\right)^{\text{th}}$  times that in air. The angle of incidence of ray of light travelling from water to diamond is (angle of refraction  $(r) = 30^\circ$ ) [ Given  $\rightarrow \sin 30^\circ = \frac{1}{2}$  ]**

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**Options:**

A.  $\sin^{-1}(9/10)$

B.  $\sin^{-1}(3/4)$

C.  $\sin^{-1}(5/12)$

D.  $\sin^{-1}(9/5)$



**Answer: A**

## Solution:

Given the problem, let's derive the needed information step-by-step:

### Velocity in Mediums:

The velocity of light in diamond ( $v_d$ ) is  $\left(\frac{5}{12}\right)$  times the velocity of light in air ( $c$ ).

The velocity of light in water ( $v_w$ ) is  $\left(\frac{3}{4}\right)$  times the velocity of light in air ( $c$ ).

### Refractive Indices:

Refractive index of diamond ( $\frac{n_d}{n_w}$ ) relative to water can be calculated using the relation between velocities:

$$\frac{n_d}{n_w} = \frac{\frac{c}{v_d}}{\frac{c}{v_w}} = \frac{\frac{12}{5}}{\frac{4}{3}} = \frac{12}{5} \times \frac{3}{4} = \frac{9}{5}$$

### Snell's Law:

Using Snell's Law:

$$n_w n_d = \frac{\sin i}{\sin r}$$

Plug in the values (with angle of refraction  $r = 30^\circ$  where  $\sin 30^\circ = \frac{1}{2}$ ):

$$\sin i = n_w n_d \times \sin r = \frac{9}{5} \times \frac{1}{2} = \frac{9}{10}$$

### Angle of Incidence:

Therefore, the angle of incidence ( $i$ ) is:

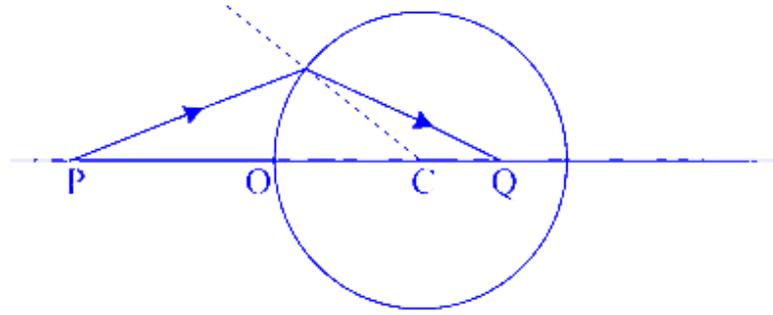
$$i = \sin^{-1} \left( \frac{9}{10} \right)$$

This calculation demonstrates how to determine the angle of incidence when light travels from water to diamond, based on the given velocities and angle of refraction.

---

## Question 42

**A point object kept at P in front of a glass sphere of radius ' R ' has its image formed at Q such that PO = QO. The refractive index of material of glass sphere is 1.4. The distance PO is equal to**



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**Options:**

A.  $\frac{R}{2}$

B.  $2R$

C.  $5R$

D.  $6R$

**Answer: D**

**Solution:**

To solve this problem, we need to determine the distance  $PO$  for which the image is formed at  $Q$  such that  $PO = QO = x$ . Given that the refractive index of the glass sphere is 1.4, we can use the lens-maker's formula for spherical surfaces:

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

In this context:

$$n_1 = 1 \text{ (refractive index of air)}$$

$$n_2 = 1.4 \text{ (refractive index of the glass)}$$

$$u = -x \text{ (since object distance is taken as negative in optics)}$$

$$v = x \text{ (since image distance here is positive)}$$

$R$  is the radius of the sphere

Substituting these values into the formula gives:

$$\frac{1.4}{x} - \left(-\frac{1}{x}\right) = \frac{1.4-1}{R}$$

Simplifying:

$$\frac{1.4}{x} + \frac{1}{x} = \frac{0.4}{R}$$

Combining the terms on the left side:

$$\frac{2.4}{x} = \frac{0.4}{R}$$

Cross-multiplying to solve for  $x$ :

$$x = \frac{2.4}{0.4} \times R$$

Solving this gives:

$$x = 6R$$

Thus, the distance PO is equal to  $6R$ .

---

## Question43

**A convex lens of refractive index  $\frac{3}{2}$  has a power 2.5. If it is placed in a liquid of refractive index 2, the new power of the lens is**

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**Options:**

A. 2.5 D

B. -2.5 D

C. 1.25 D

D. -1.25 D

**Answer: D**

**Solution:**

To determine the new power of a convex lens when it is placed in a liquid, we use the lens maker's formula. Originally, the lens has a refractive index of  $\frac{3}{2}$  and a power of 2.5 D. When immersed in a liquid with a refractive index of 2, the new power of the lens can be calculated as follows:

The lens maker's formula is given by:

$$\frac{1}{f} = P = (\mu - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

Where  $P$  is the power of the lens,  $\mu$  is the refractive index, and  $R_1$  and  $R_2$  are the radii of curvature of the lens surfaces.

When the lens is placed in a liquid, the power is recalculated using:

$$P' = (\mu' - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

To find the refractive index of the lens in the liquid,  $\mu'$ , we have:

$$\mu' = \frac{\mu}{\text{Refractive index of the liquid}} = \frac{\frac{3}{2}}{\frac{3}{4}} = \frac{3}{4}$$

We calculate the ratio of the new power,  $P'$ , to the original power,  $P$ , as follows:

$$\frac{P'}{P} = \frac{\mu' - 1}{\mu - 1} = \frac{\frac{3}{4} - 1}{\frac{3}{2} - 1} = \frac{-\frac{1}{4}}{\frac{1}{2}} = -\frac{1}{2}$$

Thus, the new power,  $P'$ , is:

$$P' = -\frac{1}{2} \times P = -\frac{1}{2} \times 2.5 = -1.25 \text{ D}$$

The lens's new power in the liquid is therefore -1.25 D.

---

## Question44

**Some water is filled in a container of height 30 cm . If is to appear half filled to the observer when viewed from the top of the container, the height upto which water should be filled in it, is [Refractive index of water =  $\frac{4}{3}$ ]**

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**Options:**

- A. 15 cm
- B. 18 cm
- C. 20 cm
- D. 24 cm

**Answer: C**

**Solution:**

Refractive index of a medium is given by,

$$n = \text{Real depth} / \text{Apparent depth} \dots(i)$$

Given that, height of container = 30 cm



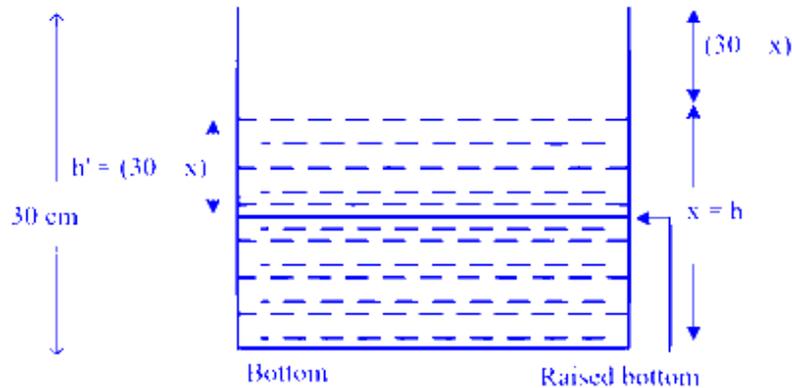
Apparent depth = 15 cm ... (ii)

Real depth =  $n \times$  Apparent depth ... [From (i)]

Given that,  $n_w = \frac{4}{3}$  ... (iii)

Real depth = 20 cm ... [From (ii) and (iii)]

$\therefore x = 20$  cm



## Question45

In an equilateral prism the ray undergoes minimum deviation when it is incident at an angle of  $50^\circ$ . The angle of minimum deviation is

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Options:

- A.  $50^\circ$
- B.  $40^\circ$
- C.  $25^\circ$
- D.  $20^\circ$

**Answer: B**

**Solution:**

In an equilateral prism, the condition for minimum deviation is given by the formula:

$$i = \frac{A + \delta_m}{2}$$

where  $i$  is the angle of incidence,  $A$  is the angle of the prism, and  $\delta_m$  is the angle of minimum deviation.

For an equilateral prism, which has an internal angle of:

$$A = 60^\circ$$

Given that the ray is incident at an angle of  $50^\circ$ , we can substitute these values into the equation:

$$50 = \frac{60 + \delta_m}{2}$$

Solving for  $\delta_m$ :

$$50 \times 2 = 60 + \delta_m$$

$$100 = 60 + \delta_m$$

$$\delta_m = 100 - 60 = 40^\circ$$

Hence, the angle of minimum deviation is  $40^\circ$ .

---

## Question46

**A person is observing a bacteria through a compound microscope. For better analysis and to improve the resolving power he should**

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**Options:**

- A. increase the wavelength of light.
- B. increase the refractive index of the medium between the object and objective lens.
- C. decrease the focal length of the eye-piece.
- D. decrease the diameter of the objective lens.

**Answer: B**

**Solution:**

To enhance the resolving power of a compound microscope when observing bacteria, it is advisable to increase the refractive index of the medium between the object and the objective lens. This improvement can be understood through the formula for the resolving power of a compound microscope:

$$\text{Resolving Power (P)} = \frac{2\mu \sin \theta}{1.22\lambda}$$

In this formula:

$\mu$  is the refractive index of the medium,

$\theta$  is the half-angle of the cone of light that can enter the objective lens,

$\lambda$  is the wavelength of light used.

By increasing the refractive index  $\mu$ , the numerator of the equation increases, thereby enhancing the resolving power. This results in a clearer and more detailed view of the bacteria being observed.

---

## Question47

**A ray of light is incident normally on a glass slab to thickness 5 cm and refractive index 1.6. The time taken to travel by a ray from source of light to surface of slab is same as to travel through glass slab. The distance of source from the surface is**

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**Options:**

- A. 5 cm
- B. 8 cm
- C. 12 cm
- D. 24 cm

**Answer: B**

**Solution:**

To find the distance of the light source from the surface of the glass slab, we can equate the time taken for light to reach the surface from the source ( $T_1$ ) with the time taken to travel through the glass slab ( $T_2$ ).

Let's break down the concepts and calculations:

**Definitions:**

$T_1$ : Time taken for light to travel from the source to the surface of the glass slab.

$s_1$ : Distance from the source to the surface of the slab.

$T_2$ : Time taken for light to travel through the glass slab.

$s_2$ : Thickness of the glass slab, which is 5 cm.

$\mu$ : Refractive index of the glass, which is 1.6.

### Equating times:

We know that  $T_1 = T_2$ .

### Time and velocity relationship for light:

Time is calculated as the distance divided by velocity (Time =  $\frac{\text{Distance}}{\text{Velocity}}$ ).

For the first part of the journey, light travels from the source to the slab in a vacuum or air with speed  $c$  (speed of light in air or vacuum).

For the second part, it travels through the slab with speed  $v$ , where  $v = \frac{c}{\mu}$ .

### Calculations:

From the equation of times:

$$\frac{s_1}{c} = \frac{s_2}{v}$$

Substitute  $v = \frac{c}{\mu}$  into the equation:

$$\frac{s_1}{c} = \frac{s_2 \times \mu}{c}$$

Solve for  $s_1$ :

$$s_1 = s_2 \times \mu = 5 \text{ cm} \times 1.6 = 8 \text{ cm}$$

Therefore, the distance from the source to the surface of the glass slab is 8 cm.

---

## Question48

**Focal length of objective of an astronomical telescope is 1.5 m . Under normal adjustment, length of telescope is 1.56 m . Focal length of the eyepiece is**

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#### Options:

- A. 0.06 m
- B. 1.04 m
- C. 2.34 m
- D. 3.06 m



**Answer: A**

## Solution:

In an astronomical telescope, the total length ( $L$ ) of the telescope under normal adjustment is the sum of the focal lengths of the objective lens ( $f_0$ ) and the eyepiece ( $f_e$ ).

Given:

Focal length of the objective lens ( $f_0$ ) = 1.5 m

Total length of the telescope ( $L$ ) = 1.56 m

The formula for the length of an astronomical telescope under normal adjustment is:

$$L = f_0 + f_e$$

Substituting the given values into the formula:

$$1.56 = 1.5 + f_e$$

To find the focal length of the eyepiece ( $f_e$ ):

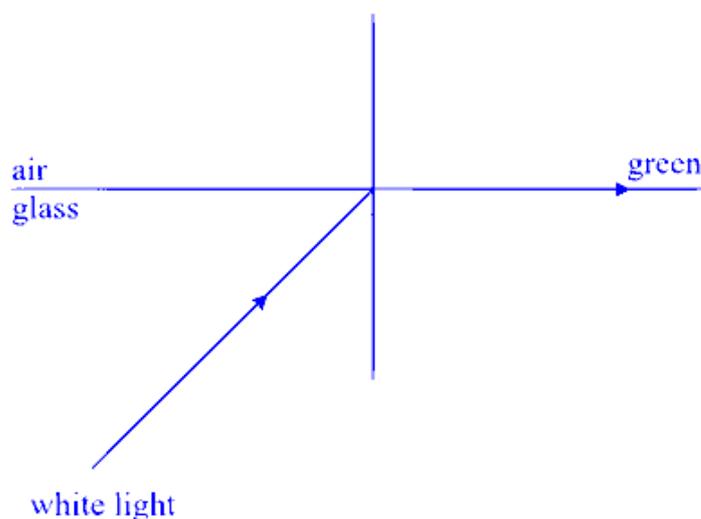
$$f_e = 1.56 - 1.5 = 0.06 \text{ m}$$

Thus, the focal length of the eyepiece is 0.06 m.

---

## Question49

**White light is incident on the interface of glass and air as shown in figure. If green light is just totally internally reflected, then reflected rays inside the glass contain**



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**Options:**

- A. yellow, orange, red
- B. violet, indigo, blue
- C. green, yellow, orange
- D. all colours except green

**Answer: B**

**Solution:**

$$i_c = \sin^{-1} \left( \frac{1}{n} \right) \text{ and } n \propto \frac{1}{\lambda}$$

Violet, indigo, blue have smaller wavelength than green, so  $n$  will be more for these rays, consequently critical angle for these rays will be low, hence if green is just totally internally reflected then red, orange and yellow rays will emerge out and violet, indigo and blue rays will be reflected inside.

---

## Question50

**A convex lens of focal length '  $f$  ' produces a real image whose size is '  $n$  ' times the size of an object. The distance of the object from the lens is**

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**Options:**

- A.  $\frac{n+1}{nf}$
- B.  $f \left( 1 - \frac{1}{n} \right)$
- C.  $\frac{nf}{n+1}$
- D.  $f \left( 1 + \frac{1}{n} \right)$

**Answer: D**

**Solution:**

Given:

A convex lens of focal length '  $f$  ' creates a real image that is '  $n$  ' times the size of the object. We are tasked with finding the object distance ( $u$ ) from the lens.

From lens formula and magnification:

$$\text{Image distance } (v): v = -nu$$

Using the lens formula:

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Substitute for  $v$  in the equation:

$$\frac{1}{f} = \frac{1}{-nu} - \frac{1}{u}$$

$$\frac{1}{f} = \frac{u+nu}{nu^2}$$

Simplifying further:

$$\frac{1}{f} = \frac{1+n}{nu}$$

Therefore, the object distance ( $u$ ) is calculated as:

$$u = f \left( \frac{1+n}{n} \right) = f \left( 1 + \frac{1}{n} \right)$$

Thus, the distance of the object from the lens is  $f \left( 1 + \frac{1}{n} \right)$ .

---

## Question51

**A convex lens of focal length '  $f$  '  $m$  forms a real, inverted image twice in size of the object. The object distance from the lens in metre is**

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**Options:**

A.  $0.5 f$

B.  $0.66 f$

C.  $f$

D.  $1.5 f$

**Answer: D**

## Solution:

To find the object distance when a convex lens creates a real, inverted image twice the size of the object, follow these steps:

**Focal Length:** Let the focal length be  $f$ .

**Magnification:** The magnification ( $m$ ) of the lens is given by the ratio of the image height ( $h'$ ) to the object height ( $h$ ), and also by the ratio of the image distance ( $v$ ) to the object distance ( $u$ ):

$$m = \frac{v}{u} = \frac{h'}{h} = -2$$

Since the image is real and inverted,  $m = -2$ . Therefore, the image distance is:

$$v = -2u$$

**Lens Formula:** The lens formula relates the image distance  $v$ , object distance  $u$ , and focal length  $f$ :

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

**Substitute the value of  $v$ :**

$$\frac{1}{-2u} - \frac{1}{u} = \frac{1}{f}$$

**Simplify the equation:**

$$\frac{u+2u}{2u^2} = \frac{1}{f}$$

$$\frac{3u}{2u^2} = \frac{1}{f}$$

**Solve for  $u$ :**

$$\frac{1.5}{u} = \frac{1}{f}$$

$$u = 1.5f$$

Thus, the object distance from the lens is  $1.5f$ .

---

## Question52

**A ray of light is incident at  $60^\circ$  on one face of a prism of angle  $30^\circ$  and the emergent ray makes  $30^\circ$  with the incident ray. The refractive index of the prism is  $\left(\sin 30^\circ = 0.5, \sin 60^\circ = \sqrt{3}/2\right)$**

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**Options:**

A. 1.732

B. 1.414

C. 1.5

D. 1.33

**Answer: A**

### **Solution:**

To solve this problem, we apply Snell's Law and the prism formula. Given:

Angle of incidence,  $i = 60^\circ$

Angle of the prism,  $A = 30^\circ$

Angle between emergent and incident ray,  $\Delta = 30^\circ$

The angle of deviation  $\delta$  is:

$$\delta = i + e - A$$

where  $e$  is the angle of emergence. Given  $\Delta = 30^\circ$ , it follows that:

$$\delta = \Delta = 30^\circ$$

Thus:

$$\delta = i + e - A = 30^\circ$$

Substitute the known values:

$$60^\circ + e - 30^\circ = 30^\circ$$

$$e = 0^\circ$$

This angle  $e$  cannot be  $0^\circ$ . Therefore, revising calculations leads us to Snell's law application at points where the ray enters and leaves the prism.

Using the prism formula for deviation  $\delta = (i + e) - A$  and Snell's law:

For the first interface:

$$n \cdot \sin 30^\circ = \sin 60^\circ$$

The condition is:

$$n \times 0.5 = \frac{\sqrt{3}}{2}$$

Solve for  $n$ :

$$n = \frac{\sqrt{3}}{2 \times 0.5}$$

$$n = \sqrt{3}$$

Calculating:

$$n = 1.732$$

Thus, the refractive index of the prism is

**Option A: 1.732**

---

## Question53

**A concave mirror of focal length '  $f$  ' produces an image '  $n$  ' time the size of the object. If the image is real, then the distance of the object from the mirror is**

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**Options:**

A.  $(n - 1)f$

B.  $\left(\frac{n-1}{n}\right)f$

C.  $\left(\frac{n+1}{n}\right)f$

D.  $(n + 1)f$

**Answer: C**

**Solution:**

To determine the distance of an object from a concave mirror when the image is real and magnified, follow these steps:

**Understand Magnification:** The magnification  $n$  for a real image produced by a concave mirror is given by:

$$-n = \frac{-v}{u}$$

Here,  $v$  is the image distance and  $u$  is the object distance. Rearranging gives:

$$v = nu$$

**Apply the Mirror Formula:** The mirror equation relates the focal length  $f$ , image distance  $v$ , and object distance  $u$ :

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

**Substituting for  $v$ :** Substitute  $v = nu$  into the mirror formula:

$$\frac{1}{f} = \frac{1}{nu} + \frac{1}{u}$$



Solve for  $u$ :

$$\frac{1}{f} = \frac{1+n}{nu}$$

$$u = \left(\frac{n+1}{n}\right)f$$

Therefore, the distance of the object from the mirror is  $\left(\frac{n+1}{n}\right)f$ .

---

## Question54

The focal length of combination of lenses formed with lenses having power of +2.50 D and  $-3.75$  D will be

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Options:

A.  $-20$  cm

B.  $-40$  cm

C.  $-60$  cm

D.  $-80$  cm

**Answer: D**

**Solution:**

To find the focal length of a combination of lenses with powers +2.50 D and -3.75 D, we start by calculating the combined power ( $P$ ) of the lenses:

$$\begin{aligned} P &= P_1 + P_2 \\ &= 2.50 + (-3.75) \\ &= 2.50 - 3.75 \\ &= -1.25 \text{ D} \end{aligned}$$

Next, we use the formula for focal length ( $f$ ) which is the reciprocal of the power:

$$f = \frac{1}{P} = \frac{1}{-1.25} = -0.8 \text{ m}$$

Converting meters to centimeters, we get:

$$f = -80 \text{ cm}$$

---

## Question55

Two thin lenses have a combined power of +9D. When they are separated by a distance of 20 cm, their equivalent power becomes  $+\frac{27}{5}$  D. The power of both the lenses in diopetre are respectively

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Options:

- A. 4, 5
- B. 3, 6
- C. 2, 7
- D. 1, 8

**Answer: B**

**Solution:**

$$P_1 + P_2 = 9D \quad \dots (i)$$

$$P_1 + P_2 - dP_1P_2 = \frac{27}{5} \quad \dots (ii)$$

where  $d = 20 \text{ cm} = 0.2 \text{ m}$

Substituting value of  $(P_1 + P_2)$  in equation (ii) we get

$$9 - 0.2P_1P_2 = \frac{27}{5}$$

$$\therefore 0.2P_1P_2 = 9 - \frac{27}{5} = \frac{18}{5}$$

$$\therefore P_1P_2 = \frac{18}{0.2 \times 5} = 18$$

Since  $P_1 + P_2 = 9$  and  $P_1P_2 = 18$

$$\therefore P_1 = 3 \text{ and } P_2 = 6$$

---

## Question56

A plane mirror produces a magnification of



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## Options:

A.  $-1$

B. zero

C.  $+1$

D.  $+2$

**Answer: C**

## Solution:

To determine the magnification produced by a plane mirror, we need to understand how magnification is defined in optics.

### Definition of Magnification:

The magnification ( $m$ ) of a mirror is given by the ratio of the height of the image ( $h'$ ) to the height of the object ( $h$ ):

$$m = \frac{h'}{h}$$

It is also related to the object distance ( $u$ ) and image distance ( $v$ ) by the formula:

$$m = -\frac{v}{u}$$

### Sign Convention:

**Object Distance ( $u$ ):** For mirrors, the object is placed in front of the mirror, so  $u$  is taken as **negative**.

**Image Distance ( $v$ ):** For a plane mirror, the image is formed behind the mirror, so  $v$  is **positive**.

**Height ( $h$  and  $h'$ ):** Upward direction is positive; since the image in a plane mirror is upright,  $h'$  has the same sign as  $h$ .

### Applying to a Plane Mirror:

#### Image Characteristics:

The image formed by a plane mirror is **virtual, upright**, and **same size** as the object.

The image distance ( $v$ ) is equal in magnitude to the object distance ( $u$ ) but opposite in sign:

$$v = -u$$

#### Calculating Magnification:

Using the magnification formula:

$$m = -\frac{v}{u} = -\frac{(-u)}{u} = -(-1) = +1$$



Alternatively, since the image height equals the object height ( $h' = h$ ):

$$m = \frac{h'}{h} = \frac{h}{h} = +1$$

**Interpretation:**

A magnification of +1 indicates that the image is **upright** and **identical in size** to the object.

The positive sign confirms that there is **no inversion** of the image.

**Conclusion:**

A plane mirror produces a magnification of +1.

---

**Answer: Option C**

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## Question57

**The telescopes, for a given wavelength, the objectives with large aperture are used for**

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**Options:**

- A. greater magnification.
- B. greater resolution.
- C. reducing lens aberration.
- D. ease of manufacture.

**Answer: B**

**Solution:**

According to mathematical equation  $R.P. \propto \frac{1}{\lambda}$ , telescopes being used in sunlight to observe celestial objects, practically there is no control on wavelength incident ( $\lambda$ ). Hence, using objective lens of large aperture is effective way to increase R.P. of telescope.

---

## Question58



**Refractive index of a glass convex lens is 1.5. The radius of curvature of each of the two surfaces of the lens is 20 cm. The ratio of the power of the lens when immersed in a liquid of refractive index 1.25 to that when placed in air is**

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**Options:**

A. 2 : 3

B. 2 : 5

C. 3 : 5

D. 5 : 2

**Answer: B**

**Solution:**

Given data:  $\mu_g = 1.5$ ,  $R_1 = R_2 = 20$  cm,  $\mu_l = 1.25$

$$P_1 = \left( \frac{\mu_g}{\mu_a} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = (1.5 - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$
$$\therefore P_2 = \left( \frac{\mu_g}{\mu_l} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = \left( \frac{1.5}{1.25} - 1 \right) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$
$$= (1.2 - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

Taking ratio,

$$\frac{P_2}{P_1} = \frac{1.2-1}{1.5-1} = \frac{2}{5}$$

---

## Question59

**When a monochromatic ray of light is passed through an equilateral glass prism, it is found that the refracted ray in glass is parallel to the base of the prism. If 'i' and 'e' denote the angles of incidence and emergence respectively, then**

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### Options:

A.  $i > e$

B.  $i < e$

C.  $i = e$

D.  $i + e = 90^\circ$

**Answer: C**

### Solution:

When light travels from one medium to another, it undergoes refraction twice in the case of a prism: first when entering the prism and second when exiting it. The path of light inside the prism is parallel to the base, which means that the angle of incidence at the first surface is equal to the angle of emergence at the second surface.

Since we are dealing with an equilateral prism, the angles at each corner are  $60^\circ$ . Let's denote the angle of the prism as  $A$ . When the ray inside the prism is parallel to the base, the angle of refraction at the first surface (inside the prism) will be equal to the angle of incidence at the second surface. Let's denote this angle as  $r$  (which is also the angle of refraction at the second surface), then according to Snell's Law, where the refractive index of glass is denoted by  $n$ :

$$n \cdot \sin(i) = \sin(r)$$

and

$$n \cdot \sin(e) = \sin(r)$$

Since the refracted ray in glass is parallel to the base of the prism, the deviation of the ray inside the prism is minimal, and this occurs when  $r$  equals  $A/2$  for an equilateral prism, so

$$r = 60^\circ/2 = 30^\circ$$

Since the values of  $\sin(i)$  and  $\sin(e)$  are both obtained by multiplying  $\sin(r)$  with the refractive index  $n$ , we have

$$\sin(i) = \sin(e)$$

Because the sine function is increasing for angles between  $0^\circ$  and  $90^\circ$ , if  $\sin(i)$  equals  $\sin(e)$ , the corresponding angles must also be equal, thus

$$i = e$$

Hence, the correct option is:

Option C  $i = e$

---



## Question60

A combination of two thin lenses in contact have power +10D. The power reduces to +6D when the lenses are 0.25 m apart. The power of individual lens is

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Options:

A. 5D, 5D

B. 6D, 4D

C. 7D, 3D

D. 8D, 2D

Answer: D

Solution:

When in contact, the equivalent power of two thin lenses is,

$$P_1 + P_2 = 10 \dots (i)$$

When the lenses are separated by 0.25 m,

$$P_1 + P_2 - 0.25P_1P_2 = 6$$

$$\therefore 0.25P_1P_2 = 4$$

$$\therefore P_1P_2 = 16$$

$$P_1 - P_2 = \sqrt{(P_1 + P_2)^2 - 4P_1P_2}$$

$$\therefore P_1 - P_2 = \sqrt{36} = 6 \dots (ii)$$

Adding equations (i) and (ii), we get,

$$P_1 = 8D$$

$$\therefore P_2 = 10 - 8 = 2D$$

---

## Question61



The angle of deviation produced by a thin prism when placed in air is ' $\delta_1$ ' and that when immersed in water is ' $\delta_2$ '. The refractive index of glass and water are  $\frac{3}{2}$  and  $\frac{4}{3}$  respectively. The ratio  $\delta_1 : \delta_2$  is

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**Options:**

A. 1 : 2

B. 2 : 1

C. 1 : 4

D. 4 : 1

**Answer: D**

**Solution:**

For thin prism,  $\delta = (\mu - 1)A$

Given,  $\mu_1 = \frac{\mu_{\text{glass}}}{\mu_{\text{air}}} = \frac{3}{2}$  and  $\frac{\mu_{\text{water}}}{\mu_{\text{air}}} = \frac{4}{3}$

$$\therefore \mu_2 = \frac{\mu_{\text{glass}}}{\mu_{\text{water}}} = \frac{\frac{3}{2}}{\frac{4}{3}} = \frac{9}{8}$$

$$\therefore \frac{\delta_1}{\delta_2} = \frac{\mu_1 - 1}{\mu_2 - 1} = \frac{\frac{3}{2} - 1}{\frac{9}{8} - 1}$$

$$\therefore \frac{\delta_1}{\delta_2} = 4$$

---

## Question62

A ray of light passes through an equilateral prism such that the angle of incidence ( $i$ ) is equal to angle of emergence ( $e$ ). The angle of emergence is equal to  $\left(\frac{3}{4}\right)$ th the angle of prism. The angle of deviation is

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**Options:**

A.  $20^\circ$

B.  $30^\circ$

C.  $39^\circ$

D.  $45^\circ$

**Answer: B**

**Solution:**

Given, angle of incidence = angle of emergence =  $\frac{3}{4} A$

Here,  $A$  = angle of prism

$\therefore$  prism is equilateral,  $A = 60^\circ$

$\therefore i = e = 60^\circ \times \frac{3}{4} = 45^\circ$

From prism formula,

Angle of deviation,  $\delta = i + e - A$   
 $= 45 + 45 - 60 = 30^\circ$

---

## Question63

**The radii of curvature of both the surfaces of a convex lens of focal length  $f$  and power  $P$  are equal. One of the surfaces is made by plane grinding. The new focal length and focal power of the lens is**

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**Options:**

A.  $\frac{2}{3} f, \frac{2}{3} P$

B.  $\sqrt{\frac{2}{f}}, \sqrt{\frac{P}{2}}$

C.  $\frac{f}{2}, 2P$

D.  $2f, \frac{P}{2}$

**Answer: D**

### Solution:

Since, the radius of curvature of both the surface is same,

$$\frac{1}{f} = (\mu - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = (\mu - 1) \left( \frac{1}{R} + \frac{1}{R} \right)$$
$$\therefore \frac{1}{f} = \frac{2(\mu - 1)}{R} \dots (i)$$

So, when one surface is made plane by grinding, we have

$$R_1 = R \text{ and } R_2 = \infty$$

$$\text{Then, } \frac{1}{f'} = (\mu - 1) \left( \frac{1}{R} - 0 \right)$$

$$\Rightarrow \frac{1}{f'} = \frac{(\mu - 1)}{R} \dots (ii)$$

From Eqs. (i) and (ii), we get

So,

$$\frac{f'}{f} = 2$$

$$\therefore f' = 2f$$

and power will be  $\frac{P}{2}$ .  $\left( \because P = \frac{1}{f} \right)$

---

## Question64

**A spherical surface of radius of curvature 'R' separates air from glass of refractive index 1.5. The centre of curvature is in the glass. A point object P placed in air forms a real image Q in the glass. The line PQ cuts the surface at point 'O' and PO = OQ = x. Hence the distance 'x' is equal to**

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**Options:**

A. 1.5 R

B. 2 R

C. 3 R

D. 5 R

**Answer: D**

**Solution:**

Given:  $u = -x, v = +x$

We know,

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$
$$\Rightarrow \frac{1.5}{x} + \frac{1}{x} = \frac{0.5}{R}$$
$$\frac{2.5}{x} = \frac{0.5}{R}$$
$$\therefore x = 5R$$

---

## Question65

**Array of light is incident at an angle of incidence 'i' on one surface of a prism of small angle A and emerges normally from the other surface. If the refractive index of the material of the prism is ' $\mu$ ', then the angle of incidence is equal to**

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**Options:**

A.  $\frac{A}{2\mu}$

B.  $\frac{A\mu}{2}$

C.  $A\mu$

D.  $\frac{A}{\mu}$



**Answer: C**

**Solution:**

Given:  $e = 0$

$$\therefore r_2 = 0, A = r_1$$

Since 'i' is small, Snell's law of refraction can be modified to,

$$\mu = \frac{i}{r_1}$$

$$\therefore i = \mu r_1 = \mu A$$

---

## Question66

**A glass prism deviates the red and violet rays through  $9^\circ$  and  $11^\circ$  respectively. A second prism of equal angle deviates them through  $11^\circ$  and  $13^\circ$  respectively. The ratio of dispersive power of second prism to first prism is**

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**Options:**

A. 5 : 6

B. 6 : 5

C. 9 : 13

D. 13 : 9

**Answer: A**

**Solution:**

$\therefore$  Dispersive Power of Prism:

$$\omega = \frac{\delta_v - \delta_r}{\delta_y}$$

$$\delta_y = \frac{\delta_v + \delta_r}{2} = \frac{11 + 9}{2}$$

$\therefore$  For first Prism,



$$\omega_1 = \frac{2(11 - 9)}{11 + 9}$$
$$= \frac{1}{5}$$

For Second Prism:

$$\omega_2 = \frac{2(13 - 11)}{13 + 11}$$
$$= \frac{1}{6}$$

Ratio:

$$\frac{\omega_2}{\omega_1} = \frac{\frac{1}{6}}{\frac{1}{5}} = \frac{5}{6}$$

∴ The ratio is 5 : 6.

---

## Question67

An ink mark is made on a piece of paper on which a glass slab of thickness ' $t$ ' is placed. The ink mark appears to be raised up through a distance ' $x$ ' when viewed at nearly normal incidence. If the refractive index of the material of glass slab is ' $\mu$ ' then the thickness of glass slab is given by

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**Options:**

A.  $\frac{\mu x}{\mu - 1}$

B.  $\frac{(\mu - 1)}{\mu}$

C.  $\frac{\mu - 1}{\mu x}$

D.  $\frac{\mu}{(\mu - 1)x}$

**Answer: A**

**Solution:**

Here, the normal shift is  $x$



The formula for the normal shift is

$$x = t \left( 1 - \frac{1}{\mu} \right)$$

$$t = \frac{x}{\left( 1 - \frac{1}{\mu} \right)}$$

$$x = t \left( 1 - \frac{1}{\mu} \right)$$

$$t = \frac{x}{\left( 1 - \frac{1}{\mu} \right)}$$

$$\therefore t = \frac{x\mu}{(\mu - 1)}$$

---

## Question68

**Converging or diverging ability of a lens or mirror is called**

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**Options:**

- A. focal power
- B. focal length
- C. magnifying power
- D. linear magnification

**Answer: A**

**Solution:**

The converging or diverging ability of a lens or mirror is referred to as its "focal power." Focal power, measured in diopters (D), is the reciprocal of the focal length (in meters). It indicates how strongly the lens or mirror converges (positive focal power) or diverges (negative focal power) light.

Therefore, the correct answer is :

Option A : focal power

---

## Question69

**One of the necessary condition for total internal reflection to take place is**

**(  $i$  = angle of incidence,  $i_c$  = critical angle)**

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**Options:**

A.  $i < i_c$

B.  $i = i_c$

C.  $i = \frac{\pi^e}{2}$

D.  $i > i_c$

**Answer: D**

**Solution:**

✔ Correct Answer: D.  $i > i_c$

✔ Explanation (Simple & Exam-Oriented)

For total internal reflection (TIR) to occur, two conditions must be satisfied:

**Condition 1: Light must travel from denser to rarer medium**

Example:

Glass → Air

Water → Air

**Condition 2: Angle of incidence must be greater than the critical angle**

$$i > i_c$$

- If  $i < i_c$ : Refraction occurs
- If  $i = i_c$ : Refracted ray grazes along the surface
- If  $i > i_c$ : Total internal reflection happens

Therefore:

✔ Required condition →  $i > i_c$



---

## Question70

A double convex lens of focal length ' $F$ ' is cut into two equal parts along the vertical axis. The focal length of each part will be

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Options:

A.  $2 F$

B.  $F$

C.  $\frac{F}{2}$

D.  $4 F$

**Answer: A**

**Solution:**

For bifocal convex lens

$$\begin{aligned}\frac{1}{f} &= (\mu - 1) \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \\ &= \frac{(\mu - 1) \times 2}{R} \quad \dots (R_1 = R_2 = R)\end{aligned}$$

For plane surface  $R_2 = \infty$

For half plane-convex lens

$$\begin{aligned}\frac{1}{f'} &= (\mu - 1) \frac{1}{R} \\ \frac{1/f}{1/f'} &= \frac{(\mu - 1)}{R} \times 2 \times \frac{R}{\mu - 1} = 2 \\ \frac{f}{f'} &= 2 \\ f' &= 2f\end{aligned}$$

As focal length is  $F$ ,  $f' = 2 F$ .

---

## Question71



The size of the real image produced by a convex lens of focal length  $F$  is ' $m$ ' times the size of the object. The image distance from the lens is

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Options:

A.  $\frac{F}{(m-1)}$

B.  $\frac{(m-1)}{F}$

C.  $F(m + 1)$

D.  $F(m - 1)$

**Answer: C**

**Solution:**

From lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{F}$$

For a convex lens,  $u$  is negative,  $v$  and  $F$  are positive.

$$\therefore \frac{1}{v} - \frac{1}{-u} = \frac{1}{F}$$

$$\therefore \frac{1}{v} = \frac{1}{F} - \frac{1}{u}$$

Multiplying by  $v$ ,

$$1 = \frac{v}{F} - \frac{v}{u}$$

$$\therefore 1 = \frac{v}{F} - m \quad \dots \left( \because \frac{v}{u} = m \right)$$

$$\therefore \frac{v}{F} = 1 + m$$

$$\therefore v = F(1 + m)$$

---

## Question72

The prism has refracting angle ' $A$ '. The second refracting surface of the prism is silvered. Light ray falling on first refracting surface with angle of incidence ' $2A$ ', reaches the second surface and returns back

through the same path due to reflection at the silvered surface. The refractive index of the material of the prism is

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**Options:**

A.  $\frac{1}{2} \sin A$

B.  $\frac{1}{2} \cos A$

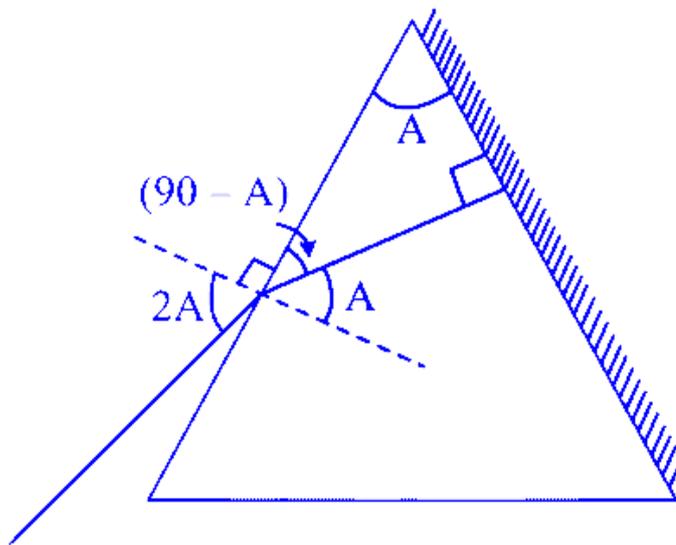
C.  $2 \sin A$

D.  $2 \cos A$

**Answer: D**

**Solution:**

Normal incidence at silvered surface



$$\therefore \mu = \frac{\sin i}{\sin r} = \frac{\sin 2A}{\sin A} = \frac{2 \sin A \cos A}{\sin A} = 2 \cos A$$

---

## Question 73

To get three images of a single object, the angle between the two plane mirrors should be

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**Options:**

- A.  $50^\circ$
- B.  $60^\circ$
- C.  $72^\circ$
- D.  $90^\circ$

**Answer: D**

**Solution:**

As the object is placed symmetrically,

$$n = \left(\frac{360^\circ}{\theta} - 1\right) \Rightarrow 3 = \left(\frac{360^\circ}{\theta} - 1\right) \Rightarrow \theta = 90^\circ$$

---

## Question74

**Two lenses of power  $-15D$  and  $+5D$  are in contact with each other. The focal length of the combination is**

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**Options:**

- A.  $-0.1$  cm
- B.  $-10$  cm
- C.  $-20$  cm
- D.  $+10$  cm

**Answer: B**

**Solution:**



$$P = \frac{1}{f}$$

For combination of lenses,

$$P = P_1 + P_2$$

Given:  $P_1 = -15D$  and  $P_2 = +5D$

$$\therefore P = -10D$$

$$\Rightarrow f = -\frac{1}{10}m$$

$$\therefore f = -10 \text{ cm}$$

---

## Question75

Which of the following is NOT involved in the formation of secondary rainbow?

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**Options:**

- A. Refraction
- B. Angular dispersion
- C. Interference
- D. Total internal reflection

**Answer: C**

**Solution:**

The option that is NOT involved in the formation of a secondary rainbow is Option C: Interference.

Rainbows are formed from the optical processes that occur when sunlight interacts with raindrops. A secondary rainbow, which appears outside the primary rainbow and is fainter and has its colors reversed, is created through three processes :

- **Refraction:** When sunlight enters a raindrop, it is bent (refracted) due to the change in medium from air to water. This bending of light is essential in separating the white sunlight into its component colors.
- **Angular dispersion:** This term refers to the separation of white light into its colors due to the different degrees of bending (refraction) for different wavelengths/colors. Violet light bends more than red light, resulting in dispersion.



- **Total internal reflection:** After refraction, the light rays strike the other side of the raindrop and reflect. In the secondary rainbow, light reflects twice inside the raindrop before emerging out. This double reflection causes the colors to be reversed as compared to the primary rainbow, and contributes to the formation of the secondary rainbow.

Interference, on the other hand, is the phenomenon where waves overlap and combine with each other, leading to patterns of constructive and destructive interference. While this process is crucial in some optical phenomena, like the thin film interference seen in soap bubbles, it is not a key process in the formation of the typical primary or secondary rainbow. In rainbows, each individual raindrop contributes to the rainbow separately, and interference between waves from different raindrops does not play a role in their formation.

---

## Question76

**A double convex air bubble in water behaves as**

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**Options:**

- A. convergent lens
- B. divergent lens
- C. plane slab
- D. concave mirror

**Answer: B**

**Solution:**

$$\mu_{\text{water}} = 1.33 \text{ and } \mu_{\text{air}} = 1$$

As air is optically rarer,  $\mu_{\text{air}} < \mu_{\text{glass}}$ , converging nature of the convex lens changes to diverging. Thus it behaves as divergent lens.

---

## Question77

**If a ray of light in denser medium strikes a rarer medium at angle of incidence  $i$ , the angles of reflection and refraction are  $r$  and  $r'$  respectively. If the reflected and refracted rays are at right angles to each other, the critical angle for the given pair of media is**



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Options:

A.  $\sin^{-1}(\tan r')$

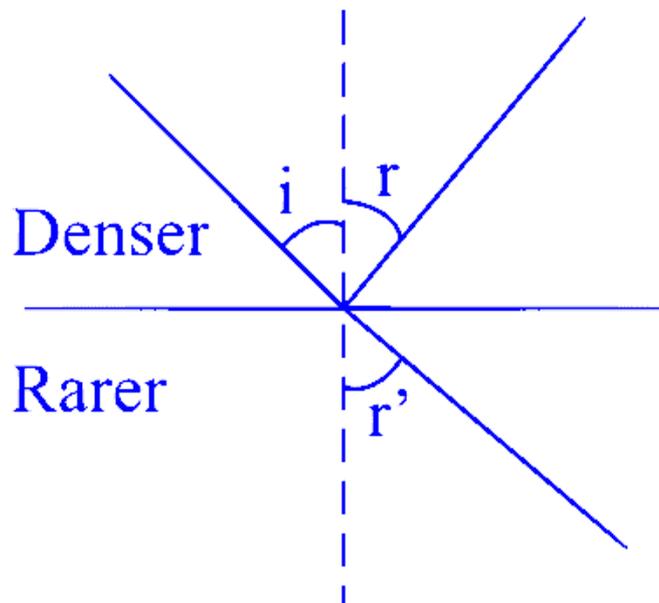
B.  $\sin^{-1}(\tan r)$

C.  $\tan^{-1}(\sin i)$

D.  $\cot^{-1}(\tan i)$

**Answer: B**

**Solution:**



According to Snell's Law,

$$\frac{\sin i}{\sin r} = \frac{1}{n}$$

But  $i = r$ ,

$$\therefore \frac{\sin r}{\sin r'} = \frac{1}{n}$$

From figure  $r' + r + 90 = 180^\circ$

$$\therefore r' = 180^\circ - 90^\circ - r = 90^\circ - r$$

$$\therefore \Rightarrow \frac{\sin r}{\sin(90^\circ - r)} = \frac{1}{n}$$

$$\frac{\sin r}{\cos r} = \frac{1}{n}$$

$$\therefore \tan r = \frac{1}{n}$$

Critical angle is given by  $\sin i_c = \frac{1}{n}$

$$\therefore \tan r = \sin i_c$$

$$\therefore i_c = \sin^{-1}(\tan r)$$

---

## Question 78

A transparent glass cube of length 24 cm has a small air bubble trapped inside. When seen normally through one surface from air outside, its apparent distance is 10 cm from the surface. When seen normally from opposite surface, its apparent distance is 6 cm. The distance of the air bubble from first surface is

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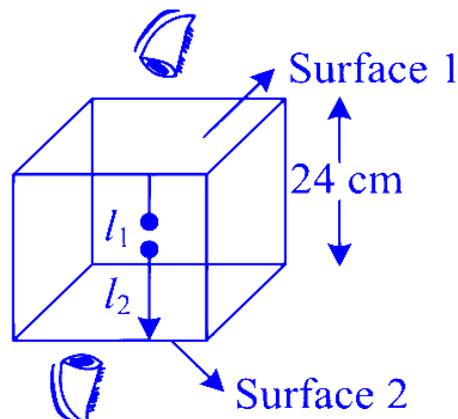
Options:

- A. 15 cm
- B. 14 cm
- C. 12 cm
- D. 8 cm

Answer: A

Solution:

Given: Length of cube = 24 cm



$$\mu = \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{l_1}{h_1} = \frac{24-l_1}{h_2}$$

putting  $h_1 = 10$  cm and  $h_2 = 6$  cm into (i), we get  $\frac{l_1}{10} = \frac{24-l_1}{6}$

$$6l_1 = 240 - 10l_1$$

$$16l_1 = 240$$

$$\therefore l_1 = 15 \text{ cm}$$

## Question 79

The angle of prism is  $A$  and one of its refracting surface is silvered. Light rays falling at an angle of incidence ' $2A$ ' on the first surface return back through the same path after suffering reflection at the silvered surface. The refractive index of the material of the prism is

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Options:

A.  $2 \sin \left( \frac{A}{2} \right)$

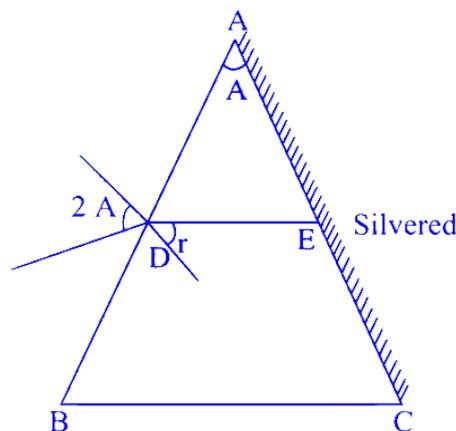
B.  $2 \tan A$

C.  $2 \cos A$

D.  $2 \sin A$

**Answer: C**

**Solution:**



Given: Angle of Prism = A, I = 2 A

As DE is falling normally on the silvered side AC,

$$r = 90 - (90 - A)$$

$$r = A$$

Using Snell's law,

$$\frac{\sin i}{\sin r} = \frac{\sin 2A}{\sin A} = \frac{2 \sin A \cos A}{\sin A} = 2 \cos A$$

---

## Question 80

The speed of light in two media  $M_1$  and  $M_2$  are  $1.5 \times 10^8$  m/s and  $2 \times 10^8$  m/s respectively. If the light undergoes total internal reflection, the critical angle between the two media is

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**Options:**

A.  $\sin^{-1} \left( \frac{3}{2} \right)$

B.  $\sin^{-1} \left( \frac{2}{3} \right)$

C.  $\sin^{-1} \left( \frac{4}{3} \right)$

D.  $\sin^{-1} \left( \frac{3}{4} \right)$

**Answer: D**

**Solution:**

$$V_{M_1} = 1.5 \times 10^8 \text{ m/s}, V_{M_2} = 2 \times 10^8 \text{ m/s}$$

$$\therefore V_{M_2} > V_{M_1}$$

$\therefore M_1$  is a denser medium and  $M_2$  is a rarer medium.

$\therefore$  For critical angle, the ray must travel from  $M_1$  to  $M_2$

$$\therefore M_1 \mu_{M_2} = \frac{V_{M_1}}{V_{M_2}} = \frac{1.5 \times 10^8}{2 \times 10^8} = \frac{3}{4}$$

$$\therefore M_1 \mu_{M_2} = \sin C = \frac{3}{4}$$

$$\therefore C = \sin^{-1} \left( \frac{3}{4} \right)$$

---

## Question81

The minimum distance between an object and its real image formed by a convex lens of focal length 'f' is

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**Options:**

A. 2f

B. 4f

C. 1.5f

D. 2.5f

**Answer: B**

**Solution:**

To find the minimum distance between an object and its real image formed by a convex lens, we need to take into account the lens formula, which is given by:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

where:

- $f$  is the focal length of the lens,
- $d_o$  is the distance of the object from the lens, and
- $d_i$  is the distance of the image from the lens.

To find the minimum distance between the object and its image, we should consider the case where the object is at a distance of  $2f$  from the lens. In this case, according to the properties of a convex lens, the image will also be formed at a distance  $2f$  on the other side of the lens. This situation corresponds to the object and the image being at the same distance from the lens and both being twice the focal length. The separation between the object and the image would then be the sum of these distances. Thus, the object distance  $d_o = 2f$  and the image distance  $d_i = 2f$ .

To find the minimum total distance between the object and image ( $D$ ), we simply add the object distance ( $d_o$ ) and the image distance ( $d_i$ ):

$$D = d_o + d_i = 2f + 2f = 4f$$

Therefore, the minimum distance between an object and its real image formed by a convex lens of focal length  $f$  is  $4f$ , which corresponds to Option B.

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## Question 82

**A ray of light is incident on one face of an equilateral glass prism having refractive index  $\sqrt{2}$ . It produces the emergent ray which just grazes along the adjacent face. The value of angle of incidence is**

$$\left( \sin 45^\circ = \cos 45^\circ = \frac{1}{\sqrt{2}} \right)$$

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**Options:**

A.  $\sin^{-1} \left( \frac{1}{\sqrt{2}} \sin 15^\circ \right)$

B.  $\sin^{-1} \left( \sqrt{2} \sin 30^\circ \right)$

C.  $\sin^{-1} \left( \frac{1}{\sqrt{2}} \sin 45^\circ \right)$

D.  $\sin^{-1} \left( \sqrt{2} \sin 15^\circ \right)$

**Answer: D**



## Solution:

The emergent ray just grazes the second face.

Hence angle of emergence  $e = 90^\circ$

$$\mu = \frac{\sin e}{\sin r_2} = \frac{\sin 90^\circ}{\sin r_2} = \frac{1}{\sin r_2}$$

$$\therefore \frac{1}{\sin r_2} = \sqrt{2} \quad \text{or} \quad \sin r_2 = \frac{1}{\sqrt{2}}$$

$$\therefore r_2 = 45^\circ; \quad A = r_1 + r_2 \quad \therefore r_1 = A - r_2 = 60 - 45 = 15^\circ$$

$$\text{Also, } \frac{\sin i}{\sin r_1} = \mu \quad \therefore \sin i = \mu \sin r_1 = \sqrt{2} \sin 15^\circ$$

$$\therefore i = \sin^{-1}(\sqrt{2} \sin 15^\circ)$$

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## Question83

**White light consists of wavelengths from 480 nm to 672 nm. What will be the wavelength range when white light is passed through glass of refractive index 1.6?**

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**Options:**

A. 420 nm – 672 nm

B. 300 nm – 480 nm

C. 300 nm – 420 nm

D. 300 nm – 672 nm

**Answer: C**

**Solution:**

To find the wavelength range of white light when it passes through a medium with a refractive index, we need to understand how wavelength changes as light enters a different medium. The refractive index  $n$  is related to the wavelength in the medium by the formula:

$$\lambda_{\text{medium}} = \frac{\lambda_{\text{vacuum}}}{n}$$

where  $\lambda_{\text{medium}}$  is the wavelength of light in the medium (glass in this case),  $\lambda_{\text{vacuum}}$  is the wavelength of light in a vacuum (or air, for practical purposes), and  $n$  is the refractive index of the medium.

Given that the refractive index of glass is 1.6, we will now calculate the new wavelength range of the light inside the glass:

The given range of wavelengths in the air is from 480 nm to 672 nm.

For the lower end of the range:

$$\lambda_{\text{glass, min}} = \frac{480 \text{ nm}}{1.6} = 300 \text{ nm}$$

For the upper end of the range:

$$\lambda_{\text{glass, max}} = \frac{672 \text{ nm}}{1.6} = 420 \text{ nm}$$

Thus, when white light passes through glass with a refractive index of 1.6, the wavelength range becomes 300 nm – 420 nm.

The correct option is:

Option C

300 nm – 420 nm

---

## Question84

**A monochromatic ray of light travels through glass slab and water column. The number of waves in glass slab of thickness 4 cm is the same as in water column of height 5 cm. If refractive index of glass is  $\frac{5}{3}$  then refractive index of water is**

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**Options:**

A. 1.33

B. 1.30

C. 1.25



D. 1.10

**Answer: A**

**Solution:**

If the number of waves is  $N$ , then wavelength in water is  $\frac{5}{N}$  cm and wavelength in glass is  $\frac{4}{N}$  cm.

$$\lambda_w = \frac{5}{N}, \lambda_g = \frac{4}{N}$$

$$w\mu_g = \frac{\lambda_w}{\lambda_g} = \frac{5}{4}$$

$$\therefore \frac{\mu_g}{\mu_w} = \frac{5}{4}$$

$$\therefore \mu_w = \frac{4}{5}\mu_g = \frac{4}{5} \times \frac{5}{3} = \frac{4}{3} = 1.33$$

---

## Question85

**The radii of curvature of both the surfaces of a convex lens of focal length 'f' and focal power 'P' are equal. One of the surfaces is made plane by grinding. The new focal length and focal power of the lens is respectively**

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**Options:**

A.  $\frac{1}{2}, 2$

B.  $2f, \frac{P}{2}$

C.  $\sqrt{\frac{2}{f}}, \sqrt{\frac{P}{2}}$

D.  $\frac{2f}{3}, \frac{2}{3}P$

**Answer: B**

**Solution:**

$$P = \frac{1}{f} = (\mu - 1) \left( \frac{1}{R} + \frac{1}{R} \right) = (\mu - 1) \frac{2}{R}$$



$$p' = \frac{1}{f'} = (\mu - 1) \frac{1}{R}$$
$$\therefore p' = \frac{p}{2} \text{ and } f' = 2f$$

---

## Question86

A glass slab has refractive index ' $\mu$ ' with respect to air and the critical angle for a ray of light in going from glass to glass to air is ' $\theta$ '. If a ray of light is incident from air on the glass with angle of incidence ' $\theta$ ', then the corresponding angle of refraction is

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Options:

A.  $\sin^{-1} \left( \frac{1}{\sqrt{\mu}} \right)$

B.  $\sin^{-1} \left( \frac{1}{\mu} \right)$

C.  $\sin^{-1} \left( \frac{1}{\mu^2} \right)$

D.  $90^\circ$

**Answer: C**

**Solution:**

In the first case  $\theta$  is the critical angle

$$\text{Hence } \sin \theta = \frac{1}{\mu}$$

$$\text{In the second case } \frac{\sin \theta}{\sin r} = \mu \quad \therefore \sin r = \frac{\sin \theta}{\mu}$$

$$\therefore \sin r = \frac{1}{\mu^2} \quad \therefore r = \sin^{-1} \left( \frac{1}{\mu^2} \right)$$

---

## Question87



'Circle of least confusion' refers to which one of the following defects occurring in images formed by mirrors or lenses?

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Options:

- A. Distortion
- B. Coma
- C. Astigmatism
- D. Spherical aberration

**Answer: D**

**Solution:**

✔ Correct Answer: **D. Spherical aberration**

✔ Explanation

When light passes through a **spherical lens or mirror**, rays farther from the axis (marginal rays) and rays close to the axis (paraxial rays) do **not converge at the same point**.

This defect is called:

◆ **Spherical Aberration**

Because of this, instead of forming a sharp focus, the image forms a **blurred region** along the axis.

Inside this blurred region, the point where the image is **least blurred** (minimum confusion) is called:

★ **Circle of Least Confusion**

It is the best possible focus when spherical aberration is present.

---

## Question88

A plano-convex lens of refractive index ( $\mu_1'$ ) fits exactly into a plano-concave lens of refractive index  $\mu_2$ . Their plane surface are parallel to each other. 'R' is the radius of curvature of the curved surface of the lenses. The focal length of the combination is



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Options:

A.  $\frac{R}{\mu_1 - \mu_2}$

B.  $\frac{R}{2(\mu_1 + \mu_2)}$

C.  $\frac{2R}{\mu_1 - \mu_2}$

D.  $\frac{R}{2(\mu_1 - \mu_2)}$

**Answer: A**

**Solution:**

$$\frac{1}{f_1} = (\mu_1 - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = \frac{(\mu_1 - 1)}{R} \text{ and}$$

$$\frac{1}{f_2} = (\mu_2 - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) = \frac{\mu_2 - 1}{-R}$$

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{\mu_1 - 1}{R} - \frac{\mu_2 - 1}{R} = \frac{1}{R} [\mu_1 - 1 - \mu_2 + 1] = \frac{\mu_1 - \mu_2}{R}$$

---

## Question 89

The magnifying power of a refracting type of astronomical telescope is 'm'. If focal length of eyepiece is doubled then the magnifying power will become

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Options:

A. m

B. 2 m

C.  $\frac{m}{2}$



D.  $\frac{m}{4}$

**Answer: C**

### Solution:

The magnifying power of a refracting astronomical telescope is given by the formula:

$$m = \frac{f_o}{f_e}$$

Here,  $f_o$  is the focal length of the objective lens and  $f_e$  is the focal length of the eyepiece.

Given that the initial magnifying power is  $m$ , we can write:

$$m = \frac{f_o}{f_e}$$

If the focal length of the eyepiece is doubled, the new focal length of the eyepiece becomes  $2f_e$ . The new magnifying power  $m'$  will be:

$$m' = \frac{f_o}{2f_e}$$

Now, we can substitute  $\frac{f_o}{f_e}$  with  $m$  to find the new magnifying power:

$$m' = \frac{m}{2}$$

Therefore, if the focal length of the eyepiece is doubled, the magnifying power will become  $\frac{m}{2}$ .

So, the correct option is:

Option C:  $\frac{m}{2}$

---

## Question90

**A ray of light travels from air to water to glass and again from glass to air. Refractive index of water w.r.t. air is 'X', glass w.r.t. water is 'Y' and air w.r.t. glass is 'Z'. Which one of the following is correct?**

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**Options:**

A.  $YZ = X$

B.  $XYZ = 1$

C.  $XY = Z$



D.  $XZ = Y$

**Answer: B**

### Solution:

To understand the correct relationship, we need to consider the concept of the refractive index and how it transforms from one medium to another. Let's break this down step by step.

The refractive index of water with respect to air is denoted as  $X$ . This means:

$$n_{water} = X \cdot n_{air}$$

The refractive index of glass with respect to water is denoted as  $Y$ . This means:

$$n_{glass} = Y \cdot n_{water}$$

The refractive index of air with respect to glass is denoted as  $Z$ . This means:

$$n_{air} = Z \cdot n_{glass}$$

Now, substituting these equations into each other, we get:

From the first relationship:

$$n_{water} = X \cdot n_{air}$$

From the second relationship:

$$n_{glass} = Y \cdot (X \cdot n_{air}) = XY \cdot n_{air}$$

From the third relationship:

$$n_{air} = Z \cdot (XY \cdot n_{air})$$

The refractive index of air is a basic unit, so the equation simplifies to:

$$1 = XYZ$$

Therefore, the correct option is:

**Option B:**  $XYZ = 1$

---

## Question91

**An object is located on a wall, its image of equal size is to be obtained on a parallel wall with the help of a convex lens. The lens is placed at a distance 'd' in front of the second wall. The required focal length of the lens is**



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Options:

- A. less than  $\frac{d}{4}$
- B. only  $\frac{d}{4}$
- C. (more than  $\frac{d}{4}$  but less than  $\frac{d}{2}$ )
- D. only  $\frac{d}{2}$

**Answer: D**

**Solution:**

Size of the image is equal to the size of the object. Hence image distance will be equal to object distance. Also if object distance  $u = 2f$ , Image distance will be  $2f$ .

$$\therefore u = v = d = 2f$$

$$\therefore u + v = 2d = 4f$$

$$\therefore f = \frac{d}{2}$$

---

## Question92

The critical angle for light going from medium 'x' to medium 'Y' is  $\theta$ . The speed of light in medium 'x' is 'V'. The speed of light in medium 'Y' is

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Options:

- A.  $V_x \sin \theta$
- B.  $V_x \tan \theta$
- C.  $\frac{V_x}{\tan \theta}$
- D.  $\frac{V_x}{\sin \theta}$

**Answer: D**



## Solution:

The critical angle,  $\theta$ , is the angle of incidence in medium  $x$  beyond which light is totally internally reflected within medium  $x$  and cannot pass into medium  $Y$ . This situation occurs when the angle of refraction in medium  $Y$  is  $90^\circ$ .

According to Snell's Law, the relationship between the angles of incidence and refraction and the indices of refraction of the two media is given by:

$$n_x \sin \theta = n_Y \sin 90^\circ$$

Where  $n_x$  and  $n_Y$  are the indices of refraction of medium  $x$  and medium  $Y$  respectively. Since  $\sin 90^\circ = 1$ , we can simplify this to:

$$n_x \sin \theta = n_Y$$

The speed of light in any medium is related to the speed of light in a vacuum ( $c$ ) and the index of refraction of that medium ( $n$ ) by the equation  $V = \frac{c}{n}$ .

Therefore, we can express the indices of refraction in terms of the speeds of light in the respective media:

$$\frac{c}{V_x} \sin \theta = \frac{c}{V_Y}$$

Rearranging it to solve for  $V_Y$ :

$$V_Y = \frac{V_x}{\sin \theta}$$

Thus, the correct answer is:

Option D

$$\frac{V_x}{\sin \theta}$$

---

## Question93

**A biconvex lens ( $R_1 = R_2 = 30$  cm) has focal length equal to the focal length of concave mirror. The radius of curvature of concave mirror is [Refractive index of material of lens = 1.6 ]**

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**Options:**

A. 30 cm

B. 40 cm

C. 50 cm



D. 20 cm

**Answer: C**

### Solution:

To solve this problem, we first need to determine the focal length of the biconvex lens using the lens maker's formula:

$$\frac{1}{f} = (n - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

Given that  $R_1 = R_2 = 30$  cm and the refractive index  $n = 1.6$ , we can substitute these values into the formula:

$$\frac{1}{f} = (1.6 - 1) \left( \frac{1}{30} - \frac{1}{-30} \right)$$

Since  $R_1$  is positive and  $R_2$  is negative as it's a biconvex lens:

$$\frac{1}{f} = 0.6 \left( \frac{1}{30} + \frac{1}{30} \right)$$

$$\frac{1}{f} = 0.6 \left( \frac{2}{30} \right)$$

$$\frac{1}{f} = 0.6 \times \frac{2}{30} = \frac{1.2}{30} = \frac{1}{25}$$

Hence, the focal length of the lens  $f = 25$  cm.

The focal length of a concave mirror is related to its radius of curvature (R) by the formula:

$$f = \frac{R}{2}$$

Since the focal length of the concave mirror is equal to the focal length of the biconvex lens:

$$25 \text{ cm} = \frac{R}{2}$$

Solving for R, we get:

$$R = 2 \times 25 \text{ cm} = 50 \text{ cm}$$

Therefore, the radius of curvature of the concave mirror is 50 cm.

**The correct answer is Option C: 50 cm**

---

## Question94

**The critical angle for light going from medium A into medium B is  $\theta$ . The speed of light in the medium A is  $V_A$ . What is the speed of light in the medium B ?**

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## Options:

A.  $V_A \sin \theta$

B.  $V_A \tan \theta$

C.  $\frac{V_A}{\tan \theta}$

D.  $\frac{V_A}{\sin \theta}$

**Answer: D**

## Solution:

To determine the speed of light in medium B, given the critical angle  $\theta$  for light transitioning from medium A to medium B and the speed of light in medium A denoted as  $V_A$ , we can use the concept of the critical angle and Snell's law. The critical angle is defined as the angle of incidence in medium A for which the angle of refraction in medium B is 90 degrees.

According to Snell's law:

$$n_A \sin \theta_c = n_B \sin 90^\circ$$

Where:

- $n_A$  is the refractive index of medium A.
- $n_B$  is the refractive index of medium B.
- $\theta_c$  is the critical angle (denoted as  $\theta$  in the problem).

Since  $\sin 90^\circ = 1$ , the equation simplifies to:

$$n_A \sin \theta = n_B$$

The refractive index of a medium is related to the speed of light in that medium. Specifically, the refractive index is the ratio of the speed of light in vacuum (or air, approximately) to the speed of light in the medium. Hence, we have:

$$n_A = \frac{c}{V_A}$$

$$n_B = \frac{c}{V_B}$$

Substituting these into the simplified Snell's law equation gives:

$$\frac{c}{V_A} \sin \theta = \frac{c}{V_B}$$

Canceling the common factor  $c$  from both sides, we get:

$$\frac{1}{V_A} \sin \theta = \frac{1}{V_B}$$

This rearranges to:

$$V_B = \frac{V_A}{\sin \theta}$$

Therefore, the speed of light in medium B, given the speed of light in medium A and the critical angle  $\theta$ , is:

**Option D:**  $\frac{V_A}{\sin \theta}$ .

---

## Question95

The refractive index of glass is 1.5 and that of water is 1.33 . The critical angle for a ray of light going from glass to water is

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**Options:**

A.  $\sin^{-1} \left( \frac{4}{7} \right)$

B.  $\sin^{-1} \left( \frac{5}{8} \right)$

C.  $\sin^{-1} \left( \frac{8}{9} \right)$

D.  $\sin^{-1} \left( \frac{2}{3} \right)$

**Answer: C**

**Solution:**

$$\mu_g = 1.5 = \frac{3}{2} \quad \mu_w = 1.33 = \frac{4}{3}$$

$$\therefore {}_w\mu_g = \frac{\mu_g}{\mu_w} = \frac{3}{2} \times \frac{3}{4} = \frac{9}{8}$$

$$\sin C = \frac{1}{{}_w\mu_g} = \frac{8}{9}$$

$$\therefore C = \sin^{-1} \left( \frac{8}{9} \right)$$

---

## Question96

A convex lens is dipped in a liquid whose refractive index is equal to refractive index of lens material. Then its focal length will

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**Options:**

- A. increase
- B. remain unchanged
- C. become infinite
- D. become zero

**Answer: C**

**Solution:**

$$\text{For a lens } \frac{1}{f} = (\mu' - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$\text{where } \mu' = \frac{\mu_g}{\mu_l} = 1$$

$$\therefore \frac{1}{f} = 0 \text{ or } f = \infty$$

---

## Question97

**A ray of light is incident at an angle 'I' on one face of thin prism. The ray emerges normally from the other face. Refractive index of the glass prism is 'n' and angle of prism is 'A'. The value of 'I' is**

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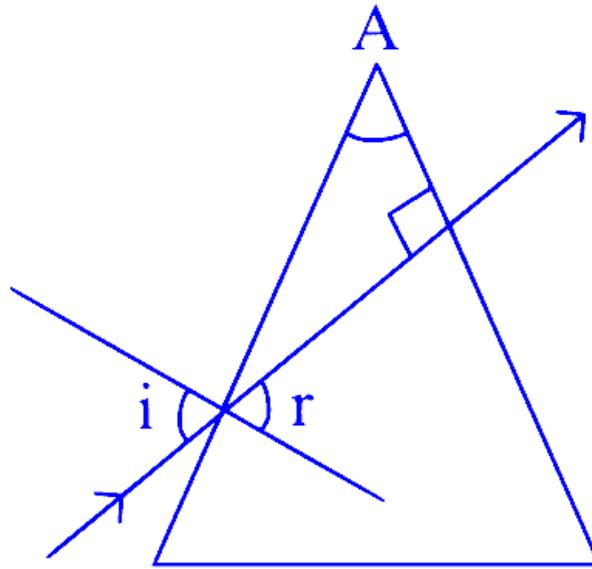
**Options:**

- A. An
- B. An<sup>2</sup>
- C.  $\frac{A}{n}$
- D.  $\frac{A}{n^2}$

**Answer: A**

**Solution:**





From the figure  $A = r$

$$n = \frac{\sin r}{\sin i} = \frac{\sin A}{\sin i} = \frac{i}{A}$$

(Angles are small)

$$\therefore i = An$$

## Question98

**A glass cube of length 24 cm has a small air bubble trapped inside. When viewed normally from one face it is 10 cm below the surface. When viewed normally from the opposite face, its apparent distance is 6 cm. The refractive index of glass is**

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**Options:**

- A. 1.50
- B. 1.40
- C. 1.45
- D. 1.55



**Answer: A**

**Solution:**

Let  $x$  be the real depth when the apparent depth is 10 cm.

$$\therefore \mu = \frac{x}{10}$$

Let  $y$  be the real depth when the apparent depth is 6 cm

$$\therefore \mu = \frac{y}{6}$$

$$\therefore \frac{x}{10} = \frac{y}{6} \quad \therefore x = \frac{5}{3}y$$

Also  $x + y = 24$

$$\therefore \frac{5}{3}y + y = 24 \quad \therefore \frac{8}{3}y = 24$$

$$\therefore y = 9 \text{ cm}$$

$$\mu = \frac{y}{6} = \frac{9}{6} = 1.5$$

---

## Question99

**A particle executes linear S.H.M. The mean position of oscillation is at the principal axis of a convex lens of focal length 8 cm. the mean position of oscillation is at 14 cm from the lens with amplitude 1 cm. The amplitude of oscillating image of the particle is nearly**

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**Options:**

A. 3 cm

B. 5 cm

C. 2 cm

D. 4 cm

**Answer: C**

**Solution:**

$f = 8$  cm, when the particle is at mean position,  $u = -14$  cm

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{8} - \frac{1}{14} = \frac{3}{56}$$
$$\therefore v = \frac{56}{3} \approx 19 \text{ cm}$$

When the particle is at one of the extreme positions its distance from the lens is  $14 + 1 = 15$  cm

$$\therefore u = -15 \text{ cm}$$

Again,  $\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{8} - \frac{1}{15} = \frac{7}{120}$

$$\therefore v = \frac{120}{7} \approx 17 \text{ cm}$$

Amplitude of the image =  $19 - 17 = 2$  cm

---

## Question100

**A convex lens of focal length  $T$  is used to form an image whose size is one fourth that of size of the object. Then the object distance is**

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**Options:**

A.  $2f$

B.  $5f$

C.  $4f$

D.  $3f$

**Answer: B**

**Solution:**

Magnification,  $m = -\frac{1}{4}$

(Since the image is real and inverted, it is taken as negative)

$$\therefore m = \frac{v}{u} = -\frac{1}{4}$$
$$\therefore v = -\frac{u}{4}$$

We have,  $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

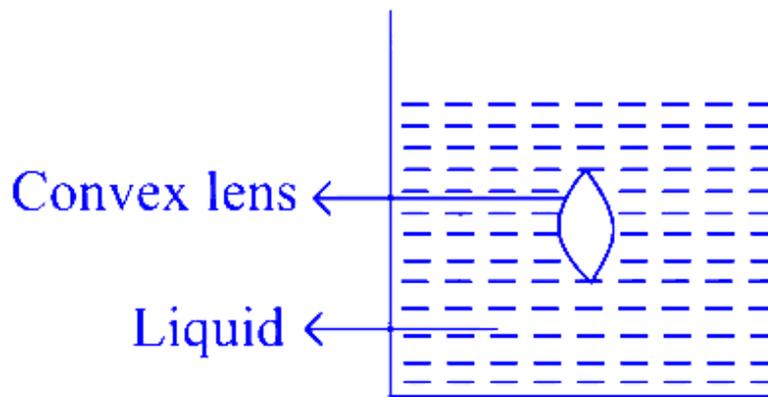
$$-\frac{4}{u} - \frac{1}{u} = \frac{1}{f}$$

$$-\frac{5}{u} = \frac{1}{f}$$

$$\therefore u = -5f$$

## Question101

Inside a vessel filled with liquid a converging lens is placed as shown in figure. The lens has focal length 15 cm when in air and has refractive index  $\frac{3}{2}$ . If the liquid has refractive index  $\frac{9}{5}$ , the focal length of lens in liquid is



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**Options:**

- A. 15 cm
- B. -60 cm
- C. 90 cm
- D. -45 cm

**Answer: D**

**Solution:**

Focal length in air is given by

$$\frac{1}{f} = (n_g - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) \dots (1)$$

Focal length in liquid is given by

$$\frac{1}{f'} = (n' - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right) \dots (2)$$

$$\text{where } n' = \frac{n_g}{n_l} = \frac{3}{2} \times \frac{5}{9} = \frac{5}{6}$$

Dividing eq. (1) and (2),

$$\frac{f'}{f} = \frac{n_g - 1}{n' - 1} = \frac{\frac{3}{2} - 1}{\frac{5}{6} - 1} = \frac{\frac{1}{2}}{-\frac{1}{6}} = -3$$
$$\therefore f' = -3f = -3 \times 15 = -45 \text{ cm}$$

---

## Question102

**A ray of light travels from a denser medium to a rarer medium. The reflected and the refracted rays are perpendicular to each other. If ' $r$ ' and ' $r_1$ ' are the angle of reflection and refraction respectively and ' $C$ ' is the critical angle, then the angle of incidence is**

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**Options:**

A.  $\cot^{-1}(\sin C)$

B.  $\sin^{-1}(\tan C)$

C.  $\tan^{-1}(\sin C)$

D.  $\cos^{-1}(\tan C)$

**Answer: B**

**Solution:**

Since reflected and refracted rays are perpendicular to each other,

$$r + r_1 = 90^\circ$$
$$\therefore r_1 = 90^\circ - r$$

Refractive index of the denser medium

$$\mu = \frac{\sin r_1}{\sin r} = \frac{\sin(90^\circ - r)}{\sin r} = \frac{\cos r}{\sin r} = \cot r$$



$$\text{Also, } \mu = \frac{1}{\sin C} \quad \therefore \quad \frac{1}{\sin C} = \cot r$$

$$\text{or } \sin C = \frac{1}{\cot r} = \tan r = \tan i$$

$$\therefore i = \tan^{-1}(\sin C)$$

---

## Question103

**A convex lens of focal length 'F' produces a real image 'n' times the size of the object. The image distance is**

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**Options:**

A.  $F(n + 1)$

B.  $F(n - 1)$

C.  $\frac{F}{(N+1)}$

D.  $\frac{F}{(n-1)}$

**Answer: A**

**Solution:**

The image is real and hence inverted.

$$\therefore \frac{v}{u} = -n \text{ or } u = -\frac{v}{n}$$

By lens equation,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\therefore \frac{1}{v} + \frac{n}{v} = \frac{1}{f}$$

$$\therefore \frac{1+n}{v} = \frac{1}{f}$$

$$\therefore v = f(1 + n)$$

---

## Question104



A ray of light is incident at an angle  $i$  on one face of a thin angled prism. The ray emerges normally from the other face. Refractive index of the glass prism is  $n$  and angle of prism is  $A$ . The value of  $i$  is

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**Options:**

A.  $An$

B.  $A^2n$

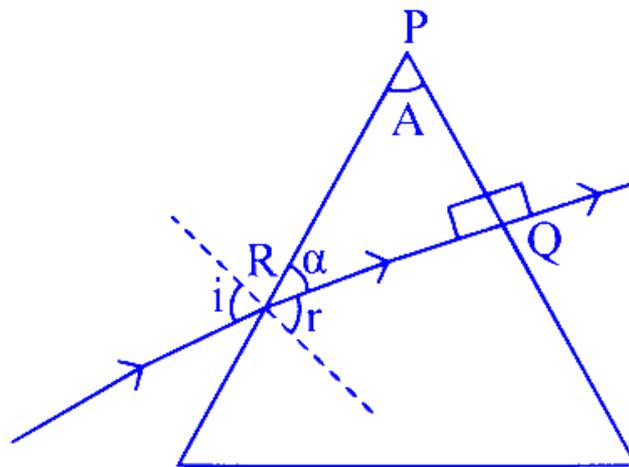
C.  $An^2$

D.  $\frac{1}{An}$

**Answer: A**

**Solution:**

Consider the figure shown below



In  $\triangle PQR$ ,

$$\alpha = 180^\circ - 90^\circ - A$$

$$\alpha = 90^\circ - A$$

$$\text{Also, } r + \alpha = 90^\circ$$

$$\Rightarrow r = 90^\circ - \alpha = 90^\circ - 90^\circ + A$$

$$\text{or } r = A$$

Using Snell's law,

$$\mu_1 \sin i = \mu_2 \sin r$$

(1)  $\sin i = n \sin A$  (given,  $\mu_2 = n$  for glass prism)

$$\Rightarrow \sin i = n \sin A$$

For small angle,

$$\sin i \simeq i \text{ and } \sin A \simeq A$$

$$\therefore i = nA$$

---

## Question105

**An object is clearly seen through an astronomical telescope of length 50 cm . The focal lengths of its objective and eye-piece respectively, can be**

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**Options:**

- A. 5 cm and 45 cm
- B. -45 cm and -5 cm
- C. 45 cm and -5 cm
- D. 45 cm and 5 cm

**Answer: D**

**Solution:**

The objective and eye-piece of an astronomical telescope consist of convex lens, whose focal length is positive.

Also, the objective of the astronomical telescope has large aperture and large focal length.

Hence, the focal lengths of its objective and eye-piece respectively can be 45 cm and 5 cm .

---

## Question106

**By increasing the aperture of the objective lens, wavelength of light, focal length of the objective lens and the resolving power of an**

**astronomical telescope respectively**

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**Options:**

- A. is not affected, increases, increases
- B. decreases, increases, is not affected
- C. increases, decreases, is not affected
- D. is not affected, increases, decreases

**Answer: A**

**Solution:**

The resolving power of astronomical telescope,

$$R = \frac{1}{\Delta x} = \frac{2\mu \sin \theta}{\lambda} = \frac{NA}{\lambda}$$

where,  $NA$  = numerical aperture of objective lens.

On increasing the aperture, the value of  $R$  increases.

On increasing the aperture of the objective lens medium remains same, hence wavelength of light is not affected on increasing the aperture of objective lens its focal length increases.

---

## Question107

**There are four convex lenses  $L_1, L_2, L_3$  and  $L_4$  of focal length 2, 4, 6 and 8 cm, respectively. Two of these lenses form a telescope of length 10 cm and magnifying power 4. The objective and eye lenses are respectively**

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**Options:**

- A.  $L_1, L_2$

B.  $L_1, L_4$

C.  $L_2, L_3$

D.  $L_4, L_1$

**Answer: D**

## Solution:

Let's break down the problem to find which lenses form a telescope with a length of 10 cm and a magnifying power of 4.

### Given Lenses and Focal Lengths:

$$L_1 = 2 \text{ cm}$$

$$L_2 = 4 \text{ cm}$$

$$L_3 = 6 \text{ cm}$$

$$L_4 = 8 \text{ cm}$$

### Telescope Characteristics:

$$\text{Length } (L) = 10 \text{ cm}$$

$$\text{Magnifying Power } (M) = 4$$

### Telescope Equations:

Magnifying power,  $M = \frac{f_o}{f_e}$ , where  $f_o$  is the focal length of the objective lens and  $f_e$  is the focal length of the eyepiece lens. Given  $M = 4$ , so:

$$f_o = 4f_e \quad (\text{i})$$

Total length of the telescope is the sum of the focal lengths of the objective and the eyepiece:

$$L = f_o + f_e$$

Substituting the known values:

$$10 = f_o + f_e$$

$$10 = 4f_e + f_e \quad (\text{from equation i})$$

$$5f_e = 10$$

$$f_e = 2 \text{ cm}$$

$$\text{Then, } f_o = 4 \times 2 = 8 \text{ cm}$$

### Conclusion:

The eyepiece has a focal length of 2 cm ( $f_e = 2 \text{ cm}$ ) and corresponds to lens  $L_1$ .

The objective lens has a focal length of 8 cm ( $f_o = 8 \text{ cm}$ ) and corresponds to lens  $L_4$ .

Therefore, the correct setup for the telescope uses  $L_1$  as the eyepiece and  $L_4$  as the objective lens.



---

## Question108

Refractive index of the medium is  $\mu$  and wavelength is  $\lambda$ , then which of the following proportionality relation is correct?

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**Options:**

A.  $\mu \propto \lambda^2$

B.  $\mu \propto \frac{1}{\lambda}$

C.  $\mu \propto \lambda$

D.  $\mu \propto \frac{1}{\lambda^2}$

**Answer: B**

**Solution:**

The refractive index of a medium, denoted as  $\mu$ , describes how light propagates through that medium. It is interconnected with the wavelength  $\lambda$  of the light. To explore this relationship, consider the following:

**Definition:**

$$\mu = \frac{c}{v}$$

where  $c$  is the speed of light in a vacuum, and  $v$  is the speed of light in the medium.

**Relation with Wavelength:**

The speed of light in a medium ( $v$ ) can also be expressed using the equation:

$$v = \lambda f$$

where  $\lambda$  is the wavelength of light, and  $f$  is its frequency.

**Considering Constant Frequency:**

When light transitions from one medium to another, its frequency  $f$  remains unchanged. With this in mind, the equation for  $\mu$  becomes:

$$\mu = \frac{c}{v} = \frac{c}{\lambda f}$$

Since both  $c$  and  $f$  are constants,  $\mu$  is inversely proportional to  $\lambda$ :

$$\mu \propto \frac{1}{\lambda}$$



This relationship indicates that as the wavelength increases, the refractive index decreases, assuming the frequency remains constant.

---

## Question109

**A ray of light travelling through glass of refractive index  $\sqrt{2}$  is incident on glass-air boundary at an angle of incidence  $45^\circ$ . If refractive index of air is 1, then the angle of refraction will be**  
 $\left[ \sin 45^\circ = \frac{1}{\sqrt{2}}, \sin 90^\circ = 1 \right]$

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**Options:**

- A.  $45^\circ$
- B.  $30^\circ$
- C.  $60^\circ$
- D.  $90^\circ$

**Answer: D**

**Solution:**

To determine the angle of refraction when a ray of light passes from glass to air using Snell's Law, we proceed as follows:

**Snell's Law Equation:**

$$\mu_i \sin i = \mu_r \sin r$$

$\mu_i$  is the refractive index of glass

$i$  is the angle of incidence

$\mu_r$  is the refractive index of air

$r$  is the angle of refraction

Given:

$$\mu_i = \sqrt{2}$$

$$i = 45^\circ$$

$$\mu_r = 1$$

Plug these values into Snell's Law:

$$\sqrt{2} \cdot \sin 45^\circ = 1 \cdot \sin r$$

$$\sqrt{2} \cdot \frac{1}{\sqrt{2}} = \sin r$$

$$1 = \sin r$$

Since  $\sin r = 1$ , the angle  $r$  is:

$$r = 90^\circ$$

Thus, the angle of refraction is  $90^\circ$ .

---

## Question110

**A ray of light is incident at an angle  $i$  on one face of prism of small angle  $A$  and emerges normally from the other surface.  $\mu$  is the refractive index of the material of the prism. The angle of incidence is**

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**Options:**

A.  $\frac{A}{2\mu}$

B.  $A\mu$

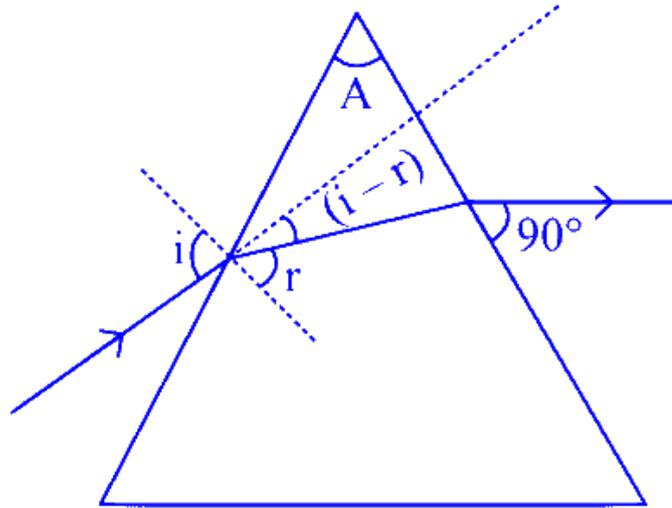
C.  $\frac{A}{\mu}$

D.  $\frac{A\mu}{2}$

**Answer: B**

**Solution:**

The path followed by ray of light is shown in figure



As, the ray emerges normally from other surface. So, angle of emergence is zero.

The angle of deviation i.e., between incident and emergent ray is

$$\delta = (i + e) - A = i - A \quad \dots (i) \quad (\because e = 0)$$

$$\text{Also, for minimum deviation, } \delta = (\mu - 1)A \quad \dots (ii)$$

From Eqs. (i) and (ii), we get

$$i - A = (\mu - 1)A$$

$$\Rightarrow i = (\mu - 1)A + A = \mu A$$

## Question111

**The magnifying power of a telescope is high, if its objective and eyepiece have respectively**

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**Options:**

- A. small focal lengths
- B. large focal lengths
- C. small and large focal length
- D. large and small focal length



**Answer: D**

**Solution:**

The magnifying power at a telescope is given by

$$m = -\frac{f_o}{f_e}$$

Therefore, the magnifying power will be high when objective lens has large focal length and eye-piece has small focal length.

---

## Question112

**Glass has refractive index  $\mu$  with respect to air and the critical angle for a ray of light going from glass to air is  $\theta$ . If a ray of light is incident from air on the glass with angle of incidence  $\theta$ , corresponding angle of refraction is**

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**Options:**

A.  $\sin^{-1}(\mu)$

B.  $\sin^{-1}\left(\frac{1}{\mu^2}\right)$

C.  $\sin^{-1}\left(\frac{1}{\sqrt{\mu}}\right)$

D.  $\sin^{-1}\left(\frac{1}{\mu}\right)$

**Answer: B**

**Solution:**

The refractive index of glass with respect to air is denoted as  $\mu$ , and the critical angle for light transitioning from glass to air is  $\theta$ .

We have:

$$\mu = \frac{1}{\sin\theta} \quad \dots(i)$$



When a ray of light originates from air and strikes the glass at an angle of incidence  $\theta$ , we need to determine the angle of refraction  $r$ . According to Snell's Law, the relationship is given by:

$$\mu = \frac{\sin \theta}{\sin r}$$
$$\Rightarrow \sin r = \frac{\sin \theta}{\mu} = \frac{1/\mu}{\mu} \quad [\text{using Eq. (i)}]$$
$$\Rightarrow \sin r = \frac{1}{\mu^2}$$
$$r = \sin^{-1} \left( \frac{1}{\mu^2} \right)$$

Thus, the corresponding angle of refraction is  $\sin^{-1} \left( \frac{1}{\mu^2} \right)$ .

---

## Question113

**The magnifying power of a telescope is nine. When it is adjusted for parallel rays, the distance between the objective and eyepiece is 20 cm . The focal length of objective and eyepiece are respectively**

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**Options:**

- A. 10 cm, 10 cm
- B. 18 cm, 2 cm
- C. 15 cm, 5 cm
- D. 11 cm, 9 cm

**Answer: B**

**Solution:**

For final image at infinity, magnifying power of a telescope is given by

$$m = \frac{f_o}{f_e} = 9$$

where,  $m$  = magnification,

$f_o$  = focal length of objective

and  $f_e$  = focal length of eyepiece



$$\Rightarrow f_o = 9f_e \dots (i)$$

Also, distance between objective and eyepiece

$$= f_o + f_e = 20 \text{ (given)}$$

$$\Rightarrow 9f_e + f_e = 20 \Rightarrow f_e = 2 \text{ cm}$$

$$f_o = 9f_e = 18 \text{ cm}$$

---

## Question 114

The refractive index of the material of crystal is 1.68 and that of castor oil is 1.2. When a ray of light passes from oil to glass, its velocity will change by a factor

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Options:

A.  $\frac{2}{3}$

B.  $\frac{3}{4}$

C.  $\frac{5}{6}$

D.  $\frac{5}{7}$

**Answer: D**

**Solution:**

We know, refractive index of crystal w.r.t. oil,

$$\mu_{co} = \frac{\mu_c}{\mu_o} = \frac{\text{speed of light in oil}}{\text{speed of light in crystal}}$$

Where,  $\mu_c$  = absolute refractive index of crystal w.r.t. vacuum.

and  $\mu_o$  = absolute refractive index of oil w.r.t. vacuum.

$$\mu_{co} = \frac{1.68}{1.2} = \frac{7}{5} = \frac{\text{speed in oil}}{\text{speed in crystal}}$$

Fractional change in velocity, when light travel from oil to crystal

$$= \frac{\text{speed in crystal}}{\text{speed in oil}} = \frac{5}{7}$$

---



## Question115

**When light enters glass from vacuum, then the wavelength of light**

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**Options:**

- A. decreases
- B. becomes zero
- C. remains same
- D. increases

**Answer: A**

**Solution:**

When a light enters glass from vacuum, then the wavelength of light decreases.

This is because the speed of light in glass is less than that in the vacuum.

From Snell's law, the refractive index in a medium is given by

$$\mu = \frac{c}{v}$$

The glass is of higher refractive index than vacuum, so speed of light decreases and as the speed of light is directly proportional to the wavelength ( $c = v\lambda$ ), so, the wavelength also be decreases.

---

## Question116

**A convex lens of focal length ' f ' is placed in contact with a concave lens of the same focal length. The equivalent focal length of the combination is**

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**Options:**

- A.  $f$
- B. infinity
- C.  $\frac{f}{2}$
- D. zero

**Answer: B**

### **Solution:**

Given, focal length of convex lens,  $f_1 = f$

and focal length of concave lens,  $f_2 = -f$ .

The focal length of combination, when two lenses are in contact is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \quad \dots (i)$$

Substituting given value in Eq. (i), we get

$$\Rightarrow \frac{1}{f} = \frac{1}{f} - \frac{1}{f} = 0 \Rightarrow f = \infty$$

Hence, the equivalent focal length of the combination is infinity.

---

## **Question117**

**The critical angle for light going from medium '  $x$  ' to medium '  $y$  ' is '  $\theta$  '. The speed of light in medium '  $x$  ' is '  $v_x$  '. The speed of light in medium '  $y$  ' is**

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**Options:**

- A.  $\frac{v_x}{\tan \theta}$
- B.  $v_x \sin \theta$
- C.  $v_x \tan \theta$
- D.  $\frac{v_x}{\sin \theta}$

**Answer: D**

## Solution:

The critical angle is the angle of incidence in a denser medium at which the angle of refraction in a rarer medium becomes  $90^\circ$ . This can be expressed as:

$$\frac{\sin \theta}{\sin 90^\circ} = \frac{\mu_y}{\mu_x}$$

where  $\theta$  is the critical angle, and  $\mu_y$  and  $\mu_x$  are the refractive indices of mediums  $y$  and  $x$  respectively. This relationship simplifies to:

$$\sin \theta = \frac{\mu_y}{\mu_x} \quad (\text{Equation 1})$$

The refractive index  $\mu$  can also be defined in terms of the speed of light as:

$$\mu = \frac{\text{speed of light in vacuum}}{\text{speed of light in the medium}} = \frac{c}{v} \quad (\text{Equation 2})$$

Substituting the expression for refractive index from Equation 2 into Equation 1, we get:

$$\sin \theta = \frac{c}{v_y} \times \frac{v_x}{c} = \frac{v_x}{v_y}$$

Solving for  $v_y$ , the speed of light in medium  $y$ , results in:

$$v_y = \frac{v_x}{\sin \theta}$$

Thus, the speed of light in medium  $y$  is given by  $\frac{v_x}{\sin \theta}$ .

---

## Question118

**A telescope has large diameter of the objective. Then its resolving power is**

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**Options:**

- A. independent of the diameter of the objective
- B. low
- C. zero
- D. high

**Answer: D**

## Solution:

Resolving power of a telescope is given,

$$x = \frac{a}{1.22\lambda} \Rightarrow x \propto a$$

where,  $a$  = diameter/aperture of objective a telescope and  $\lambda$  = wavelength of light.

So, when the aperture (diameter) of objective is large, then its resolving power is high.

---

## Question119

**A thin hollow prism of refracting angle  $3^\circ$ , filled with water gives a deviation of  $1^\circ$ . The refractive index of water is**

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**Options:**

- A. 1.59
- B. 1.33
- C. 1.46
- D. 1.51

**Answer: B**

## Solution:

The angle of deviation of a light ray caused by a prism is given by:

$$\delta = A(\mu - 1) \quad \dots (i)$$

Where:

$\delta$  is the angle of deviation,

$A$  is the angle of the prism,

$\mu$  is the refractive index of the prism.

In this problem, we are given:

$$A = 3^\circ,$$



$$\delta = 1^\circ,$$

and we need to determine  $\mu$ .

Substituting the given values into Equation (i), we have:

$$1^\circ = 3^\circ(\mu - 1)$$

Solving for  $\mu$ :

$$3(\mu - 1) = 1 \Rightarrow \mu - 1 = \frac{1}{3} \Rightarrow \mu = \frac{4}{3} = 1.33$$

Thus, the refractive index of water in this context is 1.33.

---

## Question120

**The equi-convex lens has a focal length '  $f$  '. If the lens is cut along the line perpendicular to the principal axis and passing through the pole, what will be the focal length of any half part?**

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**Options:**

A.  $\frac{f}{2}$

B.  $2f$

C.  $\frac{3f}{2}$

D.  $f$

**Answer: B**

**Solution:**

The lens Maker's formula is given as

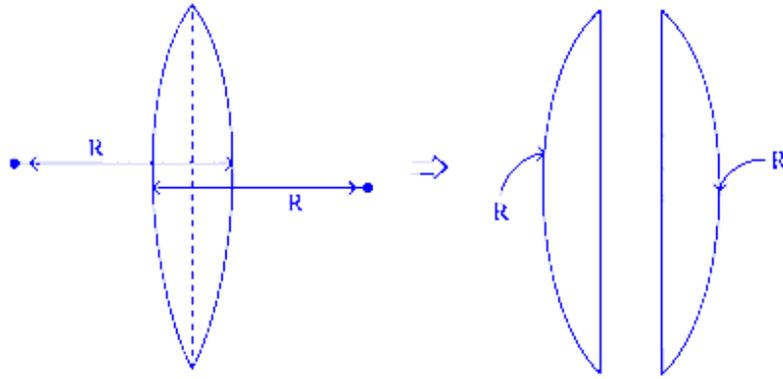
$$\frac{1}{f} = (\mu_{\text{med}} - 1) \left( \frac{1}{R_1} + \frac{1}{R_2} \right)$$

where,  $f$  = focal length of lens,  $R_1$  = radius of first curved part and  $R_2$  = Radius of second curved part

As, for equiconvex lens  $R_1 = R_2 = R$  (say)

$$\text{So, } \frac{1}{f} = (\mu_{\text{real}} - 1) \frac{2}{R} \dots (i)$$

Now, if lens is cut along the line perpendicular to the principal axis as shown in the figure,



The new cut part of the lens has,  $R_1 = R$  and  $R_2 = \infty$  Again by using the lens Maker's formula, focal length of the new part of the lens,

$$\frac{1}{f'} = (\mu_{\text{real}} - 1) \left[ \frac{1}{R} - \left( -\frac{1}{\infty} \right) \right]$$
$$\Rightarrow \frac{1}{f} = (\mu_{\text{real}} - 1) \left[ \frac{1}{R} \right] \dots \text{(ii)}$$

So, from the Eqs. (i) and (ii), we get

$$f' = 2f$$

---