Problems & Exercises

26.1 Physics of the Eye

Unless otherwise stated, the lens-to-retina distance is 2.00 cm.

1.

What is the power of the eye when viewing an object 50.0 cm away?

2.

Calculate the power of the eye when viewing an object 3.00 m away.

3.

(a) The print in many books averages 3.50 mm in height. How high is the image of the print on the retina when the book is held 30.0 cm from the eye?

(b) Compare the size of the print to the sizes of rods and cones in the fovea and discuss the possible details observable in the letters. (The eye-brain system can perform better because of interconnections and higher order image processing.)

4.

Suppose a certain person's visual acuity is such that he can see objects clearly that form an image 4.00 μm high on his retina. What is the maximum distance at which he can read the 75.0 cm high letters on the side of an airplane?

5.

People who do very detailed work close up, such as jewellers, often can see objects clearly at much closer distance than the normal 25 cm.

(a) What is the power of the eyes of a woman who can see an object clearly at a distance of only 8.00 cm?

(b) What is the size of an image of a 1.00 mm object, such as lettering inside a ring, held at this distance?

(c) What would the size of the image be if the object were held at the normal 25.0 cm distance?

26.2 Vision Correction

6.

What is the far point of a person whose eyes have a relaxed power of 50.5 D?

7.

What is the near point of a person whose eyes have an accommodated power of 53.5 D?

8.

(a) A laser vision correction reshaping the cornea of a myopic patient reduces the power of his eye by 9.00 D, with a $\pm 5.0\%$ uncertainty in the final correction. What is the range of diopters for spectacle lenses that this person might need after LASIK procedure? (b) Was the person nearsighted or farsighted before the procedure? How do you know?

9.

In a LASIK vision correction, the power of a patient's eye is increased by 3.00 D. Assuming this produces normal close vision, what was the patient's near point before the procedure?

10.

What was the previous far point of a patient who had laser vision correction that reduced the power of her eye by 7.00 D, producing normal distant vision for her?

11.

A severely myopic patient has a far point of 5.00 cm. By how many diopters should the power of his eye be reduced in laser vision correction to obtain normal distant vision for him?

12.

A student's eyes, while reading the blackboard, have a power of 51.0 D. How far is the board from his eyes?

13.

The power of a physician's eyes is 53.0 D while examining a patient. How far from her eyes is the feature being examined?

14.

A young woman with normal distant vision has a 10.0% ability to accommodate (that is, increase) the power of her eyes. What is the closest object she can see clearly?

15.

The far point of a myopic administrator is 50.0 cm. (a) What is the relaxed power of their eyes? (b) If they have the normal 8.00% ability to accommodate, what is the closest object they can see clearly?

16.

A very myopic man has a far point of 20.0 cm. What power contact lens (when on the eye) will correct his distant vision?

17.

Repeat the previous problem for eyeglasses held 1.50 cm from the eyes.

18.

A myopic person sees that their contact lens prescription is –4.00 D. What is their far point?

19.

Repeat the previous problem for glasses that are 1.75 cm from the eyes.

20.

The contact lens prescription for a mildly farsighted person is 0.750 D, and the person has a near point of 29.0 cm. What is the power of the tear layer between the cornea and the lens if the correction is ideal, taking the tear layer into account?

21.

A nearsighted man cannot see objects clearly beyond 20 cm from his eyes. How close must he stand to a mirror in order to see what he is doing when he shaves?

22.

A teacher sees that a child's contact lens prescription is 0.750 D. What is the child's near point?

23.

Repeat the previous problem for glasses that are 2.20 cm from the eyes.

24.

The contact lens prescription for a nearsighted person is –4.00 D and the person has a far point of 22.5 cm. What is the power of the tear layer between the cornea and the lens if the correction is ideal, taking the tear layer into account?

25.

Unreasonable Results

A boy has a near point of 50 cm and a far point of 500 cm. Will a –4.00 D lens correct his far point to infinity?

26.4 Microscopes

26.

A microscope with an overall magnification of 800 has an objective that magnifies by 200. (a) What is the magnification of the eyepiece? (b) If there are two other objectives that can be used, having magnifications of 100 and 400, what other total magnifications are possible?

27.

(a) What magnification is produced by a 0.150 cm focal length microscope objective that is 0.155 cm from the object being viewed? (b) What is the overall magnification if an 8× eyepiece (one that produces a magnification of 8.00) is used?

28.

(a) Where does an object need to be placed relative to a microscope for its 0.500 cm focal length objective to produce a magnification of –400? (b) Where should the 5.00 cm focal length eyepiece be placed to produce a further fourfold (4.00) magnification?

29.

You switch from a 1.40NA 60× oil immersion objective to a 1.40NA 60× oil immersion objective. What are the acceptance angles for each? Compare and comment on the values. Which would you use first to locate the target area on your specimen?

30.

An amoeba is 0.305 cm away from the 0.300 cm focal length objective lens of a microscope. (a) Where is the image formed by the objective lens? (b) What is this image's magnification? (c) An eyepiece with a 2.00 cm focal length is placed 20.0 cm from the objective. Where is the final image? (d) What magnification is produced by the eyepiece? (e) What is the overall magnification? (See Figure 26.16.)

31.

You are using a standard microscope with a 0.10NA 4× objective and switch to a 0.65NA 40× objective. What are the acceptance angles for each? Compare and comment on the values. Which would you use first to locate the target area on of your specimen? (See Figure 26.17.)

32.

Unreasonable Results

Your friends show you an image through a microscope. They tell you that the microscope has an objective with a 0.500 cm focal length and an eyepiece with a 5.00 cm focal length. The resulting overall magnification is 250,000. Are these viable values for a microscope?

26.5 Telescopes

Unless otherwise stated, the lens-to-retina distance is 2.00 cm.

33.

What is the angular magnification of a telescope that has a 100 cm focal length objective and a 2.50 cm focal length eyepiece?

34.

Find the distance between the objective and eyepiece lenses in the telescope in the above problem needed to produce a final image very far from the observer, where vision is most relaxed. Note that a telescope is normally used to view very distant objects.

35.

A large reflecting telescope has an objective mirror with a 10.0 m radius of curvature. What angular magnification does it produce when a 3.00 cm focal length eyepiece is used?

36.

A small telescope has a concave mirror with a 2.00 m radius of curvature for its objective. Its eyepiece is a 4.00 cm focal length lens. (a) What is the telescope's angular magnification? (b) What angle is subtended by a 25,000 km diameter sunspot? (c) What is the angle of its telescopic image?

37.

A 7.5× binocular produces an angular magnification of −7.50, acting like a telescope. (Mirrors are used to make the image upright.) If the binoculars have objective lenses with a 75.0 cm focal length, what is the focal length of the eyepiece lenses?

38.

Construct Your Own Problem

Consider a telescope of the type used by Galileo, having a convex objective and a concave eyepiece as illustrated in Figure 26.23(a). Construct a problem in which you calculate the location and size of the image produced. Among the things to be considered are the focal lengths of the lenses and their relative placements as well as the size and location of the object. Verify that the angular magnification is greater than one. That is, the angle subtended at the eye by the image is greater than the angle subtended by the object.

26.6 Aberrations

39.

Integrated Concepts

(a) During laser vision correction, a brief burst of 193 nm ultraviolet light is projected onto the cornea of the patient. It makes a spot 1.00 mm in diameter and deposits 0.500 mJ of energy. Calculate the depth of the layer ablated, assuming the corneal tissue has the same properties as water and is initially at 34.0°C. The tissue's temperature is increased to 100°C and evaporated without further temperature increase.

(b) Does your answer imply that the shape of the cornea can be finely controlled?

40.

Critical Thinking A microscope has the objective lens 6.00 mm from an object. The focal length of the objective lens is 4.00 mm. The eyepiece has a focal length of 50.0 mm and is initially 25.0 mm from the objective lens. (a) The objective lens is moved to 5.00 mm from the objective, effectively lengthening the microscope. How does this affect the magnification of the microscope? (b) Does moving the objective increase closer to the object increase or decrease the magnification, or does it remain the same? (c) Do you think moving the objective from 6 mm to 7 mm from the object will increase or decrease the magnification of the microscope, or will it likely remain the same? (d) What indicates whether the image is upright or inverted?