1. Below are some real life examples of 'dish shaped objects'.

SATELLITE DISH

SOLAR DISH

SOLAR ENERGY COLLECTOR

FLASHLIGHT

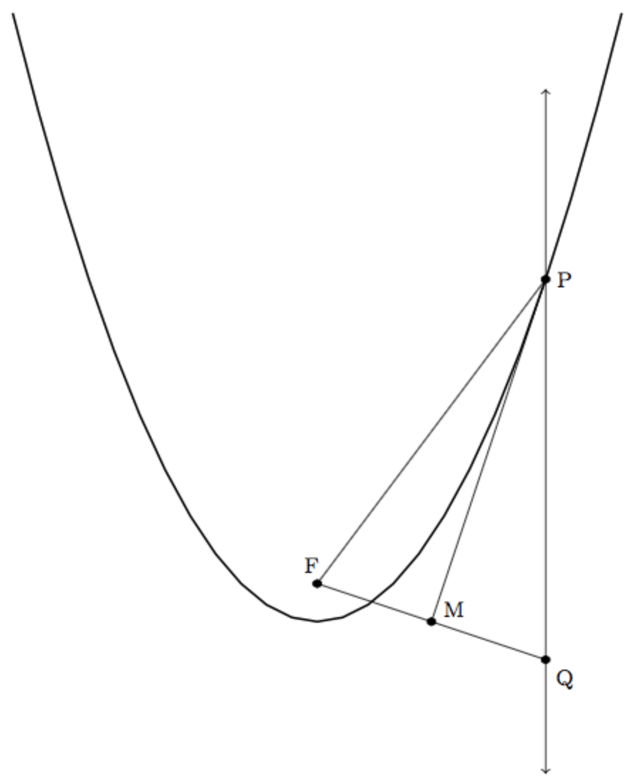
a. In each example, ‘focus’ is needed for the device to work. For example, the solar cooker focuses the sun’s rays to heat food. Explain what each of the other devices ‘focuses’ and why that is important.

b. Why is the shape of each device critical for its functioning?

2. Let's take a closer look at how the flashlight works. Flashlights are constructed so that light from the bulb reflects off a curved mirror behind it, along a line parallel to the body of the flashlight. The picture below shows a two dimensional slice of the flashlight head. The bulb is at point F and the curve is the cross section of the mirror behind the bulb.

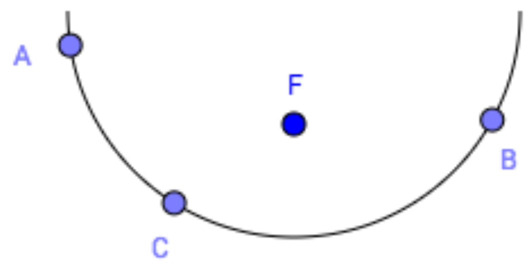
   A law of optics says that a ray of light coming from *F* and hitting the mirror at some point *P* will leave the mirror at the same angle it hits the mirror.

   If M is on the line touching the curve only at P and Q is on the line through P parallel to the body of the flashlight, what must be true for the light emanating from *F* to obey this law of optics?



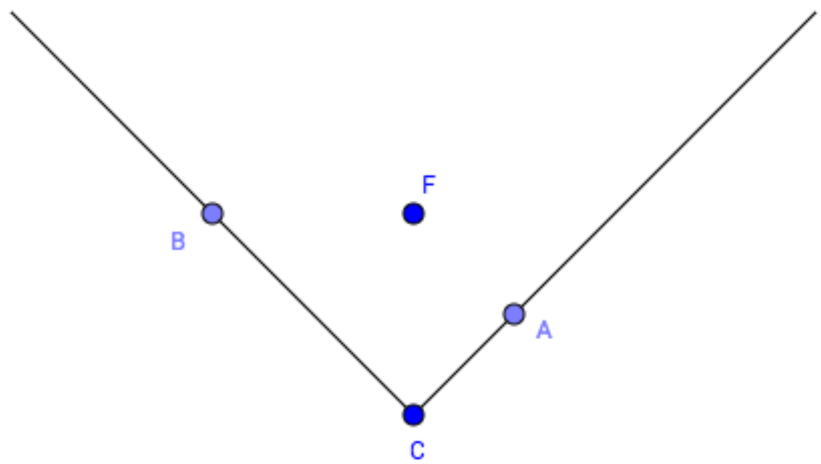
3. In this problem we consider other curves for flashlight mirrors.

   a. Suppose the curve in the two-dimensional slice was a semi-circle and the bulb at a point F, as shown below. For each of the points *A*, *B*, and *C*, sketch the line that tangent to the semi-circle the point. Use this line to help you sketch where the ray of light coming from *F* will travel when it hits the point.




   b. Would a "semi-circular mirror" make an effective flashlight? Explain. What if you move *F*?

c. Suppose the cross section of the mirror in the two-dimensional slice was a made up of two lines meeting in a right angle. Repeat the process in part b) to sketch where a ray of light coming from F will travel when it hits *A*, *B*, and *C*.




d. Would an "absolute value mirror" make an effective flashlight? Explain.

## For the Professional

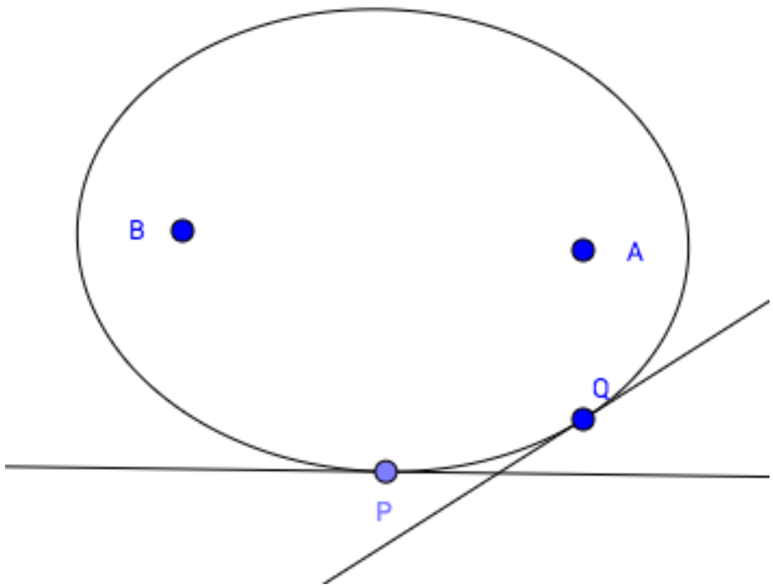
1. Suppose the curve from Problem 2) above is the set of points equidistant from $F$ and a line below the curve through $Q$ and perpendicular to line $\overleftrightarrow{QP}$. Suppose $S \neq P$ is a point on the "right side" of the curve.

   a. Show that $S$ is closer to $F$ than to $Q$.

   b. Conclude that $\overrightarrow{MP}$ is tangent to the curve at $P$.

   c. Using the law of optics mentioned in Problem 2) above, conclude that the set of points equidistant from a point in the plane and a line not passing through the point has the reflective property needed by flashlights.

2. Consider the sketch of an ellipse with foci *A* and *B* and tangent lines to the ellipse at points P and Q shown below. Sketch where a ray of light coming from A and reflecting off of *P* will travel. Do the same for a ray of light coming from A and reflecting off of *Q*.




How can this elliptic shape be used to focus light in a different way?

## Related Common Core Standards

**G-SRT.5** Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.

**G-CO.4** Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.

**G-CO.9** Prove theorems about lines and angles.