24-3 Vision and Corrective lenses

Important Ideas

- "To focus" is to make adjustments so that a screen is at the same location as a real image.
- The human eye and a camera are strikingly similar:
  1. Both systems use a convex lens to create an image. (The eye can be modeled as a convex lens.)
  2. The image is real and inverted.
  3. There is some type of system used to record the image. For an older camera, film is used. A newer camera uses a CCD, which is essentially an array of semiconductor devices that are sensitive to light. (There may be 4 million of these devices with each one giving a single pixel of the image.) The human eye has a retina with rods and cones that sense light.
  4. An aperture is used to control how much light enters the lens. The camera has a shutter and the human eye has the pupil.
- A significant difference between the eye and camera is in how each one focuses the image. In each case, the goal is to focus on objects of different object distances, For the eye, the image distance is fixed, so the focal length of the lens must be changed. For a camera, the focal length is fixed so the image distance must be changed.
- The power of a lens refers to its *focusing power*. Greater power means that it bends light more and the focal length is shorter. The power of a lens is:

$$P = \frac{1}{f} \qquad f \text{ is in meters} \tag{1}$$

  The unit of P *diopters*. One diopter is m^{-1}.

Eye

- Suppose that the image of an object is in focus. Then the image is at the retina. If the object moves *farther away* from the eye, then the image will be closer to the focal point. This means that the focal length has to *increase* so that the image is at the retina. To increase the focal length, the ciliary muscles must flatten the lens of the eye. If the object moves *closer* to the eye, then the image will be further from the focal point. This means that the focal length has to *decrease* so that the image is at the retina. To decrease the focal length, the ciliary muscles must decrease the radius of the lens of the eye and make it bulge at the middle.
- The image distance for a normal eye is approximately 25 mm (2.5 cm).
- The near point is the closest object distance at which the eye can focus the image. The normal near point is approximately 25 cm.
- The far point is the furthest object distance at which the eye can focus the image. The normal far point is infinity.

Nearsightedness

- The near point is the same as a normal eye. However, the far point is closer than infinity. If an object is at infinity, then a corrective lens is used to create a virtual image at the far point. The corrective lens is a concave lens, so f is negative.
- The focal length of a corrective lens is chosen so that if an object is at infinity, the image is at the person's far point.

Farsightedness

- The far point is the same as a normal eye (infinity). However, the near point is further than the near point for a normal eye (about 25 cm). If an object is at the normal near point, about 25 cm, then the lens creates a virtual image that is further away, at the person's near point (> 25 cm). The corrective lens is a convex lens, so f is positive. For a convex lens to create a virtual image, the object is closer to the lens than the focal point.
- The focal length of a corrective lens is chosen so that if an object is at a normal near point, the image is at the person's near point.

Examples

1. For a normal eye, with an image distance of 25 mm, what is the range of possible focal lengths for the lens of the eye?
2. You are working at a cash register and you are watching a customer walk away after paying you. As you watch the customer, the lenses of your eyes bulge _____ and the radii of curvature of the lens surfaces _____.

   (a) less ; decrease
   (b) less ; increase
   (c) more ; decrease
   (d) more ; increase

3. As you look at this question, the image of this question on the retina of your eye is _____.

   (a) real and upright
   (b) real and inverted
   (c) virtual and upright
   (d) virtual and inverted

4. A person can just barely read a book when it is held out at arm's length (50 cm). What power of reading glasses should be prescribed for him if he wants to read at 25 cm from the eye? Assume that the glasses are about 2 cm from the eye.

5. Suppose you are nearsighted and have a far point of 3 m. What kind of lens, converging or diverging, should be prescribed for you to see distant objects more clearly and what power lens do you need?