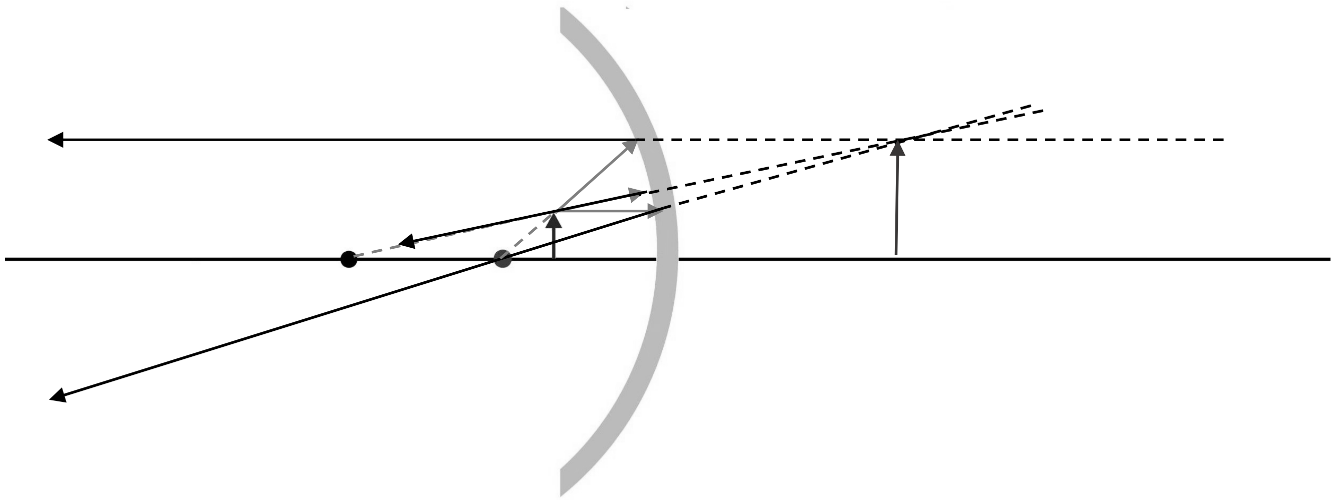
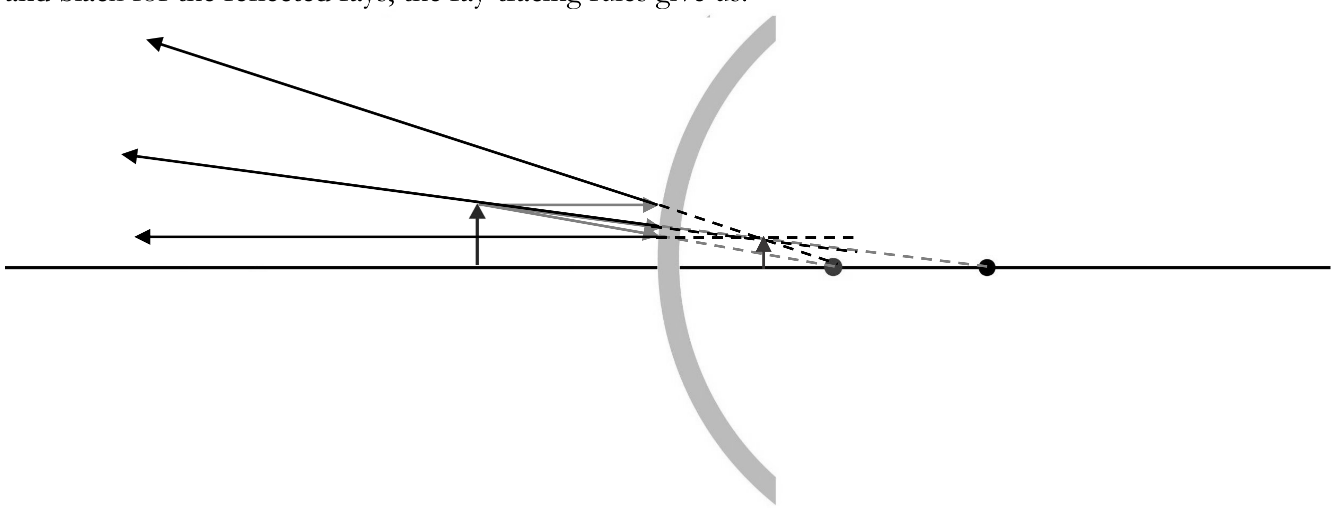
Solutions to the Extra Practice Problems for Chapter 12

1. 8.00 cm. The focal length is half the radius.

2. The image is virtual, upright, and magnified. The object is between the focal point and the mirror, closer to the focal point. Because of its position, light rays must appear to come from R and f rather than travel through them. Using grey for the light rays and black for the reflected rays, the ray-tracing rules give us:



3. The image is virtual, upright, and reduced. The object is a bit farther from the mirror than the focal point, but because this is a convex mirror, the focal point is on the other side. Using grey for the light rays and black for the reflected rays, the ray-tracing rules give us:



4. The index of refraction is 2. The index of refraction is the speed of light in a vacuum divided by the speed of light in the substance. If it's half as fast in the substance, then it's:

$$n = \frac{\cancel{\text{speed of light in a vacuum}}}{\frac{1}{2}\cancel{\text{speed of light in a vacuum}}} = \frac{1}{\frac{1}{2}} = 2$$

5. The angle is 39.4°. The light starts in flint glass, so $n_1 = 1.66$. The angle it makes with the line perpendicular to the water's surface is θ_1, so $\theta_1 = 22.5°$. It then enters air, so $n_2 = 1.000$.

$$n_1 \cdot \sin(\theta_1) = n_2 \cdot \sin(\theta_2)$$

$$(1.66) \cdot \sin(22.5) = (1.000) \cdot \sin(\theta_2)$$

$$\theta_2 = \sin^{-1}\left(\frac{(1.66) \cdot \sin(22.5)}{1.000}\right) = 39.4°$$

6. The index of refraction is 1.1. The light starts in plate glass, so $n_1 = 1.3$. The angle it makes with the line perpendicular to the surface is θ_1, so $\theta_1 = 36°$. It then enters the other medium, so $\theta_2 = 42°$.

$$n_1 \cdot \sin(\theta_1) = n_2 \cdot \sin(\theta_2)$$

$$(1.3) \cdot \sin(36) = (n_2) \cdot \sin(42)$$

$$n_2 = \frac{(1.3) \cdot \sin(36)}{\sin(42)} = 1.1$$

7. There is no refraction. The light starts in plastic, so $n_1 = 1.51$. The angle it makes with the line perpendicular to the water's surface is θ_1, so $\theta_1 = 61.5°$. It then enters air, so $n_2 = 1.000$.

$$n_1 \cdot \sin(\theta_1) = n_2 \cdot \sin(\theta_2)$$

$$(1.51) \cdot \sin(61.5) = (1.000) \cdot \sin(\theta_2)$$

$$\theta_2 = \sin^{-1}\left(\frac{(1.51) \cdot \sin(61.5)}{1.000}\right)$$

$$\theta_2 = \sin^{-1}(1.33), \text{which is impossible}$$

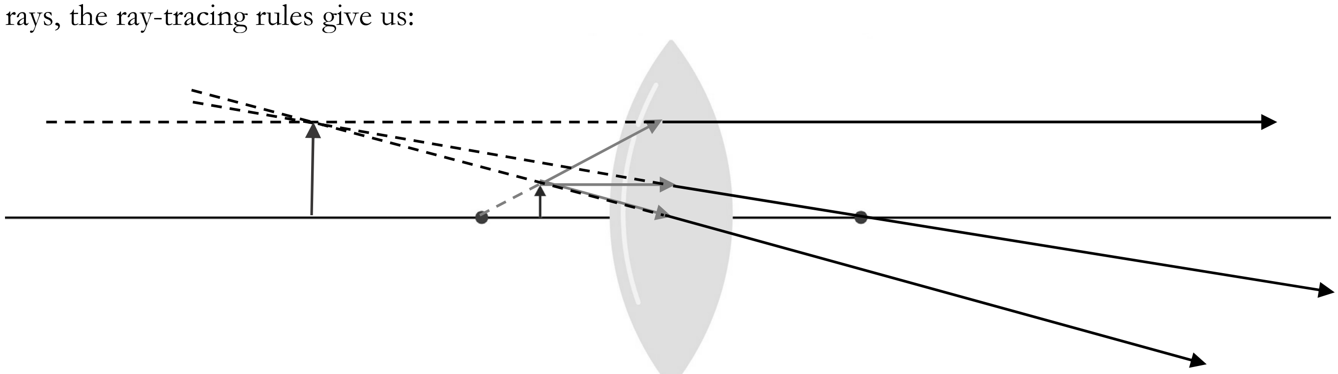
8. The angle is 0.66°. The only thing different is we don't know θ_1, and we have the angle in air, so $\theta_2 = 1.0°$.

$$n_1 \cdot \sin(\theta_1) = n_2 \cdot \sin(\theta_2)$$

$$(1.51) \cdot \sin(\theta_1) = (1.000) \cdot \sin(1.0)$$

$$\theta_1 = \sin^{-1}\left(\frac{(1.000) \cdot \sin(1.0)}{1.51}\right) = 0.66°$$

9. The image is virtual, upright, and magnified. The object is between the center of the lens and the focal point, closer to the focal point. Because of its position, the light cannot go through the focal point and hit the lens, so it has to travel as if it came from there. Using grey for the light rays and black for the reflected rays, the ray-tracing rules give us:



10. The image is virtual, upright, and reduced. The object is halfway between the center of the lens and the focal point. Using grey for the light rays and black for the reflected rays, the ray-tracing rules give us: