

## Light and Reflection

**Problem C****CONVEX MIRRORS****PROBLEM**

The largest jellyfish ever caught had tentacles up to 36 m long, which is greater than the length of a blue whale. Suppose the jellyfish is located in front of a convex spherical mirror 36.0 m away. If the mirror has a focal length of 12.0 m, how far from the mirror is the image? What is the image height of the jellyfish?

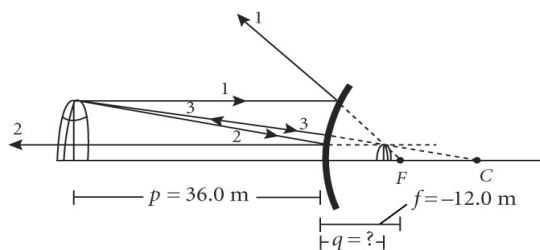
**SOLUTION****1. DEFINE**

**Given:**  $f = -12.0 \text{ m}$        $p = +36.0 \text{ m}$   
 $h = 36 \text{ m}$

The mirror is convex, so  $f$  is negative. The object is in front of the mirror, so  $p$  is positive.

**Unknown:**  $q = ?$        $M = ?$

**Diagram:**



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

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

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

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

**3. CALCULATE Substitute the values into the equation(s) and solve:**

$$\frac{1}{q} = -\frac{1}{12.0 \text{ m}} - \frac{1}{36.0 \text{ m}} = -\frac{0.0833}{1 \text{ m}} - \frac{0.0278}{1 \text{ m}} = -\frac{0.1111}{1 \text{ m}}$$

$$q = -9.001 \text{ m}$$

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

$$M = -\frac{-9.001 \text{ m}}{36.0 \text{ m}} = 0.250$$

$$h' = -\frac{qh}{p} = -\frac{(-9.001 \text{ m})(36 \text{ m})}{(36.0 \text{ m})} = 9.001 \text{ m}$$

The image appears between the focal point ( $-12.0$  m) and the mirror's surface, as confirmed by the ray diagram. The image is smaller than the object ( $M < 1$ ) and is upright ( $M > 0$ ), as is also confirmed by the ray diagram.

### ADDITIONAL PRACTICE

1. The radius of Earth is  $6.40 \times 10^3$  km. The moon is about  $3.84 \times 10^5$  km away from Earth and has a diameter of 3475 km. The Pacific Ocean surface, which can be considered a convex mirror, forms a virtual image of the moon. What is the diameter of that image?
2. A 10 g thread of wool was produced by Julitha Barber of Australia in 1989. Its length was 553 m. Suppose Barber is standing a distance equal to the thread's length from a convex mirror. If the mirror's radius of curvature is  $1.20 \times 10^2$  m what will the magnification of the image be?
3. Among the many discoveries made with the Hubble Space Telescope are four new moons of Saturn, the largest being just about 70.0 km in diameter. Suppose this moon is covered by a highly reflective coating, thus forming a spherical convex mirror. Another moon happens to pass by at a distance of  $1.00 \times 10^2$  km. What is the image distance?
4. The largest scale model of the solar system was built in Peoria, Illinois. In this model the sun has a diameter of 11.0 m. The real diameter of the sun is  $1.4 \times 10^6$  km. What is the scale to which the sun's size has been reduced in the model? If the model's sun is a reflecting sphere, where in front of the sphere is the object located?
5. Bob Henderson of Canada built a model railway to a scale of 1:1400. How far from a convex mirror with a focal length of 20.0 mm should a full-size engine be placed so that the size of its virtual image is the same as that of the model engine?
6. The largest starfish ever discovered had a diameter of 1.38 m. Suppose an object of this size is placed 6.00 m in front of a convex mirror. If the image formed is just 0.900 cm in diameter (the size of the smallest starfish), what is the radius of curvature of the mirror?
7. In 1995, a functioning replica of the 1936 Toyota Model AA sedan was made in Japan. The model is a mere 4.78 mm in length. Suppose an object measuring 12.8 cm is placed in front of a convex mirror with a focal length of 64.0 cm. If the size of the image is the same as the size of the model car, how far is the image from the mirror's surface?
8. Some New Guinea butterflies have a wingspan of about  $2.80 \times 10^2$  mm. However, some butterflies which inhabit the Canary Islands have a wingspan of only 2.00 mm. Suppose a butterfly from New Guinea is placed in front of a convex mirror. The image produced is the size of a butterfly from the Canary Islands. If the image is 50.0 cm from the mirror's surface, what is the focal length of the mirror?

