Thin Lenses

A lens is used to image an object onto a screen. If the right half of the lens is covered,

A. the left half of the image disappears.
B. the right half of the image disappears.
C. the entire image disappears.
D. the image becomes blurred.
E. the image becomes fainter.

ANS: **E**—The image becomes fainter.

The reasoning is the same as for the mirror question we had in a previous class. A partial lens will transmit rays that will focus to form an image. There will be a full image, but it will not be as bright as would be formed by a whole lens because not as much light will get through.

You have a manual camera with a focal length of 5 cm. It is focused at infinity, but you want to take a picture of an object that is only 30 cm away. What should you do?

A. Increase the distance between the lens and the film by 1 cm (move the lens out)
B. Increase the distance between the lens and the film by 5 cm
C. Decrease the distance between the lens and the film by 1 cm (move the lens in)
D. Decrease the distance between the lens and the film by 5 cm

ANS: **A**—You should increase the distance between the lens and the film by 1 cm.

Use the thin lens formula,

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

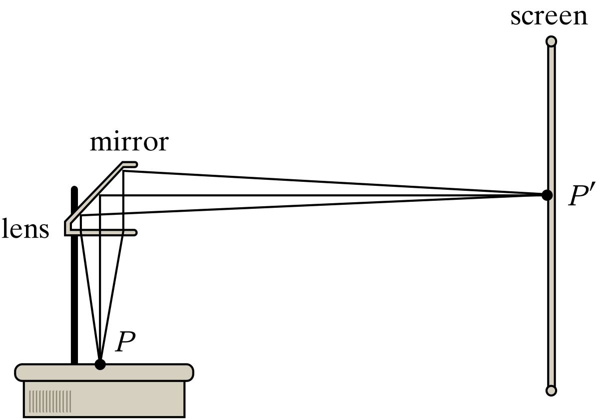
We know that the film is initially at the focal point of the lens ("focused at infinity," so $s = 0 \quad \rightarrow \quad s' = f$). If the object distance were 30 cm, then the thin lens formula gives an image distance of 6 cm. That means you must move the film (back of the camera) farther back from the lens by 1 cm. Note that the way a camera really works is that you move the lens out by 1 cm. However, doing so reduces the object distance to 29 cm, which makes the image distance not exactly 6 cm. It's easier just to move the film backward to get these numbers.

The lens in an overhead projector forms an image P' of a point P on an overhead transparency. If the screen is moved closer to the projector, the lens must be ______________ to keep the image on the screen in focus.

A. moved up

B. left in place

C. moved down



ANS: A—The lens must be moved up.

Again, use the thin lens formula. The focal length is fixed, so if you reduce s' you must increase s. Therefore, you must move the lens up, away from the object.

When your eye focuses on something far away the lens in the eye has a radius of curvature R. What is the radius of curvature when your eye focuses on something at your near-point?

A. It is still R.
B. It is less than R.
C. It is greater than R.

ANS: B—The radius of curvature is less than R.

Using the thin lens formula, decreasing the object distance while keeping the image distance (lens to retina) fixed requires you to decrease the focal length, or equivalently to make the lens surfaces more curved. This means that the lens surfaces must have smaller radii of curvature.

A pair of converging lenses are aligned on the same principal axis but separated by a distance L. For some specified object position, the first lens by itself would produce an image at a location that is *beyond* the second lens. For the two lenses together, what does this tell us about the object distance for the second lens?

A. It equals L because the first lens provides the image for the second lens

B. It is negative, so the object is virtual

C. It must be positive because objects are always real

D. There can be no image formed in this situation

ANS: B—The object distance for the second lens is negative, so the object is virtual.

Because the image is beyond the second lens, we know that the image made by the first lens is real; the image is on the outgoing side of the first lens. This image becomes the object of the second lens. However, this object is on the opposite side of the lens from the incoming rays. Therefore, the object is virtual and the object distance is negative.

What does it mean that an object is virtual? It means that the rays that reach lens 2 do not come from the object of lens 2 (which is the image of lens 1). Instead, the rays that reach lens 2 would have continued to form an image at the object, *if lens 2 wasn't there*!

Warmup Question

In William Golding's novel, "Lord of the Flies," a nearsighted boy's eyeglasses are used to start a fire by concentrating sunlight on a pile of dried twigs. Is this really possible? Explain.

ANS: No, this is not possible. A nearsighted person will have diverging eyeglass lenses. Diverging lenses cannot focus light.

Warmup Question

Estimate the focal length of your eye (either one!) and explain your line of logic.

ANS: The diameter of your eye is around 2.5 cm. We expect that distant objects, from which the rays are nearly parallel, will focus on our retina. In that case the focal length of the eye will be 2.5 cm.

Actually, because the cornea/lens system is a complicated optical design spread over some distance, the actual focal length is shorter...on the order of 1.7 cm or so. Furthermore, this focal length is adjustable, allowing you to focus on near or far objects as necessary.

Warmup Question

Knowing that a camera works by focusing light rays together onto a piece of film, which of the following kinds of lens could be used in a simple, one-lens camera?

A. bi-concave
B. bi-convex
C. plano-concave
D. bi-plano

ANS: B—You need a converging lens, of which bi-convex is an excellent example (as is a plano-convex lens).

Bi-concave and plano-concave lenses are diverging, so you cannot use them to focus an image on film (create a real image). A "bi-plano" lens is just a flat sheet of glass, neither converging nor diverging.