Spherical Mirrors

What kind of mirror is used for security in convenience stores, the kind that allows the clerk to see the entire store from the front register?

A. concave (converging)
B. convex (diverging)
C. flat

ANS: B—The mirror is convex (diverging).

Convex mirrors are useful for two reasons. First, a convex mirror always gives an upright image. This is certainly useful if you want to quickly get a sense of what's going on in the store without having to interpret an inverted image. Second, the convex mirror always gives a reduced image. This allows you to see more of the store than you would see in a flat mirror.

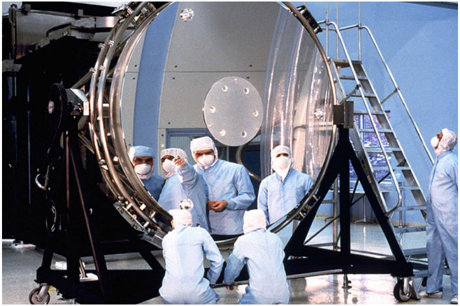
We have $M = -s'/s < 1$, so $s' > -s$. Then

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} < \frac{1}{s} + \frac{1}{-s} = 0 \ .$$

Therefore, the focal length is negative—a convex (diverging) mirror!

The picture shows scientists inspecting the mirror of the Hubble Space Telescope before it was launched. What kind of mirror is this?

A. concave (converging)
B. convex (diverging)
C. flat



ANS: A—This is a concave mirror.

The image is upright, so it could be any kind of mirror. However, you also know that the image is magnified because the images of scientists who must be located somewhere to the left of the frame are much larger than those kneeling in front of the mirror. Only a concave mirror can do this. It's is easy to prove this with your simple mirror equations.

We have $M = -s'/s > 1$, so $s' < -s$. Then

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} > \frac{1}{s} + \frac{1}{-s} = 0\ .$$

Therefore, the focal length is positive—a concave (converging) mirror!

Warmup Question

An ordinary metal spoon makes a fairly good spherical reflector, convex from one side, concave from the other. Estimate the radius of curvature and the focal length for a typical soup spoon.

ANS: I just looked at one and estimated that the focal length was around 2cm. The way I determined this is to look at the reflection of an object in the converging ("concave") face of the spoon. When the object is outside the focal point, the image will be inverted and real. When the object is inside the focal point, the image will be upright and virtual. When the object is at the focal point, no image will be formed ("image at infinity"). Move the object back and forth relative to the spoon to determine Where the image switches from upright to inverted. The switch occurs at the focal point.

Warmup Question

Given the general properties of spherical reflectors, what kind of mirrors would you expect to be used to observe shoppers in convenience stores? Why?

ANS: I would expect a *diverging* ("convex") mirror. There are two good reasons to use this. First of all, you want to make sure you always get an upright image. An inverted image of the store will be very disorienting too the observer. More importantly, you want to get a *reduced* image. You want the mirror to show you an image of a significant part (or possibly the entirety) of the store. Only a converging mirror will give you an upright, reduced image regardless of the object position.

Warmup Question

Objects in the mirror may be closer than they appear.

This warning often appears on the passenger-side mirror of a car. What leads to this impression?

A. The object is closer to the mirror than its image

B. The image is smaller than an object at the actual distance would appear

C. Both of the above

D. Neither of the above

ANS: B—The Image is smaller than an object at the actual distance would appear.

The warning is to remind you that the mirror is not a flat mirror. We humans are good at understanding flat mirrors. In these devices, the image is as large as the object. The distance between us and the image in a flat rear-view mirror is the same as the distance between us and the object (a car behind us). The farther the car is from us, the smaller it will appear in the mirror.

The passenger-side mirror, however, is convex. It will create a reduced image that will be smaller than the one produced by a flat mirror. Thinking in terms of flat mirrors could lead us to think that the car behind us in the passenger mirror is farther from us than it really is. In fact, the image in the mirror is actually closer than the original object, so answer #1 above is not correct. The image only appears farther away because it is so much smaller than the image in a flat mirror.