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Section 26.2 Snell's Law and the Refraction of Light

- 8. A beam of light passes from air into water. Which is necessarily true?
 - (a) The frequency is unchanged and the wavelength increases.
 - (b) The frequency is unchanged and the wavelength decreases.
 - (c) The wavelength is unchanged and the *frequency decreases*.
 - (d) Both the wavelength and frequency increase.
 - (e) Both the wavelength and frequency decrease.
- 9. A ray of light passes from air into a block of glass with a refractive index of 1.50 as shown in the figure.

Note: The drawing is not to scale.

What is the value of the distance *D*?

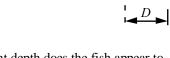
(a) 1.42 cm

(d) 2.14 cm

(b) 1.66 cm

(e) 2.38 cm

(c) 1.90 cm



- 10. A fish swims 2.00 m below the surface of a pond. At what apparent depth does the fish appear to swim if viewed from directly above? The index of refraction of water is 1.33.
 - (a) 1.33 m

(c) 2.00 m

(e) 3.00 m

(b) 1.50 m

- (d) 2.66 m
- 11. A grizzly bear is sitting on a rock in the middle of a calm river when she observes a fish directly below. If the apparent depth of the fish is 0.60 m, what is the actual depth at which the fish is swimming? The index of refraction of water is 1.33.
 - (a) $0.80 \, \text{m}$

(c) 0.62 m

(e) 0.45 m

(b) 0.71 m

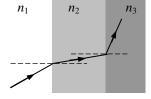
- (d) 0.53 m
- 13. The figure shows the path of a portion of a ray of light as it passes through three different materials. *Note:* The figure is drawn to scale.

What can be concluded concerning the refractive indices of these three materials?



(d)
$$n_2 < n_1 < n_3$$

- (b) $n_1 > n_2 > n_3$
- (e) $n_1 < n_3 < n_2$
- (c) $n_3 < n_1 < n_2$



- **1**4. A ray of light propagates in water (n = 1.333) and strikes a sheet of crown glass (n = 1.523). If the angle of refraction in the glass is 35.2°, determine the angle of incidence.
 - (a) 30.3°

(c) 35.2°

(e) 45.0°

(b) 32.8°

- (d) 41.2°
- 15. Light with a wavelength of 589 nm in a vacuum strikes the surface of an unknown liquid at an angle of 31.2° with respect to the normal to the surface. If the light travels at a speed of 1.97×10^{8} m/s through the liquid, what is the angle of refraction?
 - (a) 19.9°

(c) 34.2°

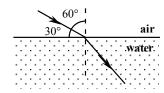
(e) 51.9°

(b) 26.1°

(d) 39.3°

Questions 16 and 17 pertain to the statement and diagram below:

The figure shows the path of a ray of light as it travels through air and crosses a boundary into water. The index of refraction of water for this light is 1.33.



- 16. What is the speed of this ray of light as it travels through the water?
 - (a) 1.54×10^8 m/s
- (c) 2.86×10^8 m/s
- (e) 4.43×10^9 m/s

- (b) $2.26 \times 10^8 \text{ m/s}$
- (d) 3.99×10^8 m/s
- 17. What is the angle of refraction for this situation?
 - (a) 0.37°

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(c) 22°

(e) 60°

(b) 0.65°

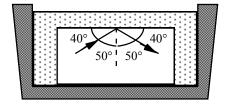
(d) 41°

Section 26.3 Total Internal Reflection

- □ 18. Complete the following statement: Fiber optics make use of
 - (a) total internal reflection.
- (c) chromatic aberration.
- (e) dispersion.

- (b) polarization.
- (d) Brewster's angle.
- \blacksquare 19. Which one of the following expressions determines the critical angle for quartz (n = 1.5) immersed in oil (n = 1.1)?
 - (a) $\theta_{\rm c} = 1.5/1.1$
- (c) $\theta_{\rm C} = \sin^{-1}(1.1/1.5)$ (e) $\theta_{\rm C} = \tan^{-1}(1.1/1.5)$

- (b) $\theta_{\rm C} = 1.5/1.1$
- (d) $\theta_{\rm C} = \sin(1.1/1.5)$
- 20. A ray of light originates in medium A and is incident upon medium B. For which one of the following pairs of indices of refraction for **A** and **B** is total internal reflection *not possible*?
 - n_{A} (a) 1.36 1.00
 - (b) 1.26
 - 1.15
 - (c) 2.54 1.63
 - (d) 1.28 1.36
 - (e) 1.12 1.06
- 21. A glass block with an index of refraction of 1.7 is immersed in an unknown liquid. A ray of light inside the block undergoes total internal reflection as shown in the figure. Which one of the following relations best indicates what may be concluded concerning the index of refraction of the liquid, n_{r} ?



(a) $n_{\rm L} < 1.0$

- (c) $n_{\rm L} \ge 1.3$

(b) $n_{_{\rm I}} \ge 1.1$

- (d) $n_{_{\rm I}} \le 1.1$
- \blacksquare 22. A light ray is traveling in a diamond (n = 2.419). If the ray approaches the diamond-air interface, what is the minimum angle of incidence that will result in all of the light reflected back into the diamond? The index of refraction for air is 1.000.
 - (a) 24.42°

(c) 54.25°

(e) 77.54°

(e) $n_{_{\rm I}} \le 1.3$

(b) 32.46°

(d) 65.58°

- 23. A fiber optic line is composed of a core with an index of refraction of 1.47 and cladding with an index of 1.31. Which one of the following relations best describes angles of incidence θ that will result in total internal reflection within the fiber optic line?
 - (a) $\theta < 63^{\circ}$

(c) $\theta < 27^{\circ}$

(e) $0 \le \theta \le 90^{\circ}$

(b) $\theta > 63^{\circ}$

- (d) $\theta > 27^{\circ}$
- **2**4. Light propagates from soda lime glass (n = 1.518) into Pyrex glass (n = 1.473). Determine the critical angle for this situation.
 - (a) 13.99°

(c) 52.48°

(e) 76.01°

(b) 45.86°

(d) 65.22°

Section 26.4 Polarization and the Reflection and Refraction of Light

- **26.** A ray of light originating in oil (n = 1.21) is incident at the *Brewster angle* upon a flat surface of a quartz crystal (n = 1.458). Determine the angle of incidence for this ray.
 - (a) 0.82°

(c) 40°

(e) 56°

(b) 1.2°

- (d) 50°
- 27. What is the Brewster angle if light is reflected from a plastic plate (n = 1.575) submerged in ethyl alcohol (n = 1.362)?
 - (a) 68.3°

(c) 59.8°

(e) 49.1°

(b) 40.8°

(d) 30.1°

Questions 28 and 29 pertain to the following situation.

Light in air is incident on a plastic plate at the Brewster angle. The angle of refraction is 35.0°.

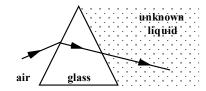
- **28.** Determine the Brewster angle.
 - (a) 35.0°

(c) 46.5°

(e) 82.3°

(b) 55.0°

- (d) 43.5°
- **2**9. What is the index of refraction of the plastic plate?
 - (a) 1.58
 - (b) 1.36
 - (c) 1.43
 - (d) 1.61
 - (e) 1.74
 - Section 26.5 The Dispersion of Light: Prisms and Rainbows
- □ 30. A ray of green light travels through air and is refracted as it enters a glass prism shown in the figure. An unknown liquid is in contact with the right side of the prism. The light then follows the path shown. Which one of the following statements concerning this situation is true?



- (a) The frequency of the light changes inside the prism.
- (b) The index of refraction of the glass is smaller than that of air.
- (c) The index of refraction of the unknown liquid is the same as that of the glass.
- (d) The speed of light is larger in the liquid than in the glass.
- (e) The refractive index of the liquid is the same as that of air.

	31.	Complete the following statement: The term <i>dispersion</i> refers to the fact that the index of refraction of certain materials							
		(b) deper		elength of light.		depends on the independs on the p	ntensity of light. oolarization of light.		
		(c) deper	nds on the angl	e of incidence.					
	32.	from the p (a) The s light (b) Some rema (c) The i refrac (d) Only obser	prism. Which of separation of which within the glass of the color coining componendex of refract cted at different some of the corved.	omponents of the white onts are observed. ion of the glass depen at angles.	atements be componented light are and ds on the was fracted by t	est explains this of the industry and the industry as the industry and the glass; and these	bservation? crease in the speed of lass and only the color components are se are the ones that are		
		prism		aced into its color comp	ponents by	total internal rend	ection within the		
		ction 26.		ation of Images by	Langag				
				uion of images by Lens Equation and		gnification Eq	uation		
	40.	 Which one of the following statements is true concerning the <i>focal length</i> of a lens? (a) The focal length is the same for all colors. (b) The focal length is different for different colors because of reflection. (c) The focal length is different for different colors because of dispersion. (d) The focal length is different for different colors because of polarization. (e) The focal length is different for different colors because of spherical aberration. 							
0	41.	An object distance?	is placed at the	e focal point of a conv	erging lens	of focal length f .	What is the image		
		(a) <i>f</i> (b) 2 <i>f</i>		(c) 1/f (d) 2/f		(e)	at an infinite distance		
0	42.	An object distance?	is placed at the	e focal point of a thin of	diverging le	ens of focal length	of. What is the image		
		(a) f (b) 2f		(c) 1/f (d) f/2		(e)	at an infinite distance		
8	43.	of the foll (a) The i (b) The i (c) The i (d) The i	owing stateme mage is virtual mage is virtual mage is real an mage is real an	om from a thin convergents is true concerning and 6.0 cm from the lead 3.0 cm from the lend d 6.0 cm from the lend d 6.0 cm from the lend d 12 cm from the lend d 12 cm from the lens	the image? ens. ens. s.		of 12 cm. Which one		

■ 44. A converging lens is used to focus light from a small bulb onto a book. The lens has a focal

the light bulb.

length of 10.0 cm and is located 40.0 cm from the book. Determine the distance from the lens to

- (a) 8.6 cm (c) 20 cm (e) 50 cm (b) 13 cm (d) 30 cm
- 45. When an object is placed 25 cm from a lens, a real image is formed. Which one of the following conclusions is *incorrect*?
 - (a) The image is upright.
 - (b) The lens is a converging lens.
 - (c) The image may be reduced or enlarged.
 - (d) The image distance can be less than 25 cm.
 - (e) The focal length of the lens is less than 25 cm.
- 46. When an object is placed 15 cm from a lens, a virtual image is formed. Which one of the following conclusions is *incorrect*?
 - (a) The lens may be a convex or concave.
 - (b) If the image is upright the lens must be a diverging lens.
 - (c) If the image is reduced, the lens must be a diverging lens.
 - (d) If the lens is a diverging lens, the image distance must be less than 15 cm.
 - (e) If the lens is a converging lens, the focal length must be greater than 15 cm.
- 47. When an object is placed 20 cm from a diverging lens, a reduced image is formed. Which one of the following statements is necessarily true?
 - (a) The image is inverted.
 - (b) The image could be real.
 - (c) The image distance must be greater than 20 cm.
 - (d) The focal length of the lens may be less than 20 cm.
 - (e) The refractive power of the lens must be greater than 0.05 diopters.
- 48. A 6.0-cm object is placed 30.0 cm from a lens. The resulting image height has a magnitude of 2.0 cm; and the image is inverted. What is the focal length of the lens?
 - (a) 7.5 cm

(c) 22.5 cm

(e) 45.0 cm

(b) 15.0 cm

- (d) 30.0 cm
- 49. A converging lens with a focal length of 12 cm produces a 3-cm high virtual image of a 1-cm high object. Which entry in the table below is correct?

	<u>image distance</u>	<u>location of image</u>
(a)	8 cm	same side of lens as object
(b)	8 cm	opposite side of lens from object
(c)	12 cm	opposite side of lens from object
(d)	24 cm	opposite side of lens from object
(e)	24 cm	same side of lens as object

- 50. A camera with a focal length of 0.0500 m (a 50-mm lens) is focused for an object at infinity. To focus the camera on a subject which is 4.00 m away, how should the lens be moved?
 - (a) 1.0 cm closer to the film

(d) 0.06 cm farther from the film

(b) 0.06 cm closer to the film

(e) 4.94 cm farther from the film

- (c) 4.94 cm closer to the film
- 51. A 4-cm object is placed in front of a converging lens of focal length 20 cm. The image is formed 60 cm on the other side of the lens. Which entry in the table below is correct?

	object distance	magnitude of the image he
(a)	15 cm	2 cm
(b)	15 cm	4 cm
(c)	30 cm	4 cm
(d)	30 cm	8 cm

(e) 60 cm

2 cm

■ 52. A 2.00-cm tall object is placed 40.0 cm from a lens. The resulting image is 8.00-cm tall and upright relative to the object. Determine the focal length of the lens.

(a) 26.6 cm

(c) 53.3 cm

(e) 80.0 cm

(b) 32.0 cm

- (d) 64.0 cm
- 53. In a slide projector, the slide is illuminated; and light passing through the slide then passes through a converging lens of focal length 0.10 m. If a screen is placed 5.0 m from the lens, a sharp image is observed. How far is the slide from the lens?

(a) 0.082 m

(c) 0.50 m

(e) 0.10 m

(b) 0.050 m

(d) 0.27 m

■ 54. Joseph uses a converging lens (f = 0.12 m) to read a map located 0.080 m from the lens. What is the magnification of the lens?

(a) +3.4

(c) +1.7

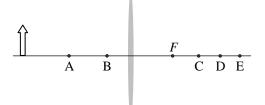
(e) +0.33

(b) +3.0

(d) +0.60

Questions 55 through 58 pertain to the statement and diagram below:

The figure is a scaled diagram of an object and a converging lens surrounded by air. Only one focal point, *F*, of the lens is shown.



■ 55. At which of the labeled points will the image be formed?

(a) A

(d) D

(b) B

(e) E

(c) C

■ 56. Which pair of terms most accurately describes the image?

(a) real, upright

(c) virtual, upright

(e) virtual, reduced

- (b) real, inverted
- (d) virtual, inverted
- 57. The index of refraction of this lens is 1.51 for red light and 1.53 for blue light. Blue light is focused at the point *F*. Which one of the following statements is true concerning the focal point for red light?

(a) It is also at F.

(d) It is to the left of and close to F.

(b) It is very close to D.

(e) It is to the right of and close to F.

(c) It is very close to the lens.

- 58. The system is immersed in a fluid other than air that has an index of refraction that is larger than that of the lens. Which one of the following statements is true concerning this new situation?
 - (a) The image will be real.
 - (b) The image will be inverted.
 - (c) The image will be enlarged relative to the object.
 - (d) The image will be formed on the same side of the lens as the object.
 - (e) The lens may act as a diverging lens or a converging lens depending on the location of the object.

Questions 59 through 61 refer to the statement below:

A diverging lens has a focal length of -10 cm. A 3-cm object is placed 25 cm from the lens.

- 59. Determine the approximate distance between the object and the image.
 - (a) 7 cm

(c) 18 cm

(e) 35 cm

(b) 10 cm

- (d) 32 cm
- 60. What is the magnification of the image?
 - (a) +0.3

(c) +0.7

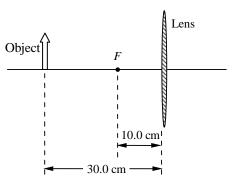
(e) +0.8

- (b) -0.3
- (d) -0.7
- 61. Which pair of terms most accurately describes the image?
 - (a) real, upright
- (c) real, inverted
- (e) real, reduced

- (b) virtual, upright
- (d) virtual, inverted

Questions 62 through 64 pertain to the statement and diagram below:

A 4.0-cm object is placed 30.0 cm from a converging lens that has a focal length of 10.0 cm as shown in the diagram. **Note**: *The diagram is not drawn to scale*.



- 62. Where is the image located?
 - (a) 15 cm to the left of the lens
 - (d)

15 cm to the right

of the lens

- (b) 7.5 cm to the left of the lens
- (b) 7.5 cm to the left of the lens

- (e) 30 cm to the right of the lens
- (c) 7.5 cm to the right of the lens
- 63. Determine the height and orientation of the image.
 - (a) 2 cm and upright
- (c) 2 cm and inverted
- (e) 8 cm and inverted

- (b) 1 cm and inverted
- (d) 8 cm and upright
- 64. A second converging lens is placed 20.0 cm to the right of the lens shown in the figure. Determine the focal length of the second lens if an inverted image (relative to the object in the diagram) is formed 13.3 cm to the right of the first lens.
 - (a) 1.33 cm

(c) 13.3 cm

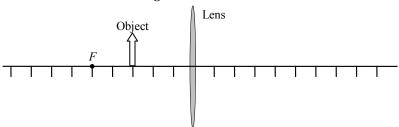
(e) 19.7 cm

(b) 6.67 cm

(d) 15.4 cm

Questions 65 through 67 pertain to the statement and diagram below:

The figure is a scaled diagram of a an object and a converging lens. The focal length of the lens is 5.0 units. An object is placed 3.0 units from the lens as shown.



- 65. Approximately, what is the image distance?
 - (a) -2.0 units

(c) +6.0 units

(e) +9.0 units

(b) -4.0 units

- (d) -7.5 units
- **66.** The object has a height of 1.5 units. What is the approximate height of the image?

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			2.0 units 1.2 units		5.0 units 3.8 units		(e)	9.8 units
0	67.	(a)	ich pair of terms most accurately real, upright real, enlarged	(c)	scribes the im real, inverted virtual, inver	l	(e)	virtual, upright
	Sec	ction 26.10 The Human Eye						
0	75.	5. An object is placed 15 cm from a converging lens with a 5.0-diopter refractive power. At what distance from the object will the image be located?						ve power. At what
			15 cm 20 cm		45 cm 60 cm		(e)	75 cm
•	76.	Rachel has a far point of 5 m. Which statement below concerning Rachel's vision is true? (a) She has normal vision. (b) She is myopic and requires diverging lenses to correct her vision. (c) She is myopic and requires converging lenses to correct her vision. (d) She is hyperopic and requires diverging lenses to correct her vision. (e) She is hyperopic and requires converging lenses to correct her vision.						
-	77.	of the	hout his contact lenses, Mr. Zhe ne lenses does he require for nor 1.25 diopters 2.75 diopters	rmal (c)		m from the eyes)	?	That refractive power -5.25 diopters
	78.	a bo (a) (b)	right lens of Josh's contact lens ook held as close as 25 cm from a far point of 15.4 cm. a far point of 40.0 cm. a far point of 66.7 cm.				righ of 15	t eye has 5.4 cm.
	79.	The from Not (a) (b)	s. York has been prescribed eyes glasses are worn 2.0 cm from hen her eyes. Which one of the foe: The near points and far point She has a far point of 3.2 m. She has a far point of 0.25 m. She has a near point of 3.2 m	er e llow	yes. With the ing statement	lenses, she can re	ad a ie? mea ar po	magazine held 25 cm sured relative to her eye. int of 6.4 m.
	80.	he cobjection (a)	thew's near point is 20.0 cm and can see objects that are infinitely act clearly when he wears his co 18 cm 22 cm	far ntac (c)	away. What		nce t	
0	81.	the (a) (b)	scene from a movie, a nearsigh nearly parallel rays of the sun to The eyeglasses have diverging The eyeglasses have convergin Sunlight cannot be used to star	star lens g ler	rt a fire. Wha es and cannot uses and canno	t is physically wro	ng w baral	vith this scene? lel rays.

- (d) A fire can only be started if the image is virtual.
- (e) Parallel rays cannot be focused.
- 82. Light that is incident upon the eye is refracted several times before it reaches the retina. As light passes through the eye, at which boundary does the majority of the overall refraction occur?
 - (a) lens/aqueous humor
- (c) lens/vitreous humor
- (e) vitreous humor/retina

(b) air/cornea

(d) aqueous humor/iris