Optics Homework

Assignment #1

Textbook: Read Section 22-3 (Honors only)
Textbook: Read Section 23-1

Online: Reflection Lesson 1a:
http://www.physicsclassroom.com/Class/refln/

* **problems are for all students**
** **problems are for honors physics**

1. * Explain how light can yield information. In particular, how does this information relate to the source of light? (Hint: think about the demonstrations done on the first day of class.)

2. * When a laser beam sent across a room, why is it normally not visible traveling through the air? Therefore, why is reflected light so important for human vision?

3. * How long does it take light to reach us from the Sun, 1.50×10^8 km away? Show answer in seconds and in minutes. **500 s, 8.33 min**

4. * A light-year is a measure of distance (not time). (a) How many meters does light travel in a year? (b) How many miles does light travel in a year? **9.46×10^{15} m, 5.88×10^{12} mi**

5. * Using the ray model of light, describe how an object is seen; that is, how does light move from source to observer? Give an example and explain how the object position is determined.

6. ** Light has wave properties that have been well known for several centuries. A modern example is laser light. Using the wave equation, $c = \lambda f$, where c is the speed of light, calculate the frequency of a red laser beam if the wavelength is 650 nanometers (nm). Look up the speed of light and the power of ten equivalent for nano in the front of the textbook or back of lab book. **4.62×10^{14} Hz**

7. ** Determine the wavelength for an FM radio signal if the station reads 97.3 MHz? (MHz means megahertz) **3.08 m**

Assignment #2

Textbook: Read Section 23-1 and 23-2

Online: Reflection Lessons 1c, 1d, 2a, 2b:
http://www.physicsclassroom.com/Class/refln/

8. * If you were stranded on an island, how would you align a mirror to use sunlight to signal a searching airplane? Using a ruler and a protractor, draw a diagram showing incident and reflected rays and normal line to mirror.

9. * Suppose that you want to take a photograph of yourself as you look at your image in a flat mirror 2.5 m away. For what distance should the camera lens be focused? Draw a diagram. **5.0 m**

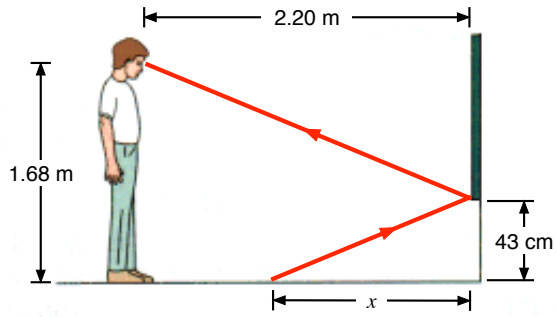
10. * When you look at yourself in a 60 cm tall plane mirror, you see the same amount of your body whether you are close to the mirror or far away. (Try it and see.) Using a ruler and protractor, carefully draw a ray diagram to prove why this is true.

11. * Compare the path of light reflected off a concrete roadway vs. a calm lake. Draw a diagram for each, and explain diffuse vs. specular reflection.

12. * Referring to the last question, explain why a car driver has some difficulty with vision on a wet roadway

13. ** A painted wall is a diffuse reflector of light, but a specular reflector of sound. Describe the wall surface in the explanation.

14. ** Determine the distance x for the diagram below. (Hint: use the law of reflection!)



75.7 cm

Assignment #3

Online: Reflection Lessons 2c, 2d, 2e, Honors 2f
http://www.physicsclassroom.com/Class/refln/

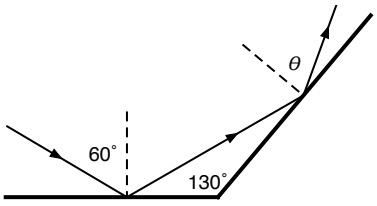
15. * A plane mirror makes an image that is the same size as the object (height, width, etc). Why then do the images produced by two opposing plane mirrors *appear* to be progressively smaller?

16. * Although a plane mirror appears to reverse left and right, it doesn't reverse up and down. Explain. Does it reverse an object in any way?

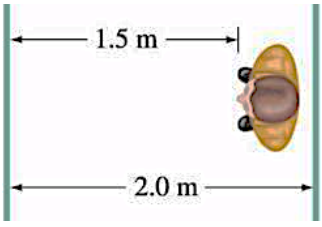
17. * Two plane mirrors make an angle of 90° with each other. An incident ray strikes one mirror at a 35° angle from the normal line, and then strikes the other mirror. Draw a ray diagram that shows the law of reflection at each mirror, with arrows on each ray, and labels on all angles.

18. * In the last question, describe a useful application for this mirror arrangement, often called a "corner reflector".

19. * Two mirrors meet at 130° angle as shown below. If a ray strikes the first mirror at an incident angle of 60°, at what angle will the ray leave the second mirror? **70°**



20. ** Two plane mirrors face each other 2.0 m apart shown in the figure. You stand 1.5 m away from one of these mirrors and look into it. You will see multiple images of yourself. (a) How far away from you are the first three images in the mirror in front of you? (b) Are these images facing toward you or away from you? Draw a diagram, and show all calculations of your work.
3.0 m, 4.0 m, 7.0 m

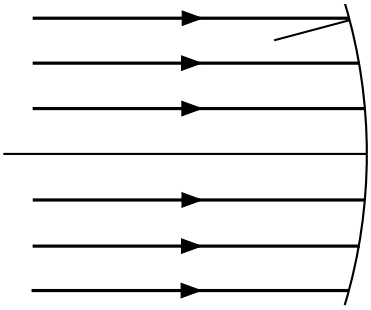


Assignment #4

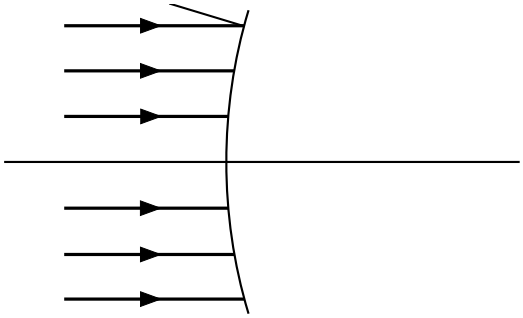
Textbook: Read Section 23-3, up to page 636

Online: Reflection Lessons 3a, 3b, 3c, 4a
http://www.physicsclassroom.com/Class/refln/

21. * The drawing below shows several parallel rays of light that are incident on a *concave* mirror. Use a protractor and a ruler to draw a small normal line to the mirror where each ray strikes the mirror. (The first normal line is shown.) Then draw the reflected ray, which must obey the law of reflection: $\theta_i = \theta_r$ The reflected rays should all converge to a focal point. Cut out the drawing (or make a copy) and put it in your homework.



22. * Repeat the last problem for a convex mirror.



23. * (a) If an object is located *outside* the focal point of a concave mirror, what type of image will be formed? Will the image appear in front of or behind the mirror? Will the image be inverted or upright? (b) If an object is located *inside* the focal point of a concave mirror, what type of image will be formed? Will the image appear in front of or behind the mirror? Will the image be inverted or upright? Explain

24. * What happens to the *real* image produced by a concave mirror if you move the original object to the location of the image? Show how the mirror equation explains the answer.

Assignment #5

Textbook: Read Section 23-3, page 637

Online: Reflection Lessons 3d, 3e, 4b, 4c
http://www.physicsclassroom.com/Class/refln/

25. * Where does a ray of light that is parallel to the principal axis of a concave mirror go after it is reflected at the mirror's surface? Give an example of a useful application for this ray.

26. * A solar cooker, really just a concave mirror pointed at the Sun, focuses the sunlight 2.6 m in front of the mirror. What is the radius of curvature of the spherical surface from which the mirror was made? (Hint: object distance is the Earth-Sun distance, so it's really large!) **5.2 m**

27. * A ray of light passes through the focal point of a concave mirror. Where does this ray of light go after it is reflected at the mirror's surface? Give an example of a useful application for this ray of light.

28. * An object is located along the principal axis of a spherical mirror. The magnification of the object is –3.0. Is the image real or virtual, inverted or upright? Is the mirror concave or convex? On which side of the mirror is the image located? Explain your answers.

29. * (a) Why are parabolic mirrors preferred over spherical mirrors, especially in optical instruments like telescopes? (b) Draw a ray diagram to give evidence of each mirror type.

Assignment #6

Textbook: Read Section 23-3, pages 638-640

Online: Lessons 3f, 3g, 4g
http://www.physicsclassroom.com/Class/refln/

30. * A concave mirror has a focal length of 12.5 cm. (a) For an object located 45.0 cm from the mirror, find the image distance, magnification, and use sign conventions to explain if the image is real or virtual and upright or inverted. (b) Repeat for an object located at 20.0 cm. (c) Repeat for an object located at 7.0 cm. **+17.3 cm, -0.384; +33.3 cm, -1.67; -15.9 cm, +2.27**

31. * A dentist uses a small mirror to magnify a tooth. When it is held 2.20 cm from a tooth it produces an upright image that is 4.5 larger. (a) What kind of mirror is used? (b) Calculate the image distance and the focal length of the mirror. (c) Use sign conventions to explain if the image is real or virtual and upright or inverted. **-9.90 cm, 2.83 cm**

32. * Side view mirrors on cars often state: "Objects in mirror are closer than they appear". (a) What kind of mirror is used? (Hint: the image orientation is the best clue!) (b) When another car is 20.0 m away, the image seen in the mirror is one-third the size of the object. What is the radius of curvature for this mirror? **-20.0 m**

33. *A mirror at an amusement park shows an upright image of any person who stands 1.4 m in front of it. (a) If the image is three times the person's height, what is the focal length of this mirror? (b) Use sign convention to explain what type of mirror is used. **2.10 m**

34. *A convex mirror with a radius of curvature of 45.0 cm forms a 1.70 cm tall image of a pencil at a distance of 15.8 cm behind the mirror. (a) Calculate the object distance and the object height for the pencil. (b) Calculate the magnification of the image. (c) Use sign conventions to explain the image type and orientation. **53.1 cm, 5.71 cm, +0.30**

35. ** You stand 3.0 m from a convex security mirror in a store. As you contemplate the "five finger discount" you observe that your image height is one-half your actual height. Determine the mirror's focal length. **-3.0 m**

36. ** Two students do a lab using a concave mirror with a radius of curvature of 40 cm. Each student places an object at a location that produces an image three times as large as the object. (a) Determine these two object locations. (b) Explain what type of image is created for each situation. **26.7 cm, 13.3 cm**

Assignment #7

Textbook: Read Section 23-4

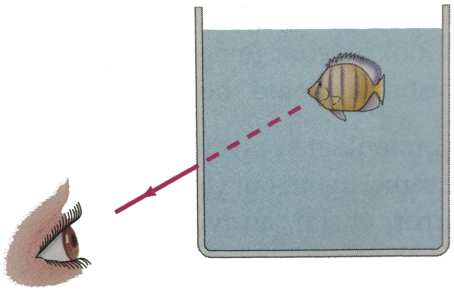
Online: Refraction Lessons 1a, 1b, 1c, 1d, 1e
http://www.physicsclassroom.com/class/refrn

37. * Explain why a partially submerged oar appears bent at the water's surface. Draw a diagram making sure it properly shows which way the oar appear bent.

38. * When you look down into a shallow pool or lake, are you likely to underestimate or overestimate its depth? Explain carefully.

39. * (a) When light travels from one medium into another, does it always bend toward the normal? Explain.
(b) Is it possible to not bend at all? Explain.

40. * Your eye looks into an aquarium and views a fish inside. One ray of light that emerges from the tank is shown below, as well as the apparent position of the fish. Trace the drawing and show an actual path of light from the actual fish. Is the fish lower or higher in the tank than it appears to the observer's eye?



41. * What is the index of refraction of a material in which the speed of light is 1.85×10^8 m/s? Does light leaving this material and traveling into air speed up or slow down as it enters air? **1.62**

42. ** The speed of light in a certain substance is 89% of its value in water. What is the index of refraction of this substance? **1.49**

Assignment #8

Textbook: Read Section 23-5

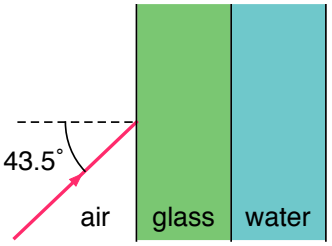
Online: Refraction Lessons 2a, 2b
http://www.physicsclassroom.com/class/refrn

43. * Measuring the speed of light directly is difficult, but using Snell's Law, how might you determine the speed of light in a solid, rectangular, transparent object.

44. * A diver shines a flashlight upward from beneath the water at a 42.5° angle to the vertical. At what angle does the light leave the water? **64.0°**

45. * A light beam coming from an underwater spotlight exits the water at an angle of 66.0° to the vertical. At what angle of incidence does it hit the air-water boundary from below the surface? **43.4°**

46. * A fish tank filled with water has flat glass sides. A beam of light from outside the fish tank strikes the glass at 43.5° angle to the perpendicular as shown below. What is the angle of this light ray when it enters:
(a) the glass, where $n = 1.52$
(b) the water, where $n = 1.33$.
(c) trace the diagram and show the rays.
26.9°, 31.2°



47. * A beam of light in air strikes glass, with index of refraction of 1.52, and is partially reflected and partially refracted. If the incident ray is at an angle of 40°, find the angle between the reflected ray and the refracted ray. **115°**

48. ** In the previous question, if the incident angle is *unknown*, and the angle of reflection is twice the angle of refraction, determine the incident angle. Hint: you will need the trig identity: $\sin 2\theta = 2 \sin\theta \cos\theta$ **81.0°**

Assignment #9

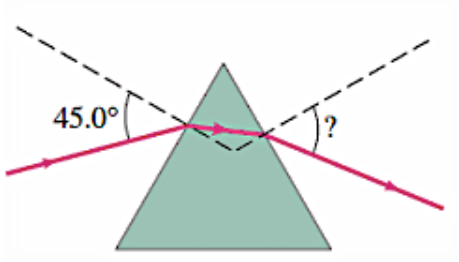
Online: Refraction Lesson 1f, 2c, 2d
http://www.physicsclassroom.com/class/refrn

49. *A friend throws a coin into a pool. You dive toward the spot where you saw it from the edge of the pool. When you reach the bottom, will the coin be in front of you or behind you?

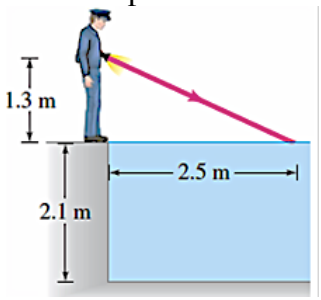
50. * A ray of light traveling in air strikes the surface of oil at an incident angle of 23.1° with the normal line to the surface. If the light travels at 2.17×10^8 m/s through the oil, what is the angle of refraction? **16.5°**

51. * Rays of the Sun are seen to make a 31.0° angle to the vertical beneath the water. At what angle above the horizon is the Sun? **46.8°**

52. * Light is incident on an equilateral glass prism ($n = 1.58$) at an angle of 45.0° angle to one side as shown below. (a) Calculate the angle at which the light emerges from the opposite side. (b) Trace the diagram and label all the angles. **60.5°**



53. ** In searching for the bottom of a pool at night, a watchman shines a narrow beam of light from his flashlight, 1.3 m above the water level, onto the surface of the water at a point 2.5 m from the edge of the pool, as shown below. If the pool is 2.1 m deep, where does the spot of light hit the bottom of the pool, measured from the wall beneath his foot? (Show all steps for solution.) **4.38 m**



Assignment #10

Textbook: Read Section 23-7

Online: Refraction Lessons 5d, 5e, 5f, 5g
http://www.physicsclassroom.com/class/refrn

54. * Can real images be projected onto a screen? Can virtual images be projected onto a screen? Can either be photographed? Discuss each.

55. * If a glass converging lens is submerged in water, will its focal length be longer or shorter than when the lens is in air? Explain, and also draw a ray diagram to justify answer.

56. * (a) Can a diverging lens form a real image? Explain, using the lens equation.
** (b) Can a diverging lens be used with another lens to form a real image?

57. * In order to get an upright image, film must be placed upside down in a movie projector. (a) What type of lens must the movie projector have? (b) Are the film (object) and the screen (image) upright or inverted? (c) Is the film inside or outside the focal point of the lens?

58. * A dog with its tail in the air stands facing a converging lens. If the nose and the tail are each projected on a screen in turn, which will have the greater magnification?

59. ** A lens is made of a material with an index of refraction of $n = 1.30$. In air, it is a converging lens. Will it still be a converging lens if placed in water? Explain, using a ray diagram.

60. ** Explain this statement: The focal point of a converging lens is the location of an image of a point object at infinity. Based on this statement, can you think of a quick method for determining the focal length of a positive lens? (Hint: it could be a dangerous method!)

Assignment #11

Textbook: Read Section 23-8

Online: Refraction Lessons 5h
http://www.physicsclassroom.com/class/refrn

61. * An image is located 7.8 cm behind a converging lens with a 6.5 cm focal length. (a) Where is the object located? (b) What is the magnification? (c) Use sign conventions to explain image type & orientation. **39 cm, -0.20**

62. * A stamp collector uses a converging lens with focal length of 24 cm to view a stamp 18 cm in front of the lens. (a) Where is the image located? (b) What is the magnification? (c) Use sign convention to explain the image type and orientation. **-72.0 cm, +4.0**

63. * An object is placed in 40 cm front of a diverging lens with a focal point 20 cm from the lens. (a) Where is the image located? (b) What is the magnification? (c) Use sign conventions to explain the image type and orientation.
-13.3 cm, +0.33
64. * An object 34.5 cm in front of a certain lens has an image 8.20 cm in front of that lens (on the same side as the object). (a) What is the focal length of this lens? (b) if the image were located instead 41.5 cm in front of the lens, what focal length would it have? (c) Use sign conventions to explain the type of each lens.
-10.8 cm, 205 cm
65. * (a) A 2.0 cm high object is 1.20 m from a 135 mm focal length lens. Where is the image located, how high is it, and what type is it? (b) What if the focal length is -135 mm? **15.2 cm, -0.254 cm, -12.1 cm, +0.20 cm**

66. ** How far apart are an object and an image if a 75.0 cm focal length converging lens forms the image, the image is *real*, and the image is 2.5 times larger than the object?
105 cm, 367.5 cm
67. ** A distance of 66.0 cm separates a bright object and a viewing screen. At what object locations between the object and the screen should a lens of focal length 12.5 cm be placed in order to produce an image on the screen? (Hint: set up and solve quadratic equation.) **49.2 cm, 16.8 cm**

Assignment #12

Textbook: Honors Read Section 23-9

68. * Where must an object be placed to form an image 30.0 cm in front of a diverging lens that has a focal point 40.0 cm from the lens? What is the magnification of the image? **120 cm, 0.25**

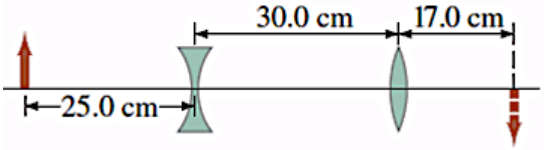
69. * (a) How far from a 50.0 mm focal length lens must an object be placed if its image is real and magnified 2 × as large? (b)What if the image is virtual and magnified 2 × as large?
7.5 cm, 2.5 cm
70. * An object's distance from a converging lens is 10 times the focal length. How far is the image from the lens? [Express the answer as a fraction of the focal length.] **10f/9**

71. * A 24 mm tall object inside an LCD projector creates a 1.80 m tall image on a screen at a distance of 7.50 m from the projector. What focal length lens is used in the LCD projector?
9.87 cm

72. * (a) When an object is placed 60.0 cm from a certain converging lens, it forms a real image. When the object is moved to 40.0 cm from the lens, the image moves 10.0 cm farther from the lens. Set up the equations to solve for the lens focal length. **(b) Solve for the lens focal length using simultaneous equations. **+20 cm**

73. ** Two 28.0 cm focal length converging lenses are placed 16.5 cm apart. An object is placed 36.0 cm in front of one lens. (a) Where will the final image (formed by the second lens) be located? (b) What is the total magnification? (c) Use sign convention to explain image type and orientation. **22.3 cm, -0.713**

74. ** Am object is 25.0 cm from a diverging lens as shown below. A converging lens with a focal length of 12.0 cm is 30.0 cm to the right of the diverging lens. The two-lens system forms a real inverted image 17.0 cm to the right of the converging lens. What is the focal length of the diverging lens? **-19.0 cm**



Assignment #13

Textbook: Read Section 23-6

Online: Refraction Lessons 3a, 3b, 3c
http://www.physicsclassroom.com/class/refrn

75. * What is the critical angle for the boundary between water, $n = 1.33$, and plastic, $n = 1.51$? To be totally internally reflected, the light must start in which material? **61.7°**

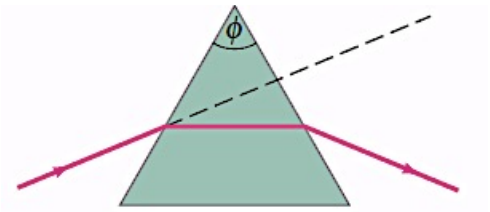
76. * The critical angle for a certain liquid-air surface is 47.7°. What is the index of refraction of the liquid? **1.35**

77. * A ray of light traveling in air strikes the surface of a liquid. If the incident angle of is 30.0° and the refracted angle is 22.0°, find the critical angle for the light traveling from the liquid back into the air. **48.8°**

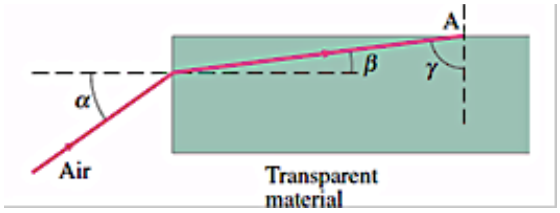
78. * The critical angle of a certain piece of plastic in air is 37.3°. What is the critical angle of the same plastic if it is immersed in water? **53.7°**

79. * A beam of light is emitted 8.0 cm beneath the surface of a liquid and strikes the surface 7.0 cm from the point directly above the source. If total internal reflection occurs, what is the minimum index of refraction of the liquid? **1.52**

80. ** If the apex angle of a prism is $\phi = 72°$ as shown below, what is the minimum incident angle for a ray if it is to emerge from the opposite side (and not be totally internally reflected), given $n = 1.50$?
49.0°



81. ** A beam of light enters the end of an optic fiber as shown below. Show that total internal reflection is guaranteed at the side surface of the material (at point A) if the index of refraction is greater than 1.414. In other words, regardless of the angle α, the light beam reflects back into the material at point A.
1.414



Assignment #14

Textbook: Read Section 24-4, 25-6

Online: Refraction Lessons 4a, 4b, 4c
http://www.physicsclassroom.com/class/refrn

82. * (a) What are the conditions necessary for the occurrence of a mirage? (b) Draw a diagram showing rays of light refracting to create a mirage.

83. * (a) Why does the arc of a rainbow appear with red color on top and violet on the bottom? Is this the same for a double rainbow? (b) Draw a ray diagram showing the angle difference for red vs. violet.

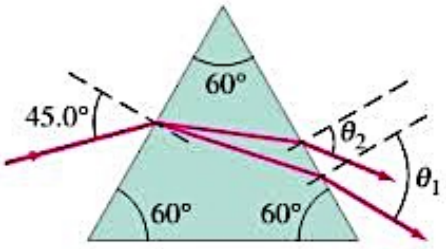
84. * Inexpensive microscopes for children's use usually produce images that are color-distorted at the edges. What refraction phenomenon causes this? How is the effect minimized in laboratory microscopes?

85. * Light from stars (and planets) "twinkle", especially when viewed near the horizon. What refraction phenomenon causes this effect? Draw a diagram to show the cause.

86. * Why does a diamond show flashes of color when observed under ordinary light? Draw a diagram and explain total internal reflection and dispersion.

87. *A light beam strikes a piece of glass at a 60.0° incident angle. The glass has an index of refraction for red light of 1.474 and for blue light 1.482. Determine the angle of refraction for the red and blue light entering the glass. **35.98°, 35.76°**

88. ** Referring to the data from the previous question, if the light enters a glass prism as shown below, determine the angles that the red and blue light leave the prism. **50.04° 50.75°**



Assignment #15

Textbook: Read Section 25-2

Online: Refraction Lessons 6a, 6b, 6c, 6d, 6e
http://www.physicsclassroom.com/class/refrn

89. *Why are reading glasses needed mainly by older people and not generally by younger people? What happens to the lens in the human eye over a long time?

90. * Some younger people wear reading glasses, and some wear glasses (or contacts) for driving, playing sports, etc. What is the most common reason for a young person to need these corrective lenses?

91. * You can tall whether a person is nearsighted or farsighted by looking at the width of the faces through their glasses. If the person's face appears narrower through the glasses, is the person farsighted or nearsighted? Explain.

92. * Is the image formed on the retina of the human eye upright or inverted? Discuss the implications of this for our perception of objects.

93. ** Reading glasses of what power are needed for a person whose near point is 115 cm, so that he can read a computer screen at 55 cm, assuming a lens-eye distance of 1.8 cm. **+0.996 diopters**

94. ** A person's left eye is corrected by a -3.50 diopter lens, placed 2.0 cm from the eye. (a) Is this person's left eye nearsighted or farsighted? (b) What is the eye's far point without the glasses? **-28.6 cm, 30.6 cm**

95. ** What is the focal length of the eye-lens system when viewing an object (a) at infinity? (b) 33.0 cm from the eye? Assume that the lens-retina distance is 2.0 cm. **2.0 cm, 1.89 cm**