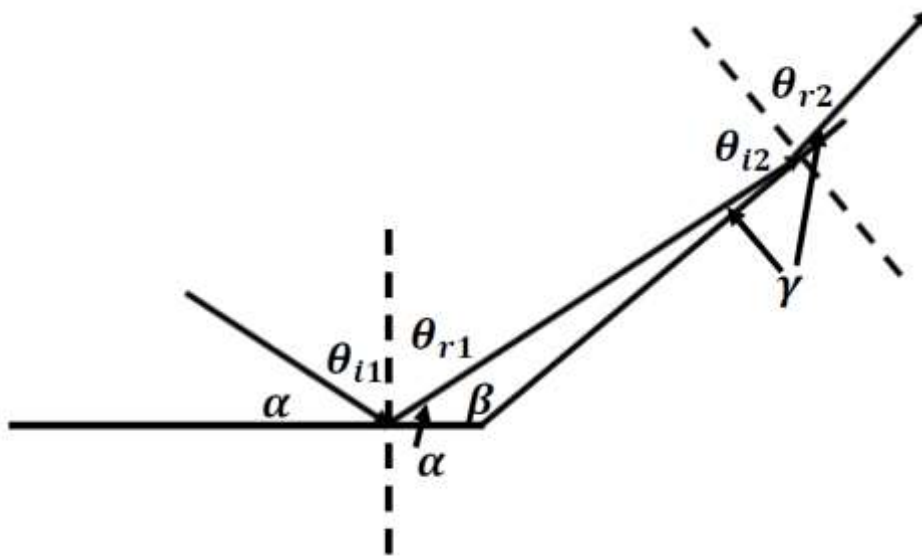


PH 221 Homework Assignment Chapter on Optics Reflections & Refraction – 29 Problems Total

1. If you look at yourself in a plane (flat) mirror which is located a distance ($o = 3.40$ m) away from you. How far from you would you determine your image of yourself to be?

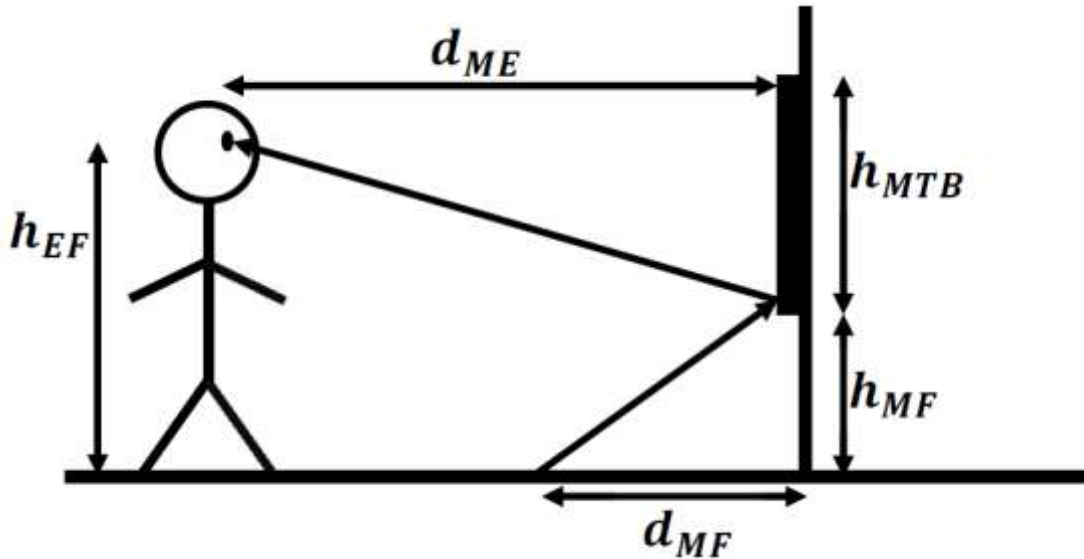
Solution for Problem 1

2. As seen below, a beam of light strikes a plane mirror that is horizontal. The light beam makes an angle ($\alpha = 33.0^\circ$) with the plane of the mirror as shown. The light reflects off the horizontal mirror and then strikes a second plane mirror which makes an angle ($\beta = 140.^\circ$). At what angle (γ) does the beam make with the second mirror as it bounces off the mirror?



Solution for Problem 2

3. A person whose eyes are located ($h_{EF} = 1.76$ m) above the floor stands a distance ($d_{ME} = 2.60$ m) from the front surface of a mirror. The mirror has a length ($h_{MTB} = 1.54$ m) and the bottom edge of the mirror is a distance ($h_{MF} = 0.420$ m) above the floor. What is the distance (d_{MF}) of the closest spot on the floor that can just be seen by the person looking into the mirror?



Solution for Problem 3

4. A simple way to make a solar cooker is to use a concave mirror. Aim it at the sun and put the food to be cooked at the focal point. If you want to put the food a distance ($i = 0.228$ m) in front of the mirror, what is the radius of curvature for the concave mirror?

Solution for Problem 4

5. A small statue is located a distance (45.0 cm) to the left of a concave mirror with a radius of curvature (26.0 cm).

- (a) What is the focal length of the mirror?
- (b) Where will the image be formed relative to the mirror?
- (c) Is the image upright or inverted?

Solution for Problem 5

6. A jeweler wants a small mirror that when a jewel is 1.46 cm from the mirror, it will produce an upright image that is five times larger.

- (a) What is the focal length of the mirror?
- (b) What type of mirror (Concave or Convex) is the mirror?

Solution for Problem 6

7. While looking into a security mirror in a store, you estimate your upright image height looks to be about one-third of your actual height. If you are 4.00 m from the mirror, what is the radius of curvature of the mirror?

Solution for Problem 7

8. The image of a distant castle is virtual and very small when it is observed in a curved mirror. The image is formed 24.0 cm behind the mirror.

- (a) What is the focal length of the mirror?
- (b) What type of mirror is it?

Solution for Problem 8

9. We want to use a concave mirror to produce an image that appears at the same location as the object we are imaging.

- (a) What should the object distance be in relation to the radius of curvature of the mirror?
- (b) Is the image real or virtual?
- (c) Is the image upright or inverted?
- (d) What is the magnification of the image?

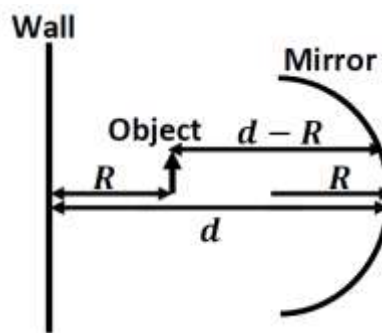
Solution for Problem 9

10. A magnifying mirror is often used for shaving or applying makeup. Let's figure out what we need if we wish to magnify an object (say your face) by the factor 1.60 when your face is a distance 25.0 cm in front of the mirror.

- (a) What is the focal length of the mirror?
- (b) What type of mirror is it?
- (c) Is the image real or virtual?
- (d) Is the image inverted or upright?

Solution for Problem 10

11. A concave mirror has a radius of curvature (R). An object is placed that same distance (R) from a flat wall. The mirror is now placed a distance (d) from the wall. A real image of the object is formed on the wall.



- (a) What is the distance (d) in terms of the mirror's radius of curvature (R) ?
- (b) What is the magnification of the image?

Solution for Problem 11

12. The index of refraction for ice is 1.31. What is the speed of light in ice?

Solution for Problem 12

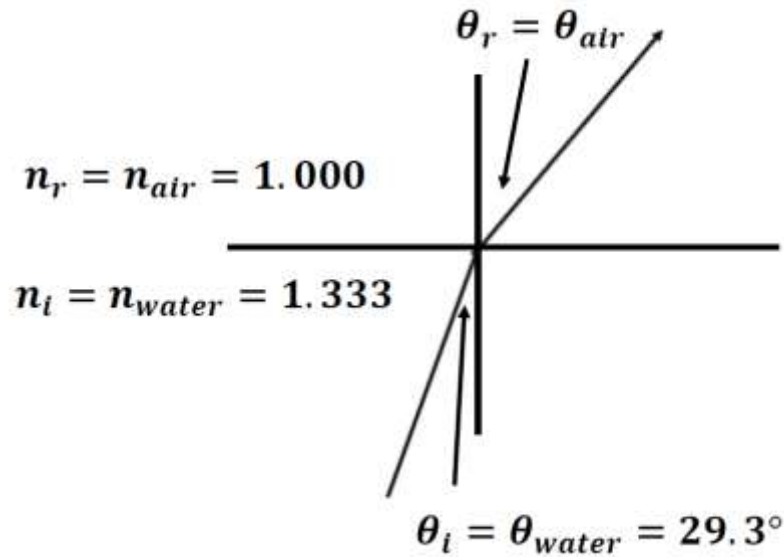
13. How long does it take light to reach us from the Sun which is located a distance 1.50×10^{11} m away?

Solution for Problem 13

14. A light beam is moving through space and encounters a rotating plate with a tiny slit cut into it. Light is incident on the slit for a time of 2.00×10^{-9} s. Then the light is blocked until the disk rotates around again. This provides a beam of discrete bursts of light each lasting for the 2.00×10^{-9} s it can pass through the slit. How long in space are these bursts?

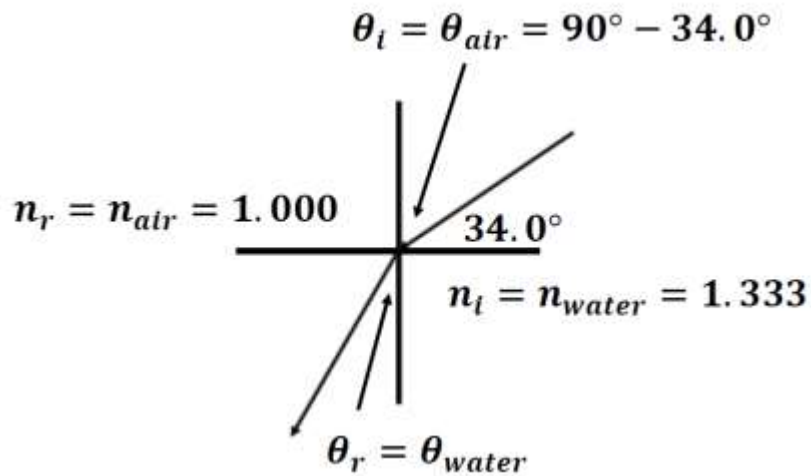
Solution for Problem 14

15. An underwater swimmer shines a flashlight up towards the surface of the water making an angle ($\theta_{\text{Water}} = 29.3^\circ$) with respect to a vertical line. At what angle with respect to a vertical line does the light make in the air above the water?



Solution for Problem 15

16. A searchlight is looking into a shipwreck area. If the spotlight makes an angle of 34.0° with the surface of the water, at what angle relative to a vertical would a diver underwater see the beam of light at?

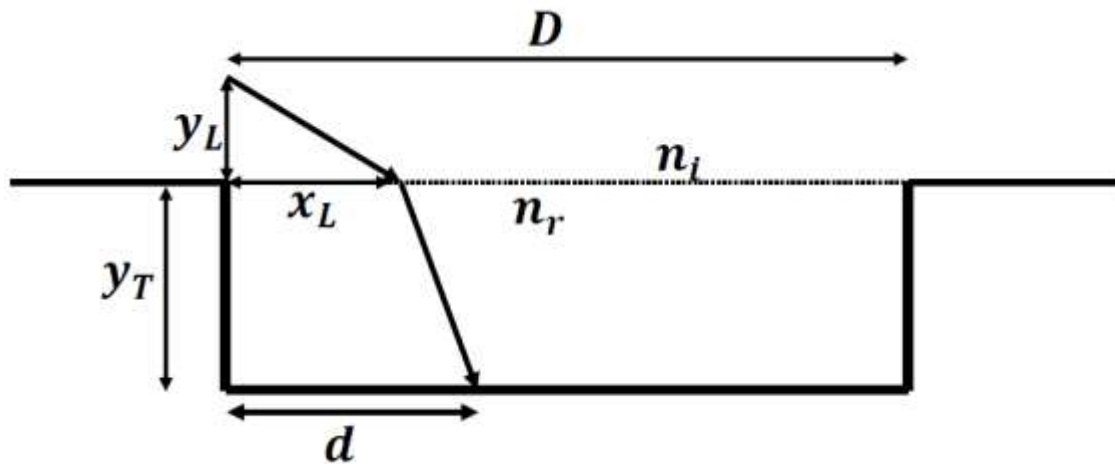


Solution for Problem 16

17. A beam of light in air ($n_{air} = 1.000$) strikes a piece of glass ($n_{glass} = 1.670$) and the beam is partially reflected and partially refracted. What is the angle of incidence if the refracted angle is one half the angle of reflection?

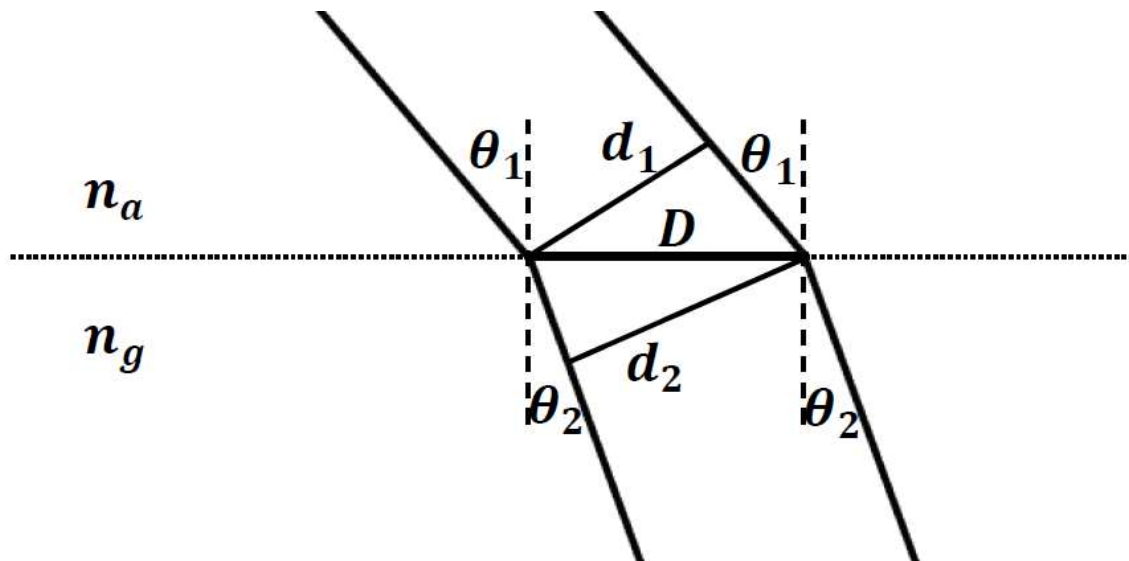
Solution for Problem 17

18. A water quality specialist is examining a water treatment tank at night and shines a flashlight down into the tank as illustrated below. The light is a distance ($y_L = 1.40$ m) above the water at the top of the tank. The flashlight is aimed so that it hits the surface of the water a distance ($x_L = 1.90$ m) from the edge of the tank. The tank has a diameter ($D = 5.00$ m) and a depth ($y_T = 3.00$ m). Assume the indices of refraction are ($n_i = n_{\text{air}} = 1.000$) and ($n_r = n_{\text{water}} = 1.333$). How far from the wall of the tank distance (d) shown below will the beam of light strike the floor of the tank?



Solution for Problem 18

19. A beam of light traveling in air ($n_a = 1.000$) has a diameter ($d_1 = 4.00$ mm). The light beam strikes a glass ($n_g = 1.465$) plate with an angle of incidence ($\theta_1 = 35.0^\circ$). This is illustrated below. Determine the diameter (d_2) of the light beam as it travels through the glass.

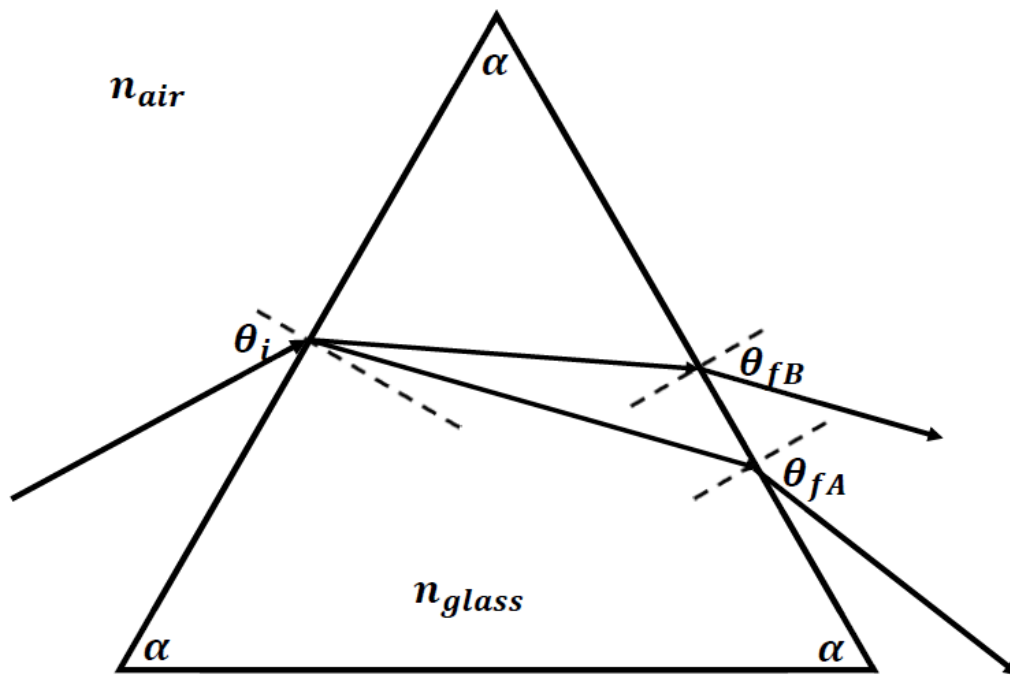


Solution for Problem 19

20. The index of refraction for blue light ($\lambda_{\text{blue}} = 450. \text{ nm}$) in silicate flint glass is ($n_{450} = 1.64$) , while for red light ($\lambda_{\text{red}} = 680. \text{ nm}$) the index is ($n_{680} = 1.61$) . What is the percent difference in the speed of light in silicate flint glass between these two colors of light?

Solution for Problem 20

21. A beam of light contains two wavelengths of light that we will focus on. The light strikes a glass equilateral triangular prism ($\theta_i = 43.2^\circ$) where each corner angle is the same ($\alpha = 60.0^\circ$) . One wavelength ($\lambda_A = 465. \text{ nm}$) and has an index of refraction in the glass prism ($n_{\text{glass A}} = 1.640$) . The second wavelength ($\lambda_B = 652. \text{ nm}$) and has an index of refraction in the glass prism ($n_{\text{glass B}} = 1.620$) . Use the index of refraction for air ($n_{\text{air}} = 1.000$) . Since the two wavelengths have different indices of refraction in the prism, the beam of light splits and two beams move inside the prism as shown.



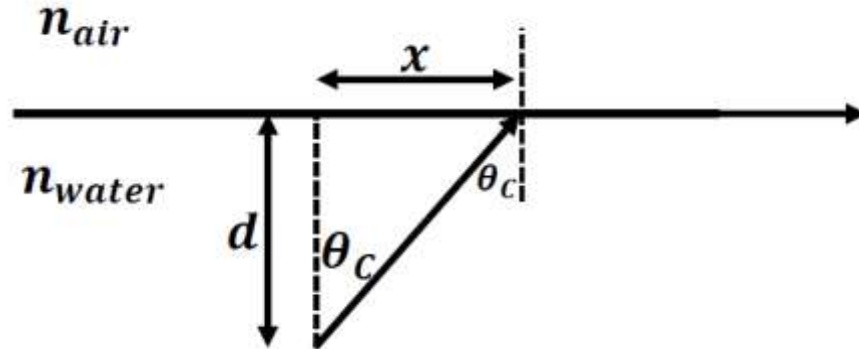
- (a) What is the exit angle for beam A (θ_{fA}) ?
- (b) What is the exit angle for beam B (θ_{fB}) ?

Solution for Problem 21

22. The critical angle for an unknown liquid – air interface is found to be 31.8° . What is the index of refraction this unknown liquid?

Solution for Problem 22

23. As shown below, a beam of light is pointed in a pool of water ($n_{\text{water}} = 1.333$) up ($d = 0.984 \text{ m}$) towards the water – air ($n_{\text{air}} = 1.000$) interface. How far away (x) from the spot directly above it must the light be aimed for the refracted not to be in the air?



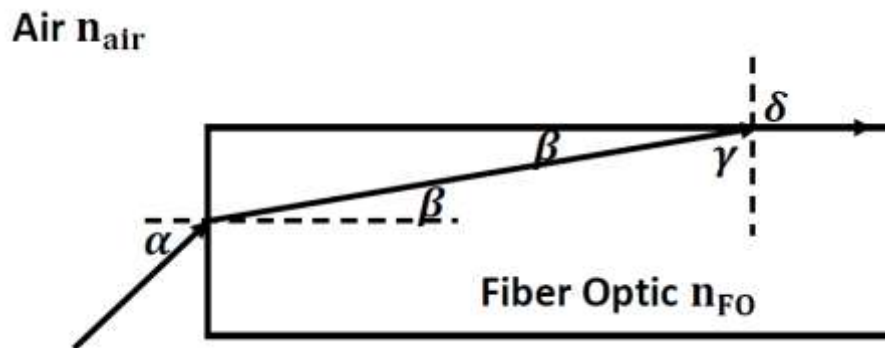
Solution for Problem 23

24. A binocular prism is made of plastic and the property of total internal reflection is used to for the prism to efficiently redirect the light beam. Assume ($n_{\text{air}} = 1.000$)

- (a) What should the index of refraction for the plastic be if an angle of incidence of ($\theta_i = 44.0^\circ$) is used as the critical angle?
- (b) If the prism of question (a) is used but the binoculars are used in water ($n_{\text{water}} = 1.333$) what is the new critical angle for the binoculars to function as designed in part (a)?
- (c) What should the index of refraction of the plastic be for the original critical angle ($\theta_i = 44.0^\circ$) to be valid when the binoculars are under water?

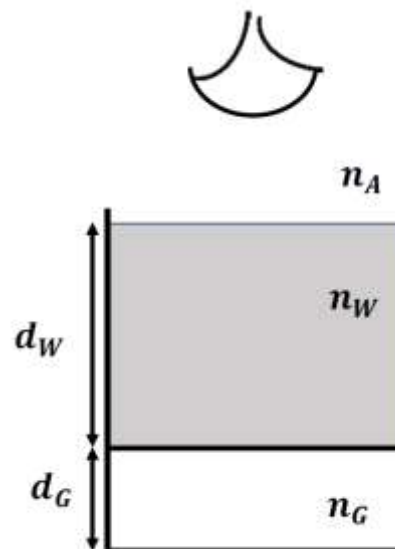
Solution for Problem 24

25. Shown below is a piece of fiber optic cable which relies on total internal reflection to propagate light signals in the cable. Consider the light ray enters the side of the fiber optic with an angle of incidence (α) from air ($n_{\text{air}} = 1.000$). What is the smallest index of refraction of the fiber optic material (n_{FO}), so that the ray inside the fiber optic will be totally internally reflected when it hits a sidewall regardless of the angle of incidence?



Solution for Problem 25

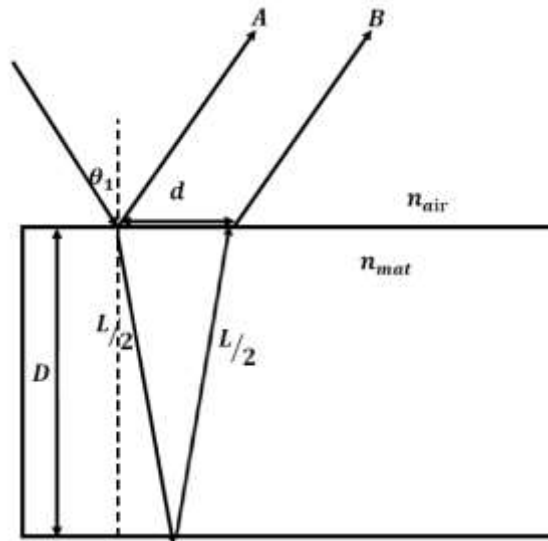
26. A unique bar glass has a thick bottom ($d_G = 7.80$ cm). The index of refraction for the glass is ($n_G = 1.67$). The glass has a depth of water ($d_W = 15.4$ cm). Of course, the index of refraction for the water is ($n_W = 1.33$), and the index of refraction for air is ($n_A = 1.00$). This is shown in the figure below.



When you are looking straight down, how far below the Air-Water interface does the bottom of the glass appear to be?

Solution for Problem 26

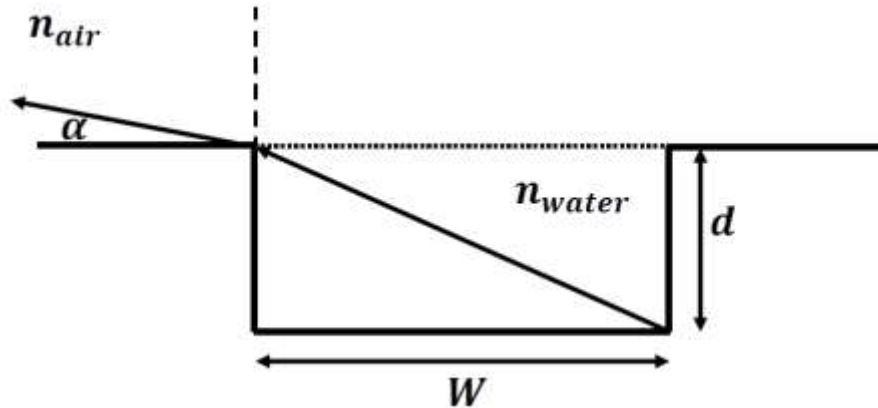
27. A beam of light is incident on a slab of material which has an index of refraction (n_{mat}) and a thickness (D). The angle of incidence is at angle (θ_1). When the light hits the top surface, part of the light is reflected at the same angle as the angle of incidence. The rest of the light refracts into the slab and travels to the far side and reflects there. When the light returns to the top surface it refracts back into the air. The first ray we label A and the second ray we label B. The B ray travels a total distance (L) through the slab. The distance between the two rays A and B above the slab is (d). This is shown below.



- (a) Determine an expression for L in terms of D , n_{mat} , and θ_1 .
- (b) Determine an expression for d in terms of D , n_{mat} , and θ_1 .
- (c) In the limit of looking directly overhead $\theta_1 \rightarrow 0^\circ$, show what the expression L evolves to.
- (d) In the limit of looking directly overhead $\theta_1 \rightarrow 0^\circ$, show what the expression d evolves to.

Solution for Problem 27

28. After a rain storm has filled up chamber in a building site, you notice the image of the bottom of the chamber and the side wall hit you at an angle ($\alpha = 19.0^\circ$) with respect to the ground. Using a laser measuring device, you determine the width of the chamber ($W = 7.54 \text{ m}$). Determine the depth of the chamber. Use the following for the indices of refraction : ($n_{\text{air}} = 1.000$ and $n_{\text{water}} = 1.333$)The situation looks like:



Solution for Problem 28

29. A certain material has a critical angle ($\theta_{\text{C-air}} = 32.8^\circ$) for total internal reflection when the interface is the material and air ($n_{\text{air}} = 1.000$).

- (a) Determine the index of refraction for the material.
- (b) Determine what the critical angle for total internal reflection would be if the interface is the material and water ($n_{\text{water}} = 1.333$) instead of air.

Solution for Problem 29

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