PHYSICS 504

OPTICS REVIEW SOLUTIONS

1

Step 1: Find n_1

$$n_1 \, sin \, i^\circ = n_2 \, sin \, r^\circ$$
$$n_1 \sin 40^\circ = 1 \sin 65^\circ$$
$$n_1 = 1.4$$

Step 2: Find critical angle (knowing $r^\circ = 90^\circ$)

$$n_1 \, sin \, i^\circ = n_2 \, sin \, r^\circ$$
$$1.4 \, sin \, i^\circ = 1 sin \, 90^\circ$$
$$sin \, i^\circ = 0.714$$
$$i^\circ = \sin^{-1} 0.714$$
$$i^\circ = 45^\circ$$

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Example of an appropriate and complete answer

Angle of reflection

90° – 70° = 20°

Angle of reflection = Angle of refraction = 20°

Calculating index of refraction of unknown medium

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

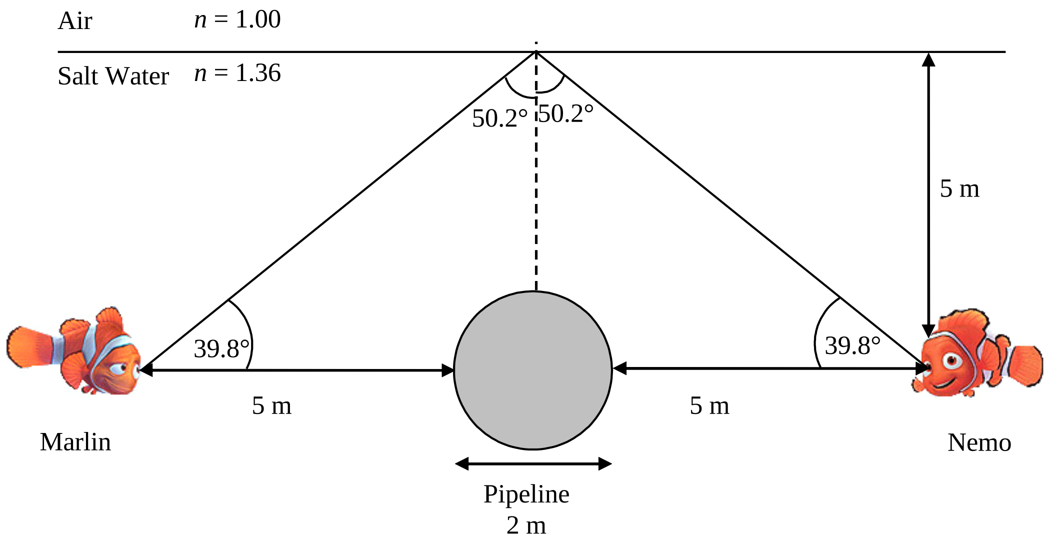
$n_2 = \dfrac{n_1 \sin\theta_1}{\sin\theta_2}$

$n_2 = \dfrac{(1.00)(\sin 40^\circ)}{\sin 20^\circ}$

$n_2 = 1.88$

Answer: The index of refraction of the unknown medium is **1.88**.

3 **Example of an appropriate and complete answer**



Tan θ: $\frac{\text{opposite}}{\text{adjacent}} = \frac{5}{6}$ Therefore θ = 39.8°

Corresponding angle at water surface: 50.2°

Critical angle: $\sin^{-1}\left(\frac{1}{1.36}\right) = 47.3°$

Answer: Marlin and Nemo can see each other because of total internal reflection.

Justification: As the complimentary angle exceeds the critical angle, total internal reflection occurs.

4 Defect in the eye : myopia

Correction is accomplished by : wearing glasses or contact lenses with divergent lenses.

5 **Example of an appropriate procedure**

1. Converging lens (magnification for a real image is negative)

$M = -4$

Therefore, $-4 = \frac{d_i}{d_o} \rightarrow d_i = 4d_o$

2. Distance from the lens to the object

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

$$\frac{1}{50\text{ cm}} = \frac{1}{d_o} + \frac{1}{4d_o}$$

$$\frac{1}{50\text{ cm}} = \frac{5}{4d_o}$$

$$d_o = \frac{5(50\text{ cm})}{4}$$

$$d_o = 62.5\text{ cm}$$

Note : A procedure based on a diagram is also acceptable.

Answer : She must place the lens 62.5 cm from the object.

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Example of an appropriate and complete answer

Calculating distance of image

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

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

$$\frac{1}{d_i} = \frac{1}{0.50\text{ m}} - \frac{1}{1.5\text{ m}}$$

$$\frac{1}{d_i} = 1.33$$

$$d_i = 0.75\text{ m}$$

Calculating height of image

$$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$h_i = -\frac{d_i\, h_o}{d_o}$$

$$h_i = -\frac{(0.75\text{ m})(0.10\text{ m})}{(1.5\text{ m})}$$

$$h_i = -5.0 \times 10^{-2}\text{ m}$$

Answer: The height of the rabbit's image is **-5.0×10^{-2} m or 5.0×10^{-2} m inverted**.

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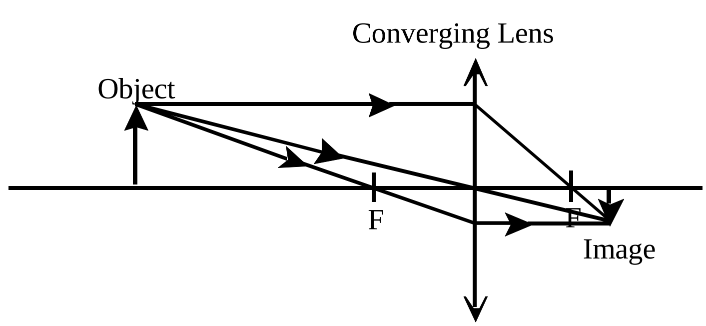
Example of an appropriate procedure



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Example of an appropriate and complete answer

f = 12.0 cm
d_o = x
d_i = 64.0 – x

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

$$\frac{1}{12.0} = \frac{1}{x} + \frac{1}{64.0 - x}$$

$$\frac{1}{12.0} = \frac{64.0 - x}{(x)(64.0 - x)} + \frac{x}{(x)(64.0 - x)}$$

$$\frac{1}{12.0} = \frac{64.0}{(x)(64.0 - x)}$$

$$\frac{1}{12.0} = \frac{64.0}{64.0x - x^2}$$

$64.0x - x^2 = 768$

$x^2 - 64.0x + 768 = 0$
$(x - 16)(x - 48) = 0$
$d_o = 16.0$ cm or 48.0 cm

$$M = -\frac{d_i}{d_o} = \frac{h_i}{h_o} > 1$$

$\therefore\ d_i > d_o$

Answer: Nadia must place the lens **16.0 cm** from the object.

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Example of an appropriate and complete answer

$$\frac{h_i}{h_o} = -\frac{d_i}{d_o} = +\frac{4}{1} \qquad \therefore \quad d_o = -\frac{d_i}{4}$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad \text{replace } d_o\text{:} \ \frac{1}{f} = \frac{1}{\frac{-d_i}{4}} + \frac{1}{d_i}$$

$$\text{Simplifying } \frac{1}{f} = \frac{-4}{d_i} + \frac{1}{d_i} \qquad \therefore \frac{1}{f} = \frac{-3}{d_i}$$

Replacing f = 19 cm $$\frac{1}{19\,\text{cm}} = \frac{-3}{d_i}$$

$$d_i = -57\text{ cm}$$

Answer: **The distance of the image from the magnifying glass is –57 cm**
OR:
57 cm, on the same side as object

NOTE: A graphical solution is also acceptable.

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$$f = 10.0\,cm = 0.100\,m$$
$$d_i = 4.10\,m$$

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

$$\frac{1}{0.100\,m} = \frac{1}{d_o} + \frac{1}{4.10\,m}$$

$d_o = 0.103\,m$ is the distance between the lens and slide.

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Example of an appropriate and complete answer

Optical power of first lens is -2.00 diopters

Optical power of second lens

$$P_2 = \frac{1}{f_2}$$

$$P_2 = \frac{1}{0.200\text{ m}}$$

$$P_2 = 5.00\text{ diopters}$$

Optical power of third lens
$P_t = P_1 + P_2 + P_3$
1.5 d = -2.00 d + 5.00 d + P_3
P_3 = -1.50 d

Focal length of third lens

$$f_3 = \frac{1}{P_3}$$

$$f_3 = \frac{1}{-1.50\text{ d}}$$

$$f_3 = -0.667\text{ m}$$

Answer: The focal length of the third lens is **-0.667 m** or -**6.67** $\times$ **10^{-1} m**