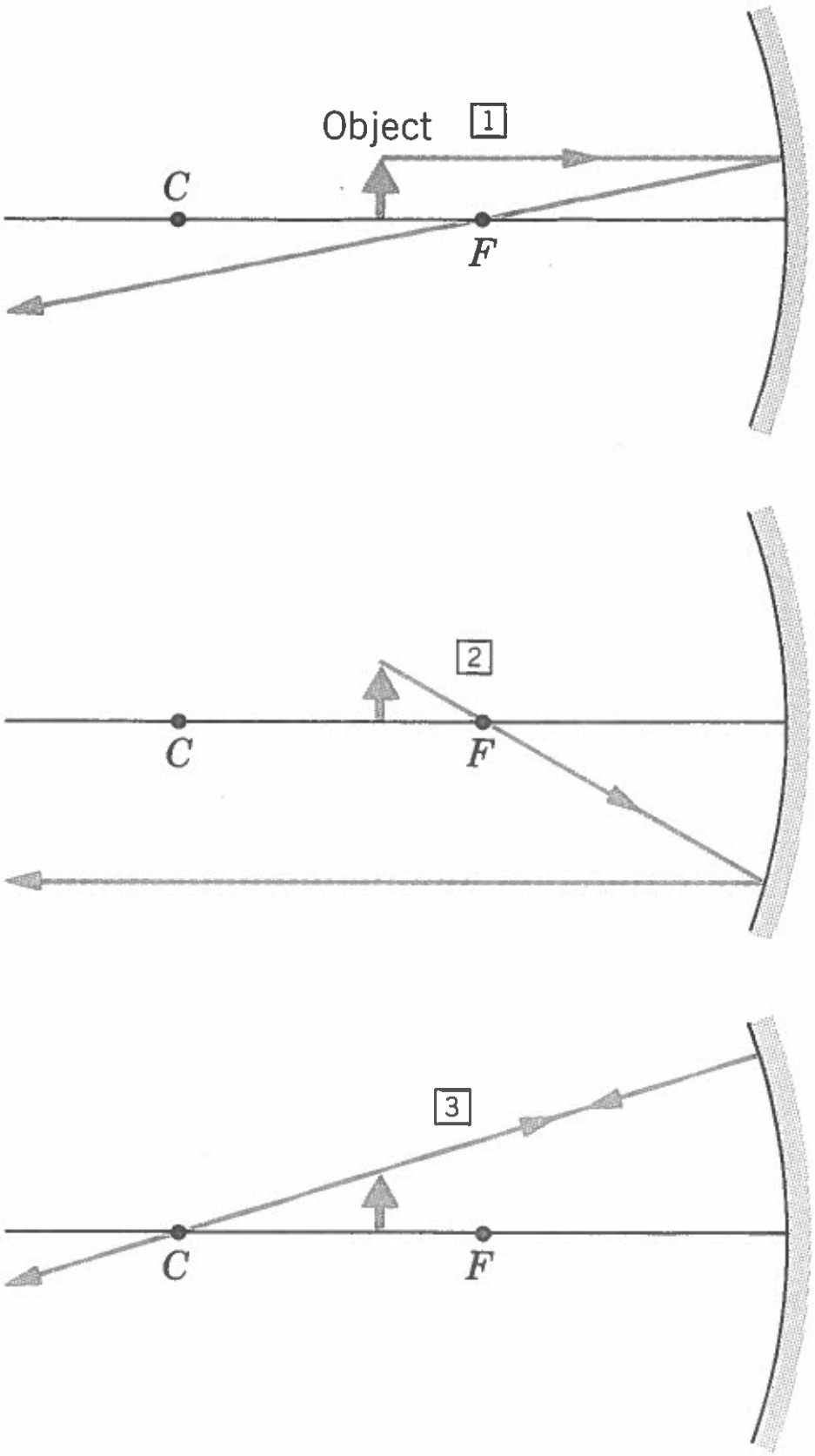


FIGURE 25.16 188

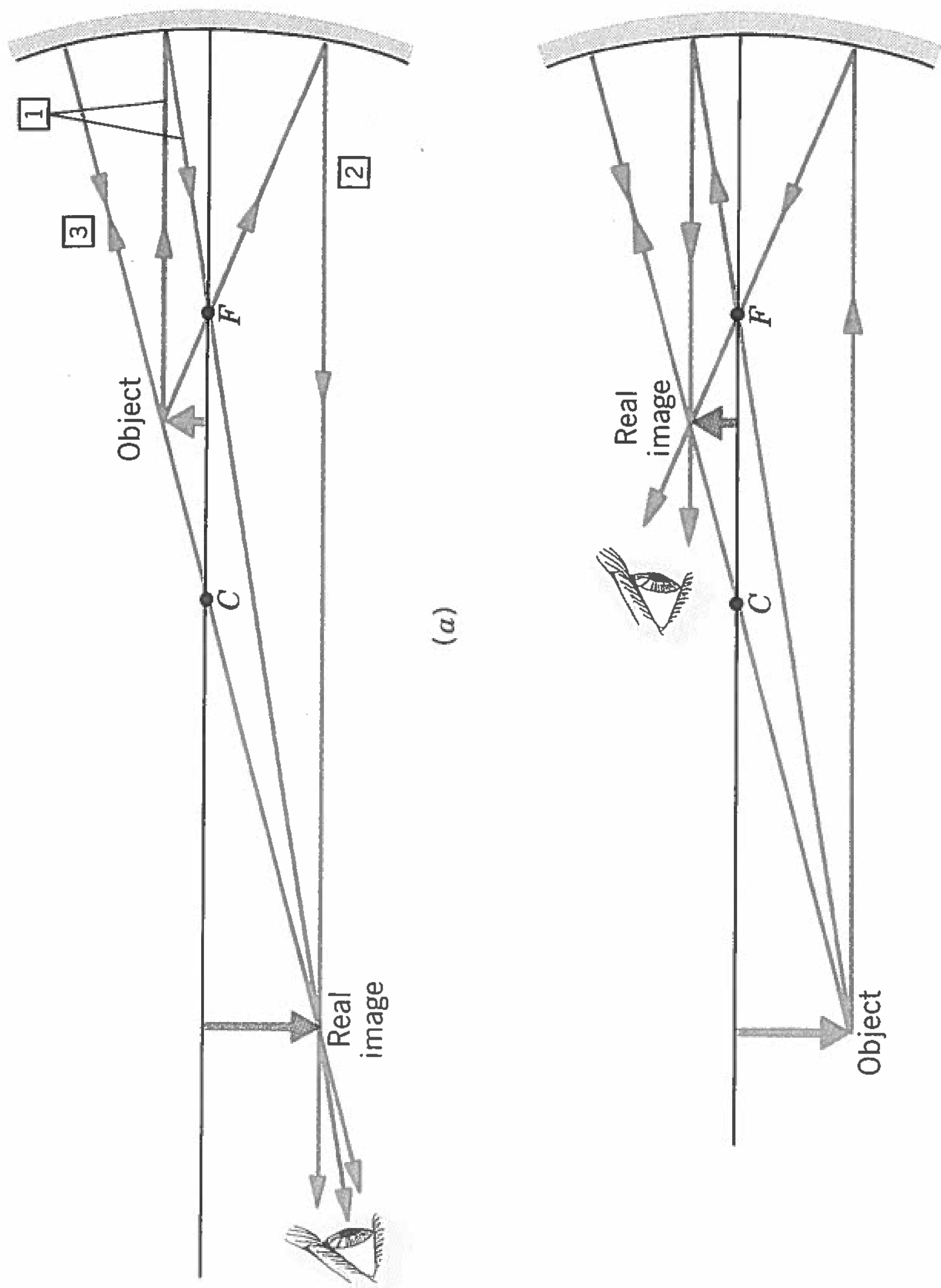


FIGURE 25.17 a, b

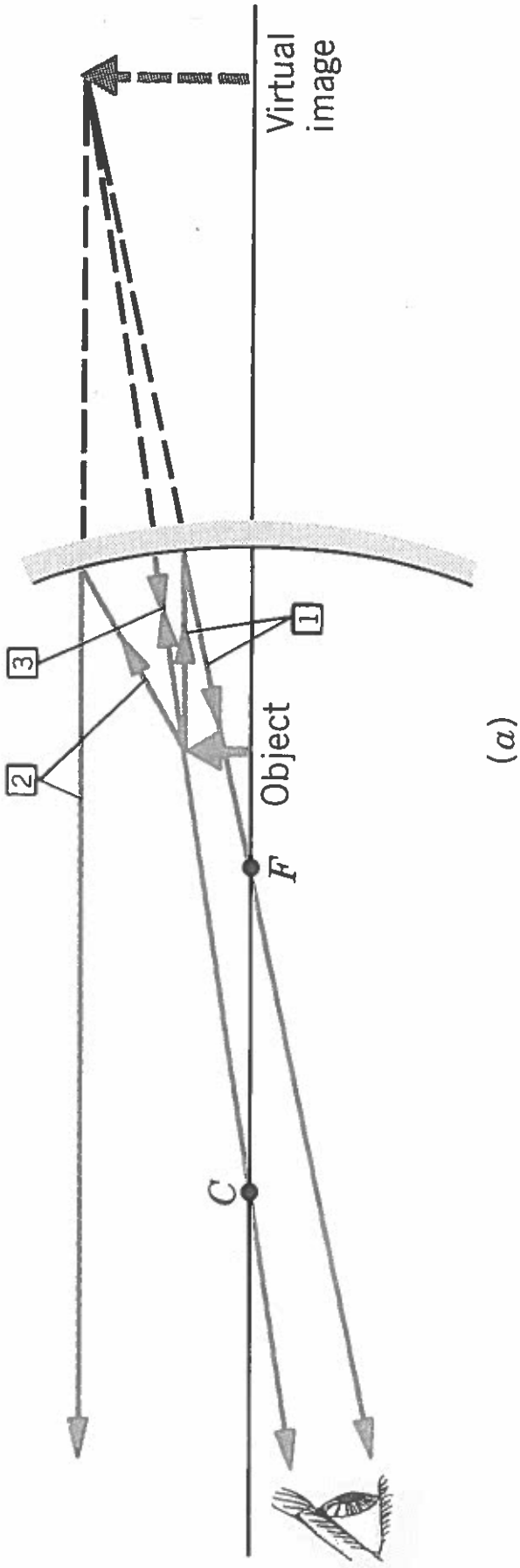


FIGURE 25.18 a 190

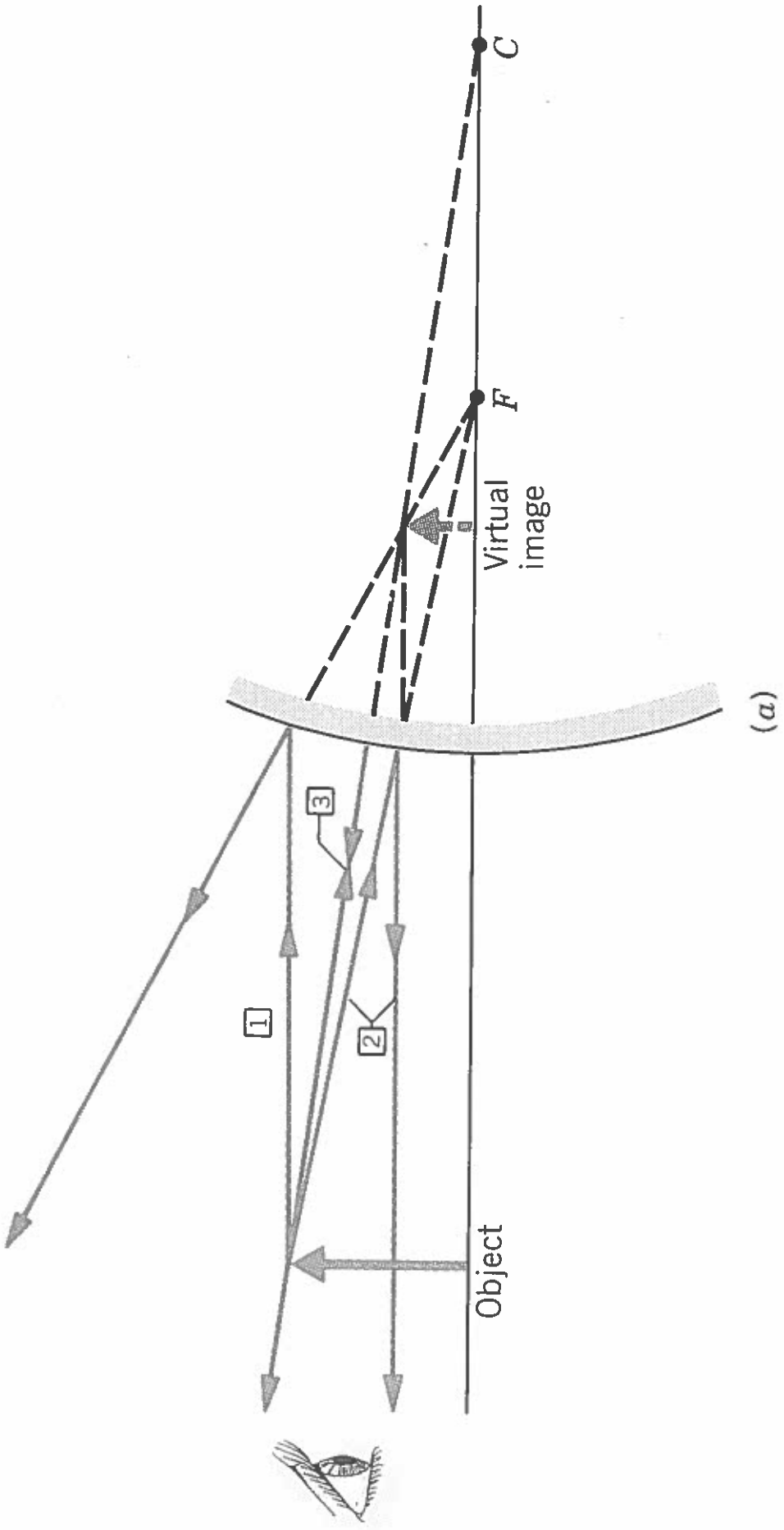
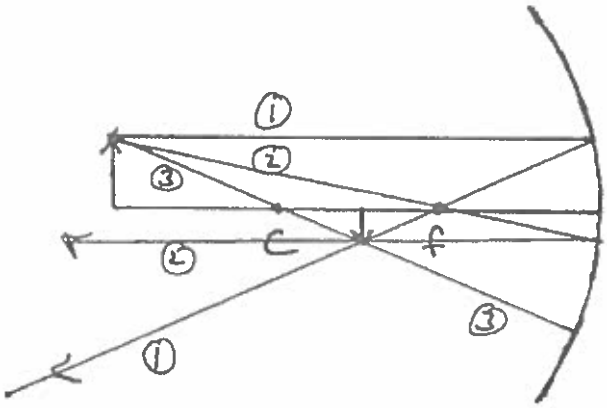


FIGURE 25.19 a 191

16. mmh A 2.0-cm-high object is situated 15.0 cm in front of a concave mirror that has a radius of curvature of 10.0 cm. Using a ray diagram drawn to scale, measure **(a)** the location and **(b)** the height of the image. The mirror must be drawn to scale.

The following diagram was done by hand on paper and then scanned to be placed it. I am including equations after to verify the drawing. Due to being scanned and copied, it may not be exactly the correct dimensions in the electronic or printed version now.



Scale is 1/2

1 cm drawing = 2 cm actual

i = 3.7 cm drawing

⇒ Location is 7.4 cm in front of mirror

height is .5 cm drawing

height of image is 1.0 cm

From the Mirror equation

$$\frac{2}{R} = \frac{1}{o} + \frac{1}{i}$$

Solve for image distance, i

$$\frac{1}{i} = \frac{2}{R} - \frac{1}{o} = \frac{2}{10\ cm} - \frac{1}{15\ cm} = \frac{6-2}{30\ cm} = \frac{4}{30\ cm} = \frac{2}{15\ cm}$$

$$i = \frac{15\ cm}{2} = 7.5\ cm$$

This is pretty close to the measured 7.4 cm!
We find height from

$$\frac{h_i}{h_o} = \frac{-i}{o}$$

Solve for image height

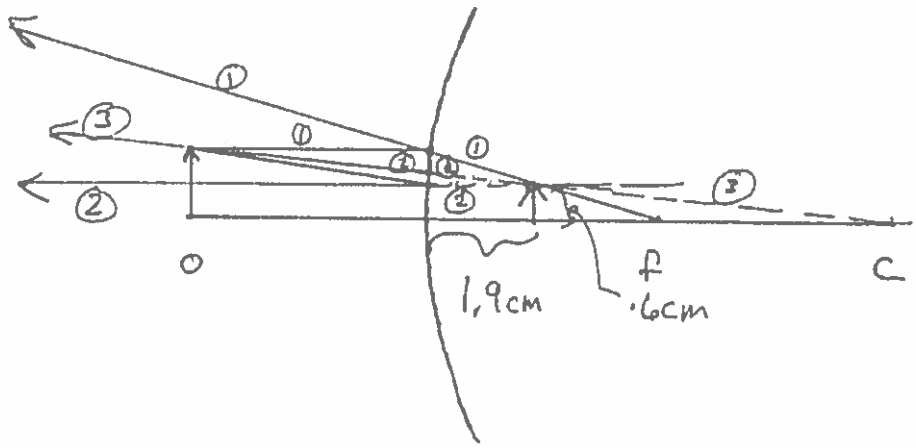
$$h_i = h_o\left(\frac{-i}{o}\right) = (2.0\ cm)\left(\frac{-7.5\ cm}{15\ cm}\right) = -1.0\ cm$$

The minus sign indicates image is upset down and this agrees with drawing which also got 1.0 cm!

17. mmh A convex mirror has a focal length of - 40.0 cm. A 12.0-cm-tall object is located 40.0 cm in front of this mirror. Using a ray diagram drawn to scale, determine the **(a)** location and **(b)** size of the image. Note that the mirror must be drawn to scale.

The following diagram was done by hand on paper and then scanned to be placed it. I am including equations after to verify the drawing. Due to being scanned and copied, it may not be exactly the correct dimensions in the electronic or printed version now.

Scale ⇒ 1 cm drawn = 10 cm real



Location ⇒ 19 cm behind mirror

height ⇒ 6 cm upright.

From the Mirror equation

$$\frac{2}{R} = \frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$

Solve for image distance, i

$$\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-40\ cm} - \frac{1}{40\ cm} = \frac{-1-1}{40\ cm} = \frac{-2}{40\ cm} = \frac{-1}{20\ cm}$$

$$i = \frac{20\ cm}{-1} = -20\ cm$$

Minus sign implies image is behind the mirror! This is pretty close to the measured 19 cm! We find height from

$$\frac{h_i}{h_o} = \frac{-i}{o}$$

Solve for image height

$$h_i = h_o\left(\frac{-i}{o}\right) = (12.0\ cm)\left(\frac{-(-20\ cm)}{40\ cm}\right) = 6.0\ cm$$

The lack of minus sign indicates image is upright and this agrees with drawing which also got 6.0 cm!

Sign Convention

Concave mirror $\Rightarrow$ $R > 0$ $f > 0$

Convex mirror $\Rightarrow$ $R < 0$ $f < 0$

upright $h > 0$

inverted $h < 0$

Real $o, i > 0$

Virtual $o, i < 0$

25-22

$h_o = 3.5\,cm$

concave mirror

image of straw inverted 1.5 cm tall located 13 cm in front of mirror

$f = ?$

$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$

$i = 13\,cm$

$f = ?$

$o = ?$

$M = \frac{h_i}{h_o} = \frac{-i}{o}$ Solve for o

$$o = -i\frac{h_o}{h_i} = -(13\,cm)\frac{(3.5\,cm)}{(-1.5\,cm)}$$

$$o = +30.33\,cm$$

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{30.33\,cm} + \frac{1}{13\,cm}$$

$$= 0.03297\,cm^{-1} + 0.07692\,cm^{-1}$$

$$= 0.10989\,cm^{-1}$$

$$f = \frac{1}{0.10989\,cm^{-1}} = \boxed{9.1\,cm}$$

25-27

image of setting sun is virtual and located 12 cm behind mirror

what is R = ? concave or convex?

$o = \infty \qquad i = -12.0\ cm$

$o > f \Rightarrow$ convex mirror

$R < 0$

$$\frac{2}{R} = \frac{1}{o} + \frac{1}{i}$$

$$\frac{2}{R} = \frac{1}{\infty} + \frac{1}{-12\ cm}$$

$$\frac{2}{R} = 0 + \frac{1}{-12cm}$$

$$\frac{R}{2} = -12\ cm$$

$$\boxed{R = -24\ cm}$$

25-23

$i = -34.0\,cm$

$o = +7.50\,cm$

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{7.50\,cm} + \frac{1}{-34.0\,cm}$$

$$\frac{1}{f} = 0.1333\,cm^{-1} + (-0.0294\,cm^{-1})$$

$$\frac{1}{f} = 0.1039\,cm^{-1}$$

$$f = \frac{1}{0.1039\,cm^{-1}} = 9.62\,cm$$

$f = +9.62\,cm \Rightarrow$ Concave!

An image 10 cm behind mirror → virtual

Concave mirror $f = 20$ cm

Where was object?

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$

$$\frac{1}{o} = \frac{1}{f} - \frac{1}{i}$$

$$\frac{1}{o} = \frac{1}{+20\text{cm}} - \frac{1}{(-10\text{cm})}$$

$$\frac{1}{o} = \frac{1}{20\text{cm}} + \frac{2}{20\text{cm}} = \frac{3}{20\text{cm}}$$

$$o = \frac{20}{3}\text{ cm} = \underline{6.67\text{ cm}}$$

25-25

Convex Mirror $f = -7.0\,m$

$o = 11\,m \qquad i = ?$

$M = ?$

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$

$$\frac{1}{i} = \frac{1}{f} - \frac{1}{o} = \frac{1}{-7.0\,m} - \frac{1}{11\,m}$$

$$\frac{1}{i} = -0.2338\ m^{-1}$$

$$i = \frac{1}{-0.2338\ m^{-1}} = -4.28\,m$$

$$M = \frac{-i}{o} = -\frac{(-4.28\,m)}{11\,m}$$

$$M = 0.39\,X$$

25-30

$o = 2.0\ cm$

Enlarged image

$i = 5.6\ cm$ behind mirror

$i = -5.6\ cm$

What kind of mirror (plane, concave or convex)

$f = ?$ $M = ?$ Orientation of image

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i} = \frac{1}{2.0\,cm} + \frac{1}{-5.6\,cm}$$

$$\frac{1}{f} = 0.500\,cm^{-1} - 0.1786\,cm^{-1} = 0.3214\,cm^{-1}$$

$$f = \frac{1}{0.3214\,cm^{-1}} = +3.11\ cm$$

Concave

$$M = \frac{-i}{o} = \frac{-(-5.6\,cm)}{2.0\,cm} = +2.80\ X$$

Orientation is upright!