Name:_____ Class:_____ Date:_____

Light and Reflection

Problem B

IMAGING WITH CONCAVE MIRRORS

PROBLEM

Lord Rosse, who lived in Ireland in the nineteenth century, built a reflecting telescope called the Leviathan. Lord Rosse used it for astronomical observations and discovered the spiral form of galaxies. Suppose the Leviathan's mirror has a focal length of 2.50 m. Where would you place an object in front of the mirror in order to form an image at a distance of 3.75 m? What would the magnification be? If the image height were 6.0 cm, what would the object height be?

SOLUTION

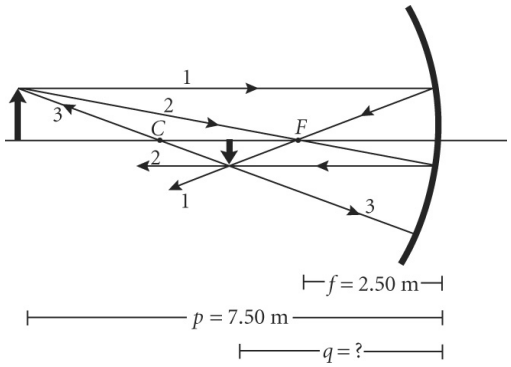
1. **DEFINE**

Given: $f = +2.50$ m $\quad q = +3.75$
$h = 6.0$ cm

The mirror is concave, so f is positive. The object is in front of the mirror, so q is positive.

Unknown: $p = ?$ $\quad M = ?$

Diagram:



2. **PLAN**

Choose the equation(s) or situation: Use the mirror equation for focal length and the magnification formula.

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f} \qquad M=-\frac{q}{p}$$

Rearrange the equation(s) to isolate the unknown(s):

$$\frac{1}{p}=\frac{1}{f}-\frac{1}{q}$$

3. **CALCULATE**

Substitute the values into the equation(s) and solve:

$$\frac{1}{p}=\frac{1}{2.50}-\frac{1}{3.75\text{ m}}=\frac{0.400}{1\text{ m}}-\frac{0.267}{1\text{ m}}=\frac{0.133}{1\text{ m}}$$

$$p=7.50\text{ m}$$

4. **EVALUATE**

Substitute the values for p and q to find the magnification of the image and h' to find the object height.

$$M = -\frac{3.75\text{ m}}{7.50\text{ m}} = -0.500$$

$$h = -\frac{ph'}{q} = -\frac{(7.50\text{ m})(0.060\text{ m})}{3.75\text{ m}} = 0.12\text{ m}$$

The image appears between the focal point (2.50 m) and the center of curvature, is smaller than the object, and is inverted ($-1 < M < 0$). These results are confirmed by the ray diagram. The image is therefore real.

ADDITIONAL PRACTICE

1. In Alaska, the top of Mount McKinley has been seen from the top of Mount Sanford, a distance of 370 km. An object is 3.70×10^2 km from a giant concave mirror. If the focal length of the mirror is 2.50×10^2 km what are the object distance and the magnification?
2. A human hair is about 80.0 μm thick. If one uses a concave mirror with a focal length of 2.50 cm and obtains an image of −59.0 cm, how far has the hair been placed from the mirror? What is the magnification of the hair?
3. A mature blue whale may have a length of 28.0 m. How far from a concave mirror with a focal length of 30.0 m must a 7.00-m-long baby blue whale be placed to get a real image the size of a mature blue whale?
4. In 1950 in Seattle, Washington, there was a Christmas tree 67.4 m tall. How far from a concave mirror having a radius of curvature equal to 12.0 m must a person 1.69 m tall stand to form a virtual image equal to the height of the tree? Will the image be upright or inverted?
5. A stalagmite that is 32 m tall can be found in a cave in Slovakia. If a concave mirror with a focal length of 120 m is placed 180 m from this stalagmite, how far from the mirror will the image form? What is the size of the image? Is it upright or inverted? real or virtual?
6. The eye of the Atlantic giant squid has a diameter of 5.00×10^2 mm. If the eye is viewed in a concave mirror with a radius of curvature equal to the diameter of the eye and the eye is 1.000×10^3 mm from the mirror, how far is the image from the mirror? What is the size of the image? Is the image real or virtual?
7. *Quick Bird* is the first commercial satellite designed for forming high-resolution images of objects on Earth. Suppose the satellite is 1.00×10^2 km above the ground and uses a concave mirror to form a primary image of a 1.00 m object. If the image size is 4.00 μm and the image is inverted, what is the mirror's radius of curvature?
8. A stalactite with a length of 10.0 m was found in Brazil. If the stalactite is placed 18.0 m in front of a concave mirror, a real image 24.0 m tall is formed. Calculate the mirror's radius of curvature.