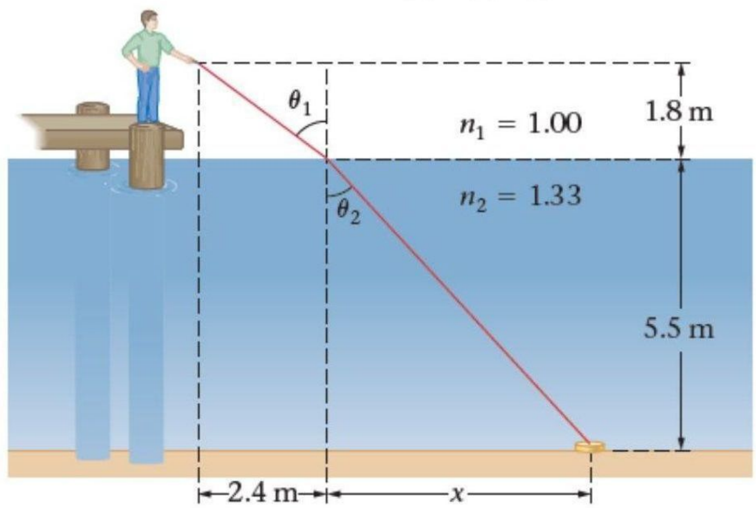
Problems:

1. A PHY_105 student walks to the end of a dock and shines his laser pointer into the water. When he shines the beam of light on the water a horizontal distance of 2.4 m from the dock, he sees a glint of light from a shiny object on the sandy bottom. If the pointer is 1.8 m above the surface of the water, and the water is 5.5 m deep, what is the horizontal distance x as indicated in the figure?

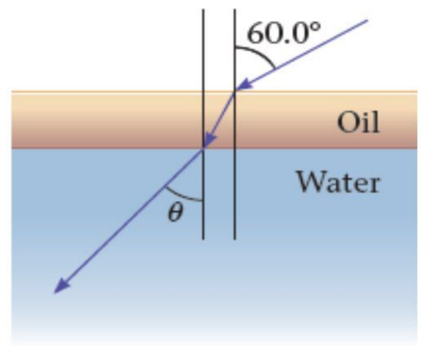


Answer: All of the known distances are indicated in the sketch, along with the angle of incidence, θ_1, and the angle of refraction, θ_2. Finally, the appropriate indices of refraction from Table 23-1 are given as well. We can use Snell's law and basic trigonometry to find the horizontal distance x. First, the information given in the problem determines the angle of incidence, θ_1. In particular, we can see from the sketch that tan θ_1 = (2.4 m)/(1.8 m). Second, Snell's law gives the angle of refraction, θ_2. Finally, we can find the distance x from θ_2, noting that tan θ_2 = x/(5.5 m).
Thus: θ_1 = 53°, θ_2 = 37°, and hence x = 4.1 m.

2. An object with a height of 2.54 cm is placed 36.3 mm to the left of a lens with a focal length of 35.0 mm. (a) Where is the image located? (b) What is the height of the image?
Answer: (a) The image is located 0.98 m to the right of the lens. (b) The image is inverted and 68 cm tall.

3. An object is located to the left of a concave lens whose focal length is -34 cm. The magnification produced by the lens is m = 1/3. (a) To decrease the magnification to m = 1/4, should the object be moved closer to the lens or farther away? (b) Calculate the distance through which the object should be moved. Answer: (a) You need to write an equation for the magnification as a function of the object distance: $m=\frac{f}{f-d_o}$. You can see from the expression that because f is negative, in order to decrease the magnification, the object should be moved farther away from the lens, making the denominator $f - d_o$ larger in magnitude and m smaller. (b) Solve for the object distance: $d_{o4} - d_{o3} = f(\frac{1}{m3} - \frac{1}{m4})$ = 34 cm. The object should be moved 34 cm farther away from the lens.

4. A film of oil, with an index of refraction of 1.48 and a thickness of 1.50 cm, floats on a pool of water, as shown. A beam of light is incident from air on the oil at an angle $\theta_1 = 60.0°$ to the vertical. (a) Find the angle θ the light beam makes with the vertical as it travels through the water. (b) How does your answer to part (a) depend on the thickness of the oil film? Explain.



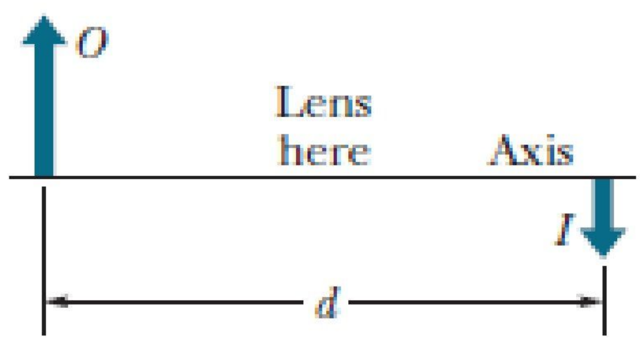
Answer: (a) Because the air/oil and oil/water interfaces are parallel, the angle of refraction at the air/oil interface will equal the angle of incidence at the oil/water interface. Write Snell's law at the air/oil interface and at the oil/water interface, and then combine the two equations and solve for the angle of refraction in water:

$$\theta = \sin^{-1}\left(\frac{n_{air}}{n_{water}}\sin\theta_1\right) = \sin^{-1}\left(\frac{n_1}{n_2}\sin\theta_1\right) = 40.6°$$

(b) The answer to part (a) does not depend upon the thickness of the oil film, because θ depends only upon the original angle of incidence and the indices of refraction of air and water.

5. As shown in the figure, a real inverted image *I* of an object *O* is formed by a particular lens (not shown); the object–image separation is *d* = 40.0 cm, measured along the central axis of the lens. The image is just half the size of the object. (a) What kind of lens must be used to produce this image? (b) How far from the object must the lens be placed? (c) What is the focal length of the lens?

Answer: This time I'll give you the answer for item c only: 8.89 cm.



Problems:

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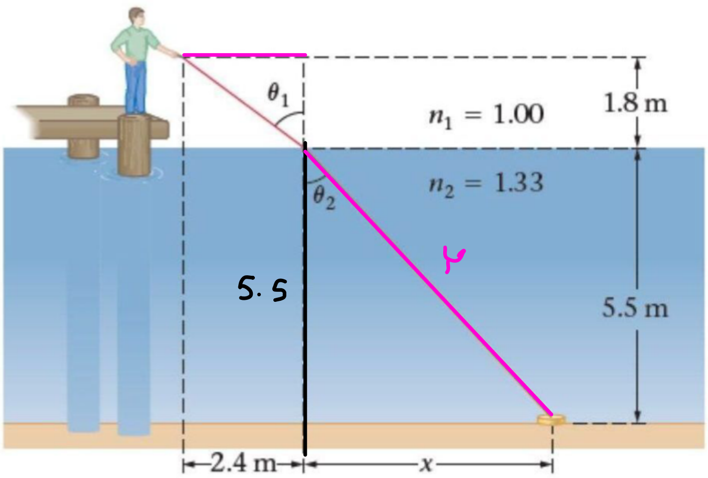

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Thus: θ_1 = 53°, θ_2 = 37°, and hence x = 4.1 m.

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

$$\sin(53.1) * 1 = \frac{x}{\sqrt{30.3 + x^2}} * 1.33$$

$$0.6 = \frac{x}{\sqrt{30.3 + x^2}}$$

$$0.6\sqrt{30.3 + x^2} = x \quad \text{(تربيع الطرفين)}$$

$$0.36(30.3 + x^2) = x^2$$

$$10.91 + 0.36x^2 = x^2$$

$$0.64x^2 = 10.91$$

$$\therefore x^2 = 17.1$$

$$\therefore x = 4.1 \text{ m}$$

$$\tan\theta_1 = \frac{2.4}{1.8}$$

$$\therefore \theta_1 = 53.1°$$

$$y^2 = 5.5 + x^2$$

$$\therefore y = \sqrt{30.3 + x^2}$$

$$\sin\theta_2 = \frac{x}{\sqrt{30.3 + x^2}}$$

2. An object with a height of $\overset{h_o}{\underline{2.54\text{ cm}}}$ is placed $\overset{d_o}{\underline{36.3\text{ mm}}}$ to the left of a lens with a focal length of $\overset{f}{\underline{35.0}}$ mm. (a) Where is the image located? (b) What is the height of the image?
Answer: (a) The image is located 0.98 m to the right of the lens. (b) The image is inverted and 68 cm tall.

(A) $$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \longrightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \longrightarrow \frac{1}{d_i} = \frac{1}{35} - \frac{1}{36.3}$$

$$\therefore d_i = 977.3 \text{ mm}$$

(B) $$\frac{h_o}{d_o} = \frac{h_i}{d_i} \longrightarrow \frac{2.54 \times 10 \cancel{\text{mm}}}{36.3 \cancel{\text{mm}}} = \frac{h_i}{977.3}$$

$$\therefore h_i = -683.8 \text{ mm}$$

inverted

3. An object is located to the left of a concave lens whose focal length is -34 cm. The magnification produced by the lens is m = 1/3. (a) To decrease the magnification to m = 1/4, should the object be moved closer to the lens or farther away? (b) Calculate the distance through which the object should be moved. Answer: (a) You need to write an equation for the magnification as a function of the object distance: $m = \frac{f}{f - d_o}$. You can see from the expression that because f is negative, in order to decrease the magnification, the object should be moved farther away from the lens, making the denominator $f - d_o$ larger in magnitude and m smaller. (b) Solve for the object distance: $d_{o4} - d_{o3} = f\left(\frac{1}{m3} - \frac{1}{m4}\right)$ = 34 cm. The object should be moved 34 cm farther away from the lens.

(A) $$m = \frac{-d_i}{d_o} \longrightarrow \frac{1}{3} = \frac{-d_i}{d_o} \longrightarrow d_o = -3d_i$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \longrightarrow \frac{-1}{34} = \frac{-1}{3d_i} + \frac{1}{d_i}$$

$$\frac{-1}{34} = \frac{2\cancel{d_i}}{3d_i^{\cancel{2}}} \longrightarrow \frac{-1}{34} = \frac{2}{3d_i} \longrightarrow d_i = -22.67 \text{ cm}$$

$$\therefore d_o = 68 \text{ cm}$$

$$m = \frac{-d_i}{d_o} \longrightarrow \frac{1}{4} = \frac{-d_i}{d_o} \quad \therefore d_o = -4d_i$$

$$\frac{-1}{34} = \frac{-1}{4d_i} + \frac{1}{d_i} \longrightarrow \frac{-1}{34} = \frac{3\cancel{d_i}}{4d_i^{\cancel{2}}} \longrightarrow d_i = -25.5$$

$$\therefore d_o = 102$$

when the magnification decrease to $\frac{1}{4}$ the object must moved away the Lens

(B)

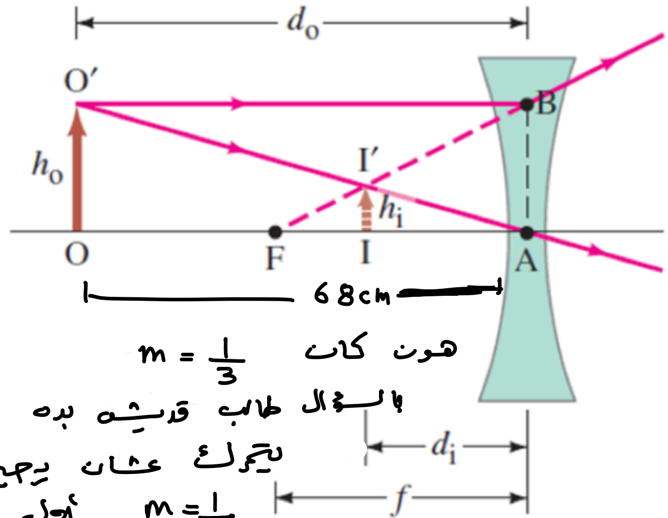
d_o when $m = \frac{1}{3}$

$= 68$ cm

d_o when $m = \frac{1}{4}$

102 cm

(A) حسبناهم في الفرع



$\therefore 102 - 68 = 34$cm

هون كان $m = \frac{1}{3}$

بالسؤال طالب قديشه بده

يتحرك عشان يصير

أول اشي $m = \frac{1}{4}$

بدنا نحسب d_o لما يكون

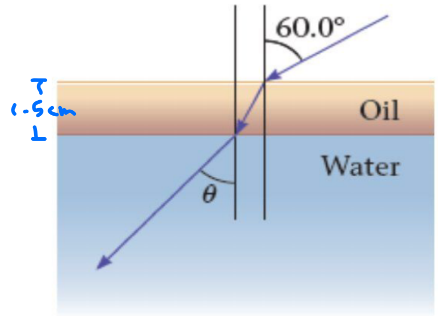
$m = \frac{1}{3}$ وبعدين نحسب d_o

لما يكون $m = \frac{1}{4}$ ونطرحهم

من بعض

n_{oil}

4. A film of oil, with an index of refraction of 1.48 and a thickness of 1.50 cm, floats on a pool of water, as shown. A beam of light is incident from air on the oil at an angle θ_1= 60.0° to the vertical. (a) Find the angle θ the light beam makes with the vertical as it travels through the water. (b) How does your answer to part (a) depend on the thickness of the oil film? Explain.



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(b) The answer to part (a) does not depend upon the thickness of the oil film, because θ depends only upon the original angle of incidence and the indices of refraction of air and water.

A air $\rightarrow$ water

$$\sin\theta_1 * n_{air} = \sin(\theta) * n_w$$

$$\therefore \sin(\theta) = \frac{\sin(60) * 1}{1.33} = \sin\theta = 0.65 \quad \therefore \theta = 40.6°$$

note: air ($n_1, \sin\theta$) $\rightarrow$ oil ($n_2, \sin\theta_2$) $\rightarrow$ water ($n_3, \sin\theta_3$) رح تعطي نفس الزاوية

الاثبات : air $\rightarrow$ oil

$$\boxed{\sin\theta_1 * n_1 = \sin\theta_2 * n_2}$$

oil $\rightarrow$ water

$$\boxed{\sin\theta_2 * n_2} = \sin\theta_3 * n_3$$

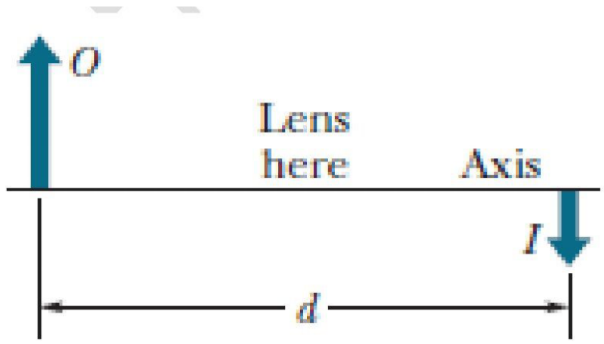
$$\boxed{\sin\theta_1 * n_1 = \sin\theta_3 * n_3}$$

air $\rightarrow$ water

so, it not depened on the thickness of oil

Converging Lens

5. As shown in the figure, a real inverted image *I* of an object *O* is formed by a particular lens (not shown); the object–image separation is $d = 40.0$ cm, measured along the central axis of the lens. The image is just half the size of the object. (a) What kind of lens must be used to produce this image? (b) How far from the object must the lens be placed? (c) What is the focal length of the lens? Answer: This time I'll give you the answer for item c only: 8.89 cm.



distance between object and image is 40cm

$h_i = \frac{1}{2} h_o$

(A) converging Lens

(B) $d_o + d_i = 40\,\text{cm}$ | $h_i = \frac{1}{2} h_o$

$$\frac{h_o}{d_o} = \frac{h_i}{d_i} \longrightarrow \frac{2\cancel{h_i}}{d_o} = \frac{\cancel{h_i}}{(40 - d_o)}$$

$80 - 2d_o = d_o$

$\therefore 3d_o = 80 \longrightarrow d_o = 26.67$ cm away the Lens

$\therefore d_i = 13.3$

(C) $$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \longrightarrow \frac{1}{f} = \frac{1}{26.67} + \frac{1}{13.3}$$

$\therefore f = 8.89$ cm