PH 202 Homework Assignment Chapter on Optics Refraction – 40 Problems Total

1. A plate glass window (n = 1.5) has a thickness of 4.0 x 10^{-3} m. How long does it take light to pass perpendicularly through the plate?

Solution for Problem 1

2. In an ultra-low-temperature experiment, a collection of sodium atoms enter a special state called a *Bose-Einstein condensate* in which the index of refraction is 1.57 x 10^{7}. What is the speed of light in this condensate?

Solution for Problem 2

3. The frequency of a light wave is the same when the light travels in ethyl alcohol or in carbon disulfide. Find the ratio of the wavelength of the light in ethyl alcohol to that in carbon disulfide.

Solution for Problem 3

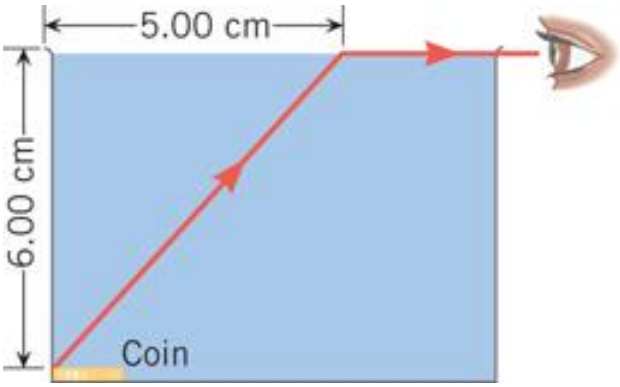
4. A flat sheet of ice has a thickness of 2.0 cm. It is on top of a flat sheet of crystalline quartz that has a thickness of 1.1 cm. Light strikes the ice perpendicularly and travels through it and then through the quartz. In the time it takes the light to travel through the two sheets, how far (in centimeters) would it have traveled in a vacuum?

Solution for Problem 4

5. A layer of oil (n = 1.45) floats on an unknown liquid. A ray of light originates in the oil and passes into the unknown liquid. The angle of incidence is 64.0°, and the angle of refraction is 53.0°. What is the index of refraction of the unknown liquid?

Solution for Problem 5

6. The drawing shows a coin resting on the bottom of a beaker filled with an unknown liquid. A ray of light from the coin travels to the surface of the liquid and is refracted as it enters into the air. A person sees the ray as it skims just above the surface of the liquid. How fast is the light traveling in the liquid?



Solution for Problem 6

7. Amber (n = 1.546) is a transparent brown-yellow fossil resin. An insect, trapped and preserved within the amber, appears to be 2.5 cm beneath the surface when viewed directly from above. How far below the surface is the insect actually located?

Solution for Problem 7

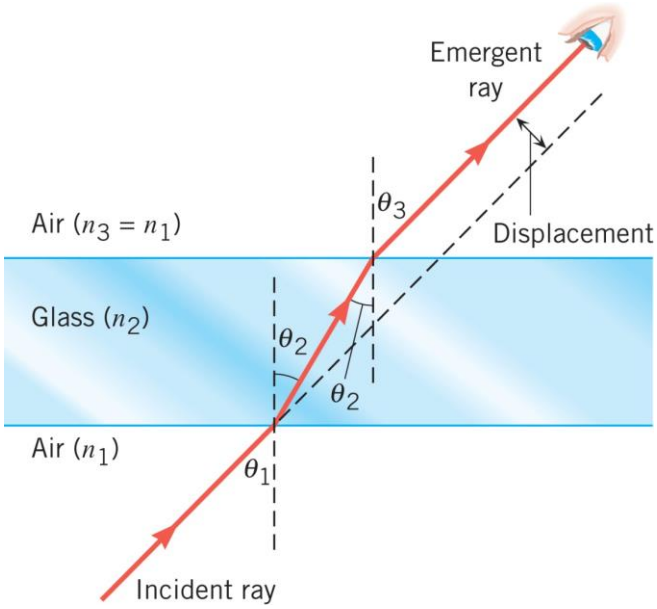
8. A beam of light is traveling in air and strikes a material. The angles of incidence and refraction are 63.0° and 47.0°, respectively. Obtain the speed of light in the material.

Solution for Problem 8

9. A stone held just beneath the surface of a swimming pool is released and sinks to the bottom at a constant speed of 0.48 m/s. What is the apparent speed of the stone, as viewed from directly above by an observer who is in air?

Solution for Problem 9

10. In Figure 26.6, suppose that the angle of incidence is $\theta_1 = 30.0°$, the thickness of the glass pane is 6.00 mm, and the refractive index of the glass is $n_2 = 1.52$. Find the amount (in mm) by which the emergent ray is displaced relative to the incident ray.



Solution for Problem 10

11. A small logo is embedded in a thick block of crown glass (n = 1.52), 3.20 cm beneath the top surface of the glass. The block is put under water, so there is 1.50 cm of water above the top surface of the block. The logo is viewed from directly above by an observer in air. How far beneath the top surface of the water does the logo appear to be?

Solution for Problem 11

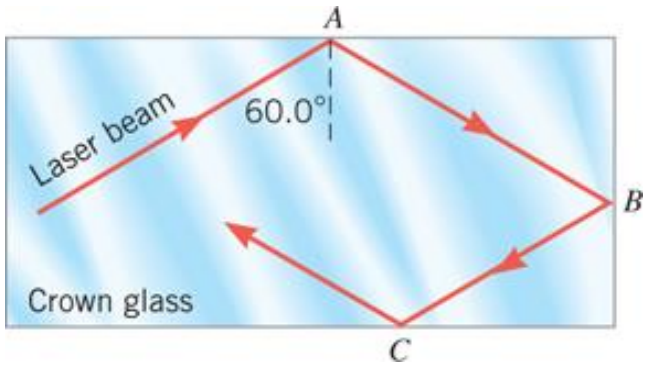
12. A point source of light is submerged 2.2 m below the surface of a lake and emits rays in all directions. On the surface of the lake, directly above the source, the area illuminated is a circle. What is the maximum radius that this circle could have?

Solution for Problem 12

13. A ray of light is traveling in glass and strikes a glass–liquid interface. The angle of incidence is 58.0°, and the index of refraction of glass is n = 1.50. **(a)** What must be the index of refraction of the liquid so that the direction of the light entering the liquid is not changed? **(b)** What is the largest index of refraction that the liquid can have, so that none of the light is transmitted into the liquid and all of it is reflected back into the glass?

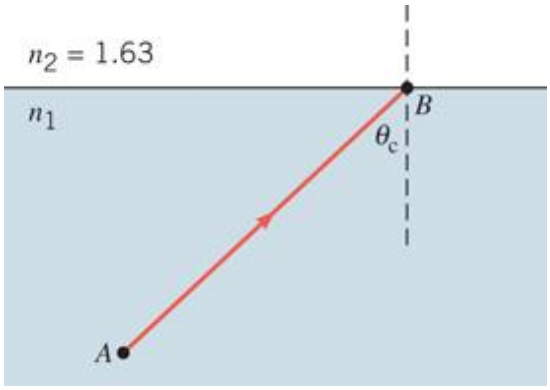
Solution for Problem 13

14. The drawing shows a crown glass slab with a rectangular cross section. As illustrated, a laser beam strikes the upper surface at an angle of 60.0°. After reflecting from the upper surface, the beam reflects from the side and bottom surfaces. **(a)** If the glass is surrounded by air, determine where part of the beam first exits the glass, at point *A*, *B*, or *C*. **(b)** Repeat part (a), assuming that the glass is surrounded by water instead of air.



Solution for Problem 14

15. The drawing shows a ray of light traveling from point *A* to point *B*, a distance of 4.60 m in a material that has an index of refraction n_1. At point *B*, the light encounters a different substance whose index of refraction is $n_2 = 1.63$. The light strikes the interface at the critical angle of $\theta_c = 48.1°$. How much time does it take for the light to travel from *A* to *B*?



Solution for Problem 15

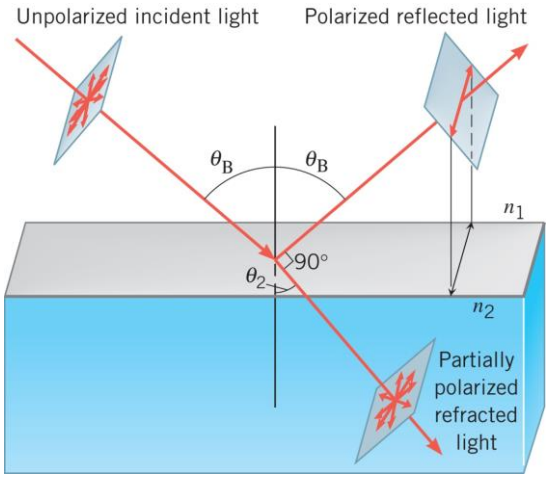
16. Light is reflected from a glass coffee table. When the angle of incidence is 56.7°, the reflected light is completely polarized parallel to the surface of the glass. What is the index of refraction of the glass?

Solution for Problem 16

17. Light is incident from air onto the surface of a liquid. The angle of incidence is 53.0°, and the angle of refraction is 34.0°. At what angle of incidence would the reflected light be 100% polarized?

Solution for Problem 17

18. In the figure below light strikes the surface of a liquid at the Brewster angle, and the reflected light is 100% polarized. Suppose the light originates in air and the angle of refraction in Figure 26.17 is θ_2 = 33.7°. Find the value of the index of refraction n_2 of the liquid.



Solution for Problem 18

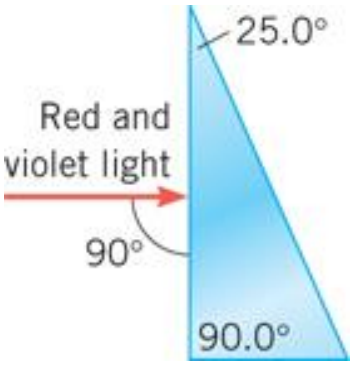
19. A beam of sunlight encounters a plate of crown glass at a 45.00° angle of incidence. Using the data given below, find the angle between the violet ray and the red ray in the glass.

Index of Refraction Data:

$$n_{red} = 1.520 \qquad n_{violet} = 1.538$$

Solution for Problem 19

20. Horizontal rays of red light (λ = 660 nm, in vacuum) and violet light (λ = 410 nm, in vacuum) are incident on the flint-glass prism shown in the drawing. The indices of refraction for the red and violet light are n_{red} = 1.662 and n_{violet} = 1.698. The prism is surrounded by air. What is the angle of refraction for each ray as it emerges from the prism?



Solution for Problem 20

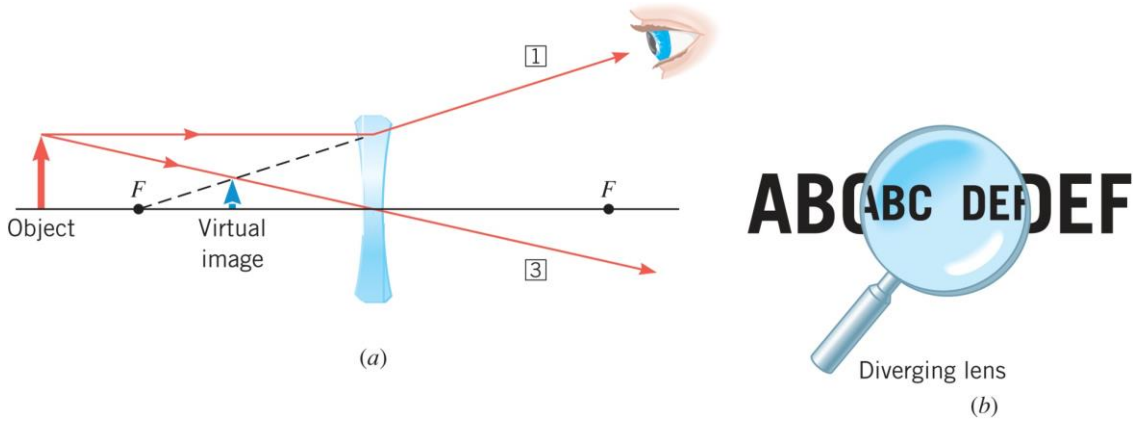
21. An object is located 9.0 cm in front of a converging lens (f = 6.0 cm). Using an accurately drawn ray diagram, determine where the image is located.

Solution for Problem 21

22. A camera is supplied with two interchangeable lenses, whose focal lengths are 35.0 and 150.0 mm. A woman whose height is 1.60 m stands 9.00 m in front of the camera. What is the height (including sign) of her image on the image sensor, as produced by **(a)** the 35.0-mm lens and **(b)** the 150.0-mm lens?

Solution for Problem 22

23. When a diverging lens is held 13.0 cm above a line of print, as in Figure 26.29, the image is 5.0 cm beneath the lens. **(a)** Is the image real or virtual? **(b)** What is the focal length of the lens?



Solution for Problem 23

24. A slide projector has a converging lens whose focal length is 105.00 mm. **(a)** How far (in meters) from the lens must the screen be located if a slide is placed 108.00 mm from the lens? **(b)** If the slide measures 24.0 mm x 36.0 mm, what are the dimensions (in mm) of its image?

Solution for Problem 24

25. A tourist takes a picture of a mountain 14 km away using a camera that has a lens with a focal length of 50 mm. She then takes a second picture when she is only 5.0 km away. What is the ratio of the height of the mountain's image on the camera's image sensor for the second picture to its height on the image sensor for the first picture?

Solution for Problem 25

26. An object is placed to the left of a lens, and a real image is formed to the right of the lens. The image is inverted relative to the object and is one-half the size of the object. The distance between the object and the image is 90.0 cm. **(a)** How far from the lens is the object? **(b)** What is the focal length of the lens?

Solution for Problem 26

27. The distance between an object and its image formed by a diverging lens is 49.0 cm. The focal length of the lens is - 233.0 cm. Find **(a)** the image distance and **(b)** the object distance.

Solution for Problem 27

28. An object is 18 cm in front of a diverging lens that has a focal length of - 12 cm. How far in front of the lens should the object be placed so that the size of its image is reduced by a factor of 2.0?

Solution for Problem 28

29. Two identical diverging lenses are separated by 16 cm. The focal length of each lens is - 8.0 cm. An object is located 4.0 cm to the left of the lens that is on the left. Determine the final image distance relative to the lens on the right.

Solution for Problem 29

30. A converging lens (f = 12.0 cm) is located 30.0 cm to the left of a diverging lens (f = - 6.00 cm). A postage stamp is placed 36.0 cm to the left of the converging lens. **(a)** Locate the final image of the stamp relative to the diverging lens. **(b)** Find the overall magnification. **(c)** Is the final image real or virtual? With respect to the original object, is the final image **(d)** upright or inverted, and is it **(e)** larger or smaller?

Solution for Problem 30

31. An object is placed 20.0 cm to the left of a diverging lens (f = - 8.00 cm). A concave mirror (f = 12.0 cm) is placed 30.0 cm to the right of the lens. **(a)** Find the final image distance, measured relative to the mirror. **(b)** Is the final image real or virtual? **(c)** Is the final image upright or inverted with respect to the original object?

Solution for Problem 31

32. A nearsighted person cannot read a sign that is more than 5.2 m from his eyes. To deal with this problem, he wears contact lenses that do not correct his vision completely, but do allow him to read signs located up to distances of 12.0 m from his eyes. What is the focal length of the contacts?

Solution for Problem 32

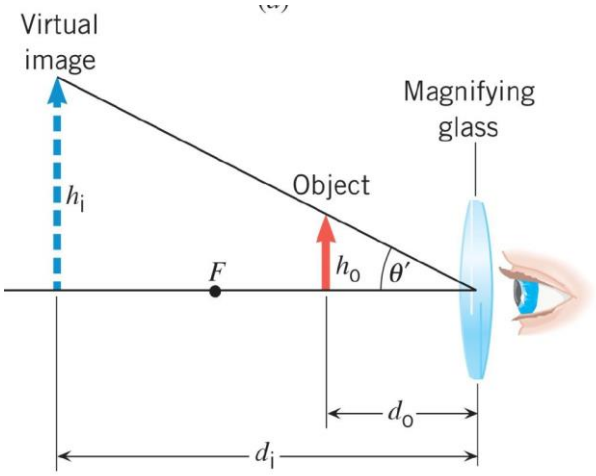
33. A woman can read the large print in a newspaper only when it is at a distance of 65 cm or more from her eyes. **(a)** Is she nearsighted (myopic) or farsighted (hyperopic), and what kind of lens is used in her glasses to correct her eyesight? **(b)** What should be the refractive power (in diopters) of her glasses (worn 2.0 cm from the eyes), so she can read the newspaper at a distance of 25 cm from her eyes?

Solution for Problem 33

34. A person has far points of 5.0 m from the right eye and 6.5 m from the left eye. Write a prescription for the refractive power of each corrective contact lens.

Solution for Problem 34

35. A jeweler whose near point is 72 cm from his eye uses a magnifying glass as in the figure below to examine a watch. The watch is held 4.0 cm from the magnifying glass. Find the angular magnification of the magnifying glass.



Solution for Problem 35

36. A spectator, seated in the left-field stands, is watching a baseball player who is 1.9 m tall and is 75 m away. On a TV screen, located 3.0 m from a person watching the game at home, the image of this same player is 0.12 m tall. Find the angular size of the player as seen by **(a)** the spectator watching the game live and **(b)** the TV viewer. **(c)** To whom does the player appear to be larger?

Solution for Problem 36

37. A compound microscope has a barrel whose length is 16.0 cm and an eyepiece whose focal length is 1.4 cm. The viewer has a near point located 25 cm from his eyes. What focal length must the objective have so that the angular magnification of the microscope will be -320?

Solution for Problem 37

38. In a compound microscope, the objective has a focal length of 0.60 cm, while the eyepiece has a focal length of 2.0 cm. The separation between the objective and the eyepiece is L = 12.0 cm. Another microscope that has the same angular magnification can be constructed by interchanging the two lenses, provided that the distance between the lenses is adjusted to a value L'. Find L'.

Solution for Problem 38

39. Mars subtends an angle of 8.0×10^{-5} rad at the unaided eye. An astronomical telescope has an eyepiece with a focal length of 0.032 m. When Mars is viewed using this telescope, it subtends an angle of 2.8×10^{-3} rad. Find the focal length of the telescope's objective lens.

Solution for Problem 39

40. An amateur astronomer decides to build a telescope from a discarded pair of eyeglasses. One of the lenses has a refractive power of 11 diopters, and the other has a refractive power of 1.3 diopters. **(a)** Which lens should be the objective? **(b)** How far apart should the lenses be separated? **(c)** What is the angular magnification of the telescope?

Solution for Problem 40

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