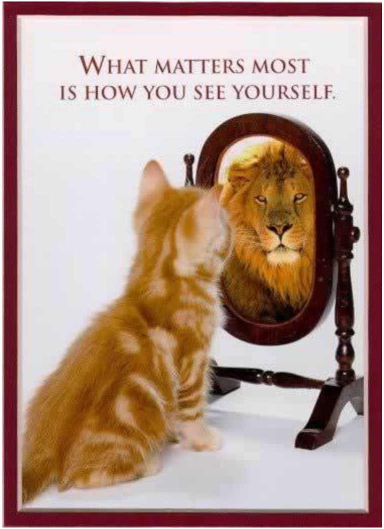
Light, Images, and Reflection



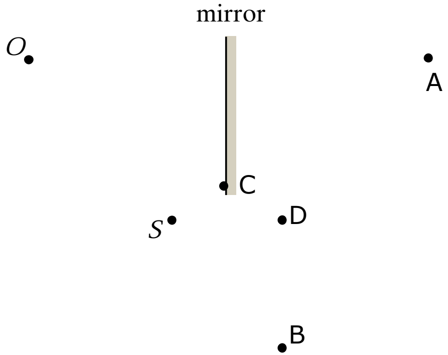
Human eyes have a certain minimum distance at which they can focus clearly. Anything closer than that distance, which is about 24 cm for young eyes, would be out of focus. If you look into an ordinary, flat mirror to see whether a speck of dirt is in your eye, what is the closest distance you can get to the mirror and still see the speck?

A. Arbitrarily close
B. 12 cm
C. 24 cm
D. 36 cm
E. 48 cm
F. other

ANS: B—You can't be closer than 12 cm.

The image created by a flat mirror is just as far behind the mirror as the object is in front of it. In other words, a flat mirror is always located exactly halfway between the object and its mirror image. The image of your face can be no closer than 24 cm to your eye for you to be able to focus on it, so the mirror must be no closer than 12 cm from your eye. This gives an object distance (eye to mirror) of 12 cm, and an image distance (mirror to image of eye) of 12 cm.

An observer O, facing a mirror, observes a light source S.
Where does O perceive the mirror image of S to be located?



A–D. as shown on the diagram.

E. Some other location.

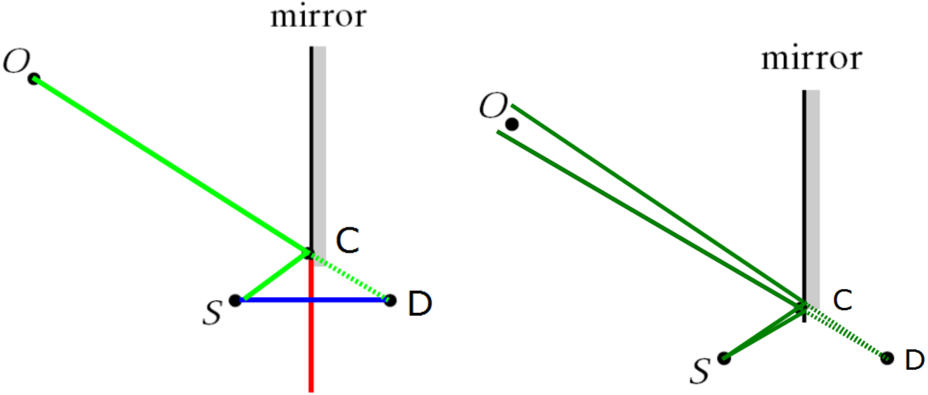
F. The image of S cannot be seen by O when O and S are located as shown.

ANS: The image is located at position **D**.

A flat mirror always produces an image that is directly "behind" the mirror. In other words, if you draw a line from the object at S perpendicular to the mirror, the image of S will lie exactly on this line the same distance behind the mirror (at point D). You may object that there is actually no "mirror" between the object and image points, but that does not matter. All that matters is that a ray from S reflects off the mirror and arrives at point O (the observer). In fact, such a ray will strike the mirror at point C and reflect back upward to O.

This allows us to devise a very simple set of instructions for drawing images in a plane mirror. (See the picture below.) Even if the mirror is not long enough, extend a line beyond the mirror to "pretend" that it is large enough to reflect the object (red line). Draw the image exactly the same distance behind the mirror as the object is in front of it (along the blue line). Draw a line from the observer to the image. The point where this line crosses the mirror is the point where the ray from the object will reflect back to the observer (point C). If this point of reflection is actually on the real mirror (not its imaginary extension) then the observer will see the image in the mirror. If not, the observer will not see the image. In our case, this point is just on the mirror so the person at O will see the image of S in the mirror.

See the next slide for a diagram.

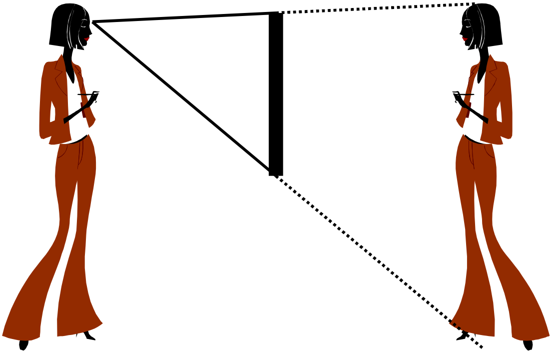


mirror
O
C
S
D
mirror
O
C
S
D

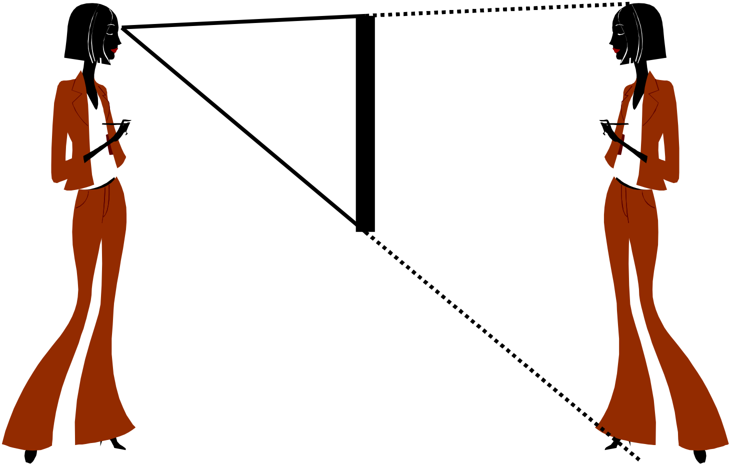
You are standing in front of a flat mirror. What minimum length must the mirror be for you to see your entire body in the mirror at one moment? You may raise or lower the mirror to an optimal position.

A. It depends on how close you are
B. Your full height
C. Three quarter height
D. Half your height
E. One quarter of your height

ANS: D—The mirror can be as small as half your height, if placed appropriately.



It is easy to construct a ray diagram for this. Your image will be exactly as far behind the mirror as you are in front of it. Draw rays from your eyes to the top of the image's head and to the bottom of the image's feet. These rays set the limits on where the top and bottom of the mirror must be. Assuming all points on your body are equidistant from the mirror, the top of the mirror should be at least as high ad the point vertically halfway between your eyes and the top of your head, while the bottom of the mirror should be at least as low as the point vertically halfway between your eyes and the bottom of your feet. This means that the mirror should be half of your height.



To look at a tattoo on the back of her shaved head, a lady holds a hand mirror behind her head and looks into a wall mirror. The back of her head is 4 feet from the wall mirror and 1 foot from the hand mirror. How far from the surface of the wall mirror is the image of the exceedingly cool tattoo she sees?

A. 3 ft
B. 4 ft
C. 5 ft
D. 6 ft
E. 8 ft
F. 10 ft

ANS: D—The image is 6 ft from the wall mirror.

The image of her tattoo in the hand mirror is one foot behind the hand mirror, or two feet behind her head. Therefore, the image of her tattoo in the hand mirror is six feet from the wall mirror. This means that the image of the tattoo in the wall mirror will be six feet behind the wall mirror.

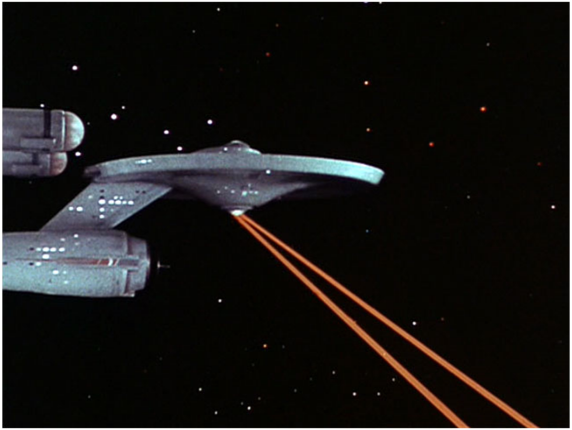
Warmup Question

You own a highly polished mirror that allows you to admire your lovely visage. While you're in class, your evil roommate paints the mirror's surface with a perfectly white paint. Upon your return, with the room lights turned on as before, why can you can you longer see your image in the mirror? Please be specific about what has changed and why that matters.

ANS: The "mirror" still reflects most of the light that hits it, but now the reflection is *diffuse*, or disorganized, rather than *specular*, or organized. Light rays coming in from different angles will be reflected at various angles. The law of reflection will not apply and no image will be formed.

Warmup Question

From what you know about optics (and not just cheesy sci fi), what's wrong with this picture?



ANS: Light rays travel in a straight line. If you are not in the path of the ray, you will not see the ray unless some of the light scatters off something in the way, reflecting the light into the direction of your eye. This is why you see sunbeams in dusty, smoky rooms and under certain weather conditions. The Enterprise is firing its lasers in the vacuum of space, so there's nothing for the rays to scatter (reflect) from.
(Note: you can see a hint of "nebulosity," gas and dust, surrounding the star in the background. I suppose that the nebulosity extends, however sparsely, into the region around the ship. If that were the case, then maybe you'd see some scattering of the phaser beam. However, I doubt it would appear that bright.)

Warmup Question

Light travels in a line we call a

A. bob
B. ray
C. stream
D. queue

ANS: Light travels in lines called *rays*. The study of simple lenses and mirrors, which is the limit of our study of optics in this class, is called "ray optics" or "geometric optics".