

PHYSICS • CLASS 12

CHAPTER 9

Ray Optics and Optical Instruments

NCERT SOLUTIONS



CONCAVE MIRROR AND CANDLE — EXERCISE 9.1

- Q. A candle of height 2.5 cm is 27 cm in front of a concave mirror of radius 36 cm. Find where to place a screen for a sharp image; give nature and size. How must the screen move if the candle moves closer?

Solution:

Radius of curvature $R = 36$ cm.

Focal length of a concave mirror:

$$f = -\frac{R}{2} = -\frac{36}{2} = -18 \text{ cm.}$$

Object distance (candle in front):

$$u = -27 \text{ cm.}$$

Mirror formula:

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

$$\frac{1}{-18} = \frac{1}{v} + \frac{1}{-27}$$

$$\frac{1}{v} = -\frac{1}{18} + \frac{1}{27} = -\frac{1}{54} \text{ cm}^{-1}$$

$$v = -54 \text{ cm.}$$

A real image is formed 54 cm in front of the mirror. So the screen should be placed 54 cm in front of the mirror (on the object side).

Magnification:

$$m = -\frac{v}{u} = -\frac{(-54)}{(-27)} = -2.$$

Height of image:

$$h' = mh = (-2)(2.5 \text{ cm}) = -5.0 \text{ cm.}$$

The negative sign shows the image is inverted. Thus, the image is real, inverted and twice the candle's size (height 5.0 cm).

How the screen must move:

As the candle moves toward the focus from beyond it, the image distance increases, so the screen must be moved farther away from the mirror. When the candle reaches the focus, the image is at infinity; and if the candle is moved inside the focus, no real image can be obtained on a screen.

CONVEX MIRROR AND NEEDLE – EXERCISE 9.2

Q. A 4.5 cm needle is 12 cm in front of a convex mirror with focal length 15 cm. Find image location, magnification, nature, and what changes when needle moves farther away.

Answer:

Cartesian sign convention: $f = +15$ cm, $u = -12$ cm.

Using mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, so $\frac{1}{v} = \frac{1}{15} + \frac{1}{12} = \frac{3}{20} \text{ cm}^{-1}$.

Hence, $v = +6.67$ cm.

Magnification, $m = -\frac{v}{u} = -\frac{6.67}{-12} = +0.556$.

Height of image, $h' = m h = 0.556 \times 4.5 = 2.50$ cm.

Therefore, the image is formed behind the mirror. It is virtual, upright and diminished.

When the needle is moved farther away, the image moves towards the focus behind the mirror, i.e., from 6.67 cm towards 15 cm. The magnification falls towards zero.

APPARENT DEPTH – EXERCISE 9.3

Q. Water depth is 12.5 cm; a needle at the bottom appears 9.4 cm deep through a microscope. Find n_{water} . If replaced by another liquid $n = 1.63$ to the same level, how far and which way move microscope to refocus?

Answer:

For near-normal viewing, the refractive index of the liquid is given by

$$n = \frac{\text{real depth}}{\text{apparent depth}}$$

For water,

$$n_{\text{water}} = \frac{12.5}{9.4} \approx 1.33$$

If the water is replaced by another liquid of refractive index $n = 1.63$ to the same level, the new apparent depth is

$$d' = \frac{\text{real depth}}{n} = \frac{12.5}{1.63} = 7.67 \text{ cm}$$

The shift in the apparent position of the needle is

$$\text{Shift} = 9.4 - 7.67 = 1.73 \text{ cm}$$

The new image looks 1.73 cm closer to the surface; therefore, the microscope should be moved upward by 1.73 cm to focus it.

WATER TO GLASS REFRACTION – EXERCISE 9.4

Q. In original Fig. 9.27, air incidence $i = 60^\circ$ gives glass refraction 35° in (a) and water refraction 47° in (b). Find refraction angle in glass when incidence in water is 45° in (c).

Answer: Apply Snell's law to get indices relative to air, then at water-glass interface.

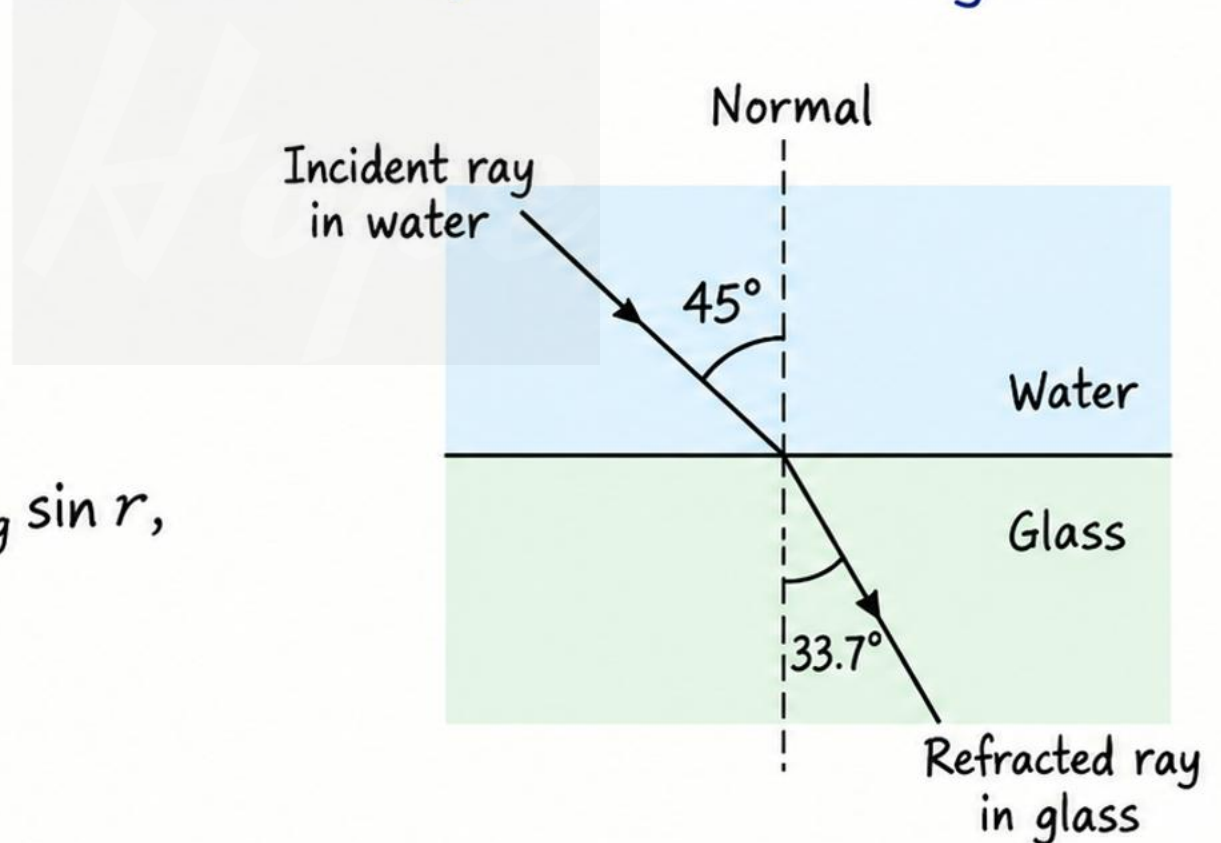
$$n_g = \frac{\sin 60^\circ}{\sin 35^\circ} \quad ; \quad n_w = \frac{\sin 60^\circ}{\sin 47^\circ}$$

$$\text{Thus } \frac{n_w}{n_g} = \frac{\sin 35^\circ}{\sin 47^\circ}.$$

At water-glass interface, $n_w \sin 45^\circ = n_g \sin r$,

$$\text{so } \sin r = \left(\frac{\sin 35^\circ}{\sin 47^\circ} \right) \sin 45^\circ$$

$$\sin r \approx 0.554 \Rightarrow r \approx 33.7^\circ.$$





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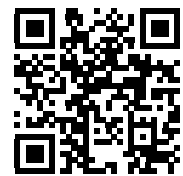


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