

FOCAL POINT

grades 6–12

Objective

To observe how the primary mirror of a telescope reflects light to a focal point.

Introduction

A basic reflecting telescope consists of a primary mirror that collects light and a secondary mirror that reflects the light to a detector. There are three different shapes for mirrors that each reflect light in a different way. Mirrors can be concave (they turn inward like a bowl), convex (they turn outward like a speed bump), or planar (flat as a pancake).

The light that enters a telescope is reflected so that all the light intersects at a point called the focal point. The location of the focal point is a vital piece of information about a telescope; it is where all of the light collected from a distant object is focused. Astronomers need to know the exact location of the focal point in order to build an efficient telescope. In this activity students can observe the location of the focal point of a mirror. The apparatus offers an inexpensive alternative to an advanced (and expensive) optical bench.

Background Reading for Educators

Telescopes: Super Views of Space, available at
http://www.amnh.org/education/resources/rfl/pdf/du_x02_telescopes.pdf

Materials

Black construction paper

Flashlight

Index card

Ruler

Aluminum foil tape (a roll of reflective foil tape can be purchased from Home Depot, \$2.96 per roll)

1-liter soda bottle

Scissors

Optional additional materials:

Exact-o knife

Piece of clay or play-dough

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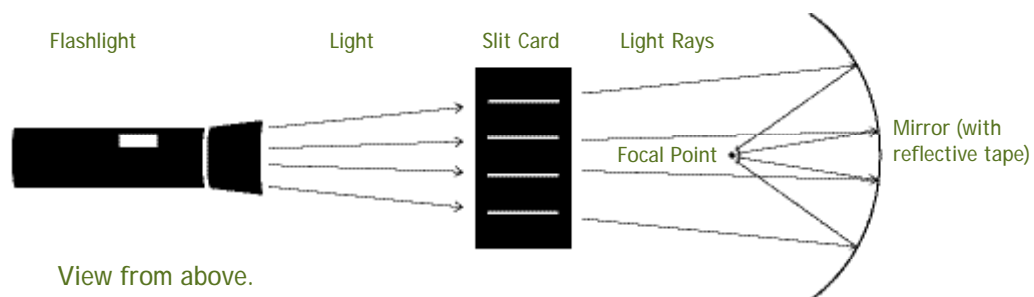
Cut top and bottom of bottle, retaining center portion as shown by dashed lines.



Meg Carlough/AMNH

Procedure

- 1] Cover an index card with a piece of black construction paper.
- 2] Measure four slits on the card. The slits should be 1 inch long, $\frac{1}{8}$ inch wide, and $\frac{1}{4}$ inch apart. Center the slits in the middle of the card. An Exact-o knife works best for cutting because it creates the smoothest slits. It is important to avoid ragged or uneven edges.
- 3] Cut the bottom and top from the soda bottle, leaving a round, smooth center section at least 5 cm long. Make sure that the piece is round and even. If you have a bottle with bumps at the bottom, as most 1-liter cola bottles have, then make sure to cut above the bumps.
- 4] Cut the tube you made in half so that you have two semi-circles of plastic. Choose one of the semicircles (they should be identical, so it doesn't matter which one you choose) and cover the inside of the concave shape you have just created with the reflective aluminum foil tape. This is your makeshift telescope primary mirror.
- 5] Prop up a few small books or magazines on a desk or table at a 30-degree angle. Place a piece of black construction paper on the slope you made. Now place the index card (with the slits in it) at the base of the slope. You must keep this card upright. You can have a student hold it in place, or you can use two pieces of clay or play-dough as support.



- 6] Place the flashlight 2 to 2.5 feet from the foot of the slope. Adjust this setup until you can see four parallel rays of light on your construction paper. Move the flashlight closer and farther from the index card and adjust the angle of the slope so that the four slits are parallel to one another, just as they are on the index card. You should see four bright light rays on the black construction paper.
Explain: When we see light from a distant object, we are essentially receiving the light in rays like these. The students will now build a telescope that will focus all of this light to a single point.
- 7] Place the mirror you constructed in front of the light rays. You can put it anywhere on the black surface as long as all of the light rays hit the reflective material.
Ask: What happens when the light passes through the slits and hits the curved mirror?
Explain: The light rays are all reflected to a bright point at what is called the “focal point” of the mirror.
- 8] Move the mirror closer and farther from the slit to make the focus as bright and clear as possible.
Ask: Look closely at the bending light rays and point out the different paths. What do you notice?
Explain: Each ray is reflected off of the mirror and bends according to the angle at which it hits the mirror. The four light rays hit the mirror at different spots on the curve, so they are each reflected along a different path. The focal point is where all of these paths meet.
- 9] Since the mirror you have constructed is flexible, you can change the radius of the curve and therefore change your focal point. Stretch the mirror a bit, and observe what happens to the focal point. As you increase the radius, the focal point gets farther from the mirror. (If you had a flat mirror the focal point would be infinitely far away.)
Ask: What is the importance of the focal point for telescopes? Why do astronomers need to know where the focal point is?
Explain: The focal point is where the telescope focuses the light it collects. If your eye were located at the focal point of a mirror it would receive all of this light. Since this is an inconvenient place to put your eye (and your head would block the light coming toward the mirror), astronomers place a small secondary mirror at this location and reflect the light to a convenient viewing place.
- 10] Turn the mirror around so that you have a convex mirror. Observe that the light rays now spread out from the mirror as if they are emerging from some focal point behind the mirror. This should make it clear to your students why astronomers use a mirror that dips inward as opposed to one that bulges outward.
Ask: What is the obvious disadvantage of using a convex mirror in a telescope?
Explain: Light would be scattered and we would have no way of collecting all of the light rays.
- 11] Flatten the mirror so that you have a planar surface. The light now bounces from the mirror in parallel rays that do not converge to a focal point. A planar mirror is not useful for focusing distant starlight because it does not allow us to collect all of the starlight at one point.