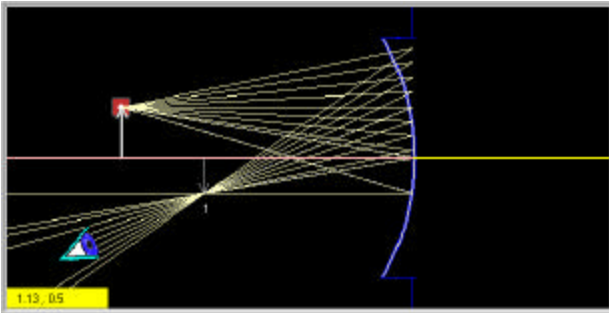


Geometrical Optics: Curved Mirrors Worksheet

Part I: Curved Mirrors (from Exploration 33.2 in *Physlet Physics*)



This first exercise explores the difference between real and virtual images (**position is in meters and angle is given in degrees**)? Restart.

- a. Drag the object back and forth. In this animation, when the image is on the left of the mirror it is a real image, but when it is on the right it is a virtual image. Place the object so that the image is to the right of the mirror (a virtual image). Now, let's identify where your eye/brain thinks the light is coming from. First, note that you (or your eye/brain) think light travels in a straight line. Furthermore, when light diverges from (spreads out from) a point, your brain assumes that the point it diverges from (the image point) is where the light originated. If your eye is where the eye is in the diagram, where does your eye/brain think the light is coming from?

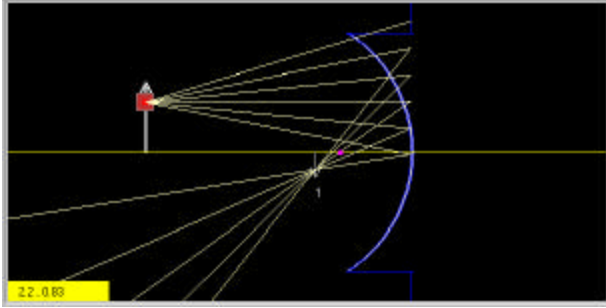
- b. Now consider a real image. Place the object at some point so that the image forms somewhere in front of the eye. Where does the eye think the light comes from?

- c. What does the eye see? In other words, is the image upright or inverted, bigger or smaller than the object?

- d. Move the object so the image point is beyond the eye. (Notice that for this case, the light doesn't seem to have a convergence point so you'd see a blurry image.)
- e. Considering the above cases, in which of them is light actually traveling through the image point?

This is how you can identify real and virtual images: For real images, the light actually travels through the image. If you put up a screen (for the light to reflect off of), then a real image can be formed on a screen whereas if you put up a screen at the point of a virtual image, you won't see anything on the screen (it is behind the mirror).

Part II: Ray Diagrams (from Exploration 33.3 in *Physlet Physics*)



Often, you will use ray diagrams in order to determine where an image of an object will be, whether it will be real or virtual, and whether it will be inverted or upright. The animation shows an object arrow, a mirror, and a pink dot to show the focal point of the mirror. You can move the object using the slider (**position is given in meters**). Restart.

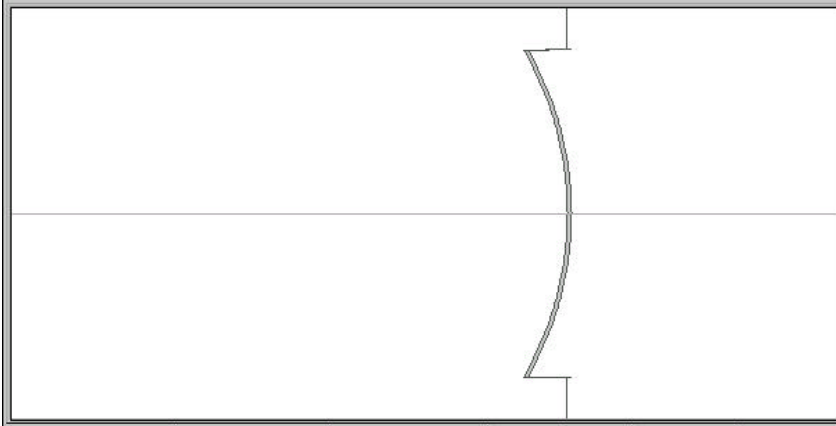
- a. One point source is attached to the object in the animation. Move the point source up and down. Where does the light converge? (Sketch an example of the position of the point source and the point where the light converges with the image.)

- b. In order to sketch a diagram of the object, lens and the approximate position of the image, you need to know where the light from every point on the object converges. Instead of trying to draw a large number of the rays from many points on the object, we generally use three rays from the tip of the object in a "ray diagram". As you move the object (with the slider) or move the point source, there is a ray that always passes through the focal point. Describe that ray-- this is a ray generally included in a ray diagram.

- c. Now switch to the "ray diagram" view. Describe the other two rays :

- d. As you move the object, describe what stays the same about the rays even when the object is in a different position and the image is changing position and size.

- e. Draw an object in the diagram below, mark a focal point and then sketch a ray diagram, labeling the three standard rays described below:

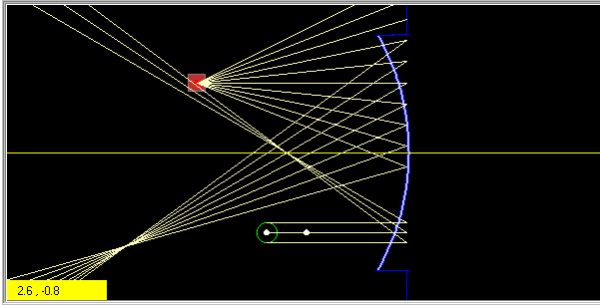


- i. Ray travels from the object parallel to the optical axis reflects from the mirror and crosses the optical axis at the focal point.
- ii. Ray travels from the object through the focal point reflects from the mirror parallel to the optical axis
- iii. Ray travels from the object and hits the mirror at its intersection with the optical axis reflects back at the same angle (relative to the optical axis) with which it entered the mirror.

- f. Finally, move the object between the focal point and the mirror. Sketch a ray diagram:

- g. What is the difference between the "point source" and "ray diagram" views?

Part III: Putting it Together (from Exploration 33.4 in *Physlet Physics*)



In this animation, you have the option of adding both a parallel beam source and a point source of light with mirrors (**position is given in meters**). Whenever you add a mirror, all the light sources will be cleared off the screen. Restart.

of the mirror.)

- a. First, add a concave mirror and then a parallel beam source. Where do the light rays converge? Does this point change when you move the beam source around? (This is the focal point

- b. Now, add a point source of light. Where do the rays converge? (Draw a sketch.)

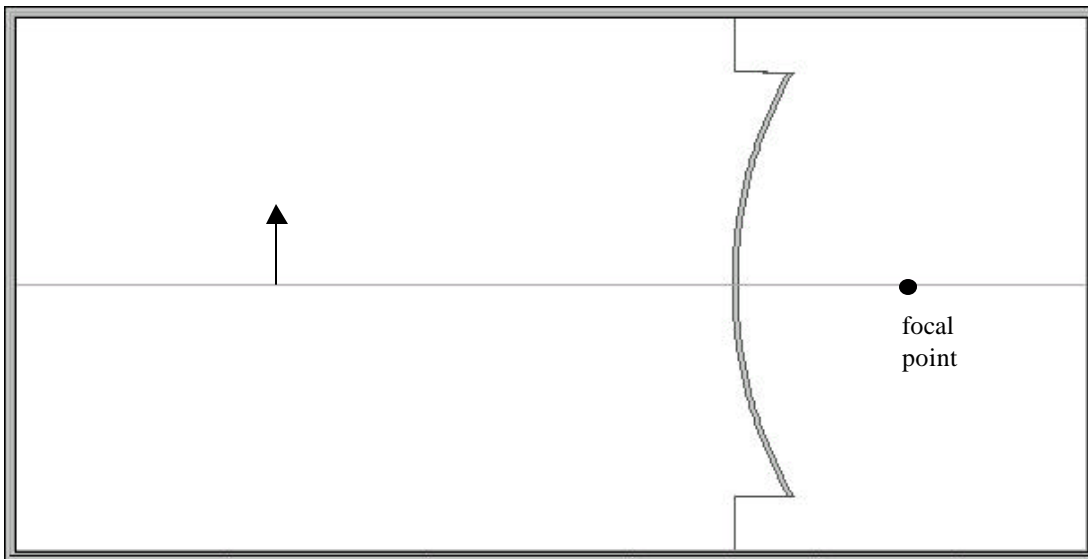
- c. Do the rays from part (b) converge at the focal point?

- d. Move the source around---what happens to the point where the rays converge?

- e. Now add an object. Put the object and point source at the same place. Where is the image in relation to the point where the rays converge? (Sketch a diagram.)

- f. What is the difference between the focal point and an image point?

- g. What happens when you move the object to the focal point of the mirror? Why?
- h. What about when the object is between the focal point of the mirror and the mirror itself? What is the difference between images when the object is inside the focal point and outside the focal point? (If you find that the screen is too cluttered to see what is happening, you can clear the screen and add simply a concave mirror and object.)
- i. Which images are real images and which ones are virtual? How can you tell?
- j. Now, consider a convex mirror and an object. Predict, by drawing ray diagrams in the space below, the image formed:



- k. Clear the screen and add a convex mirror and an object to check your prediction. If your prediction was incorrect, redraw your diagram to show the correct image (add a point source to the animation if you need to see some rays).

