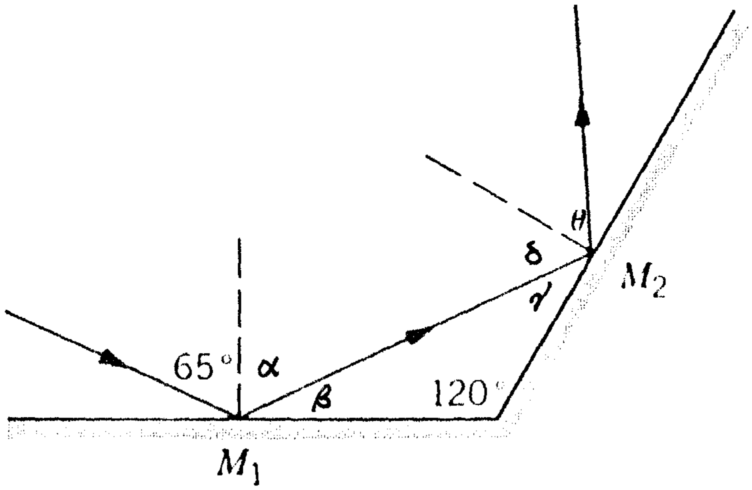
25.5



I have labled various angles in this enlarged copy from the text.

Since, the angle of incidence on M_1 is $65°$:

$\alpha = 65°$ (law of reflection)

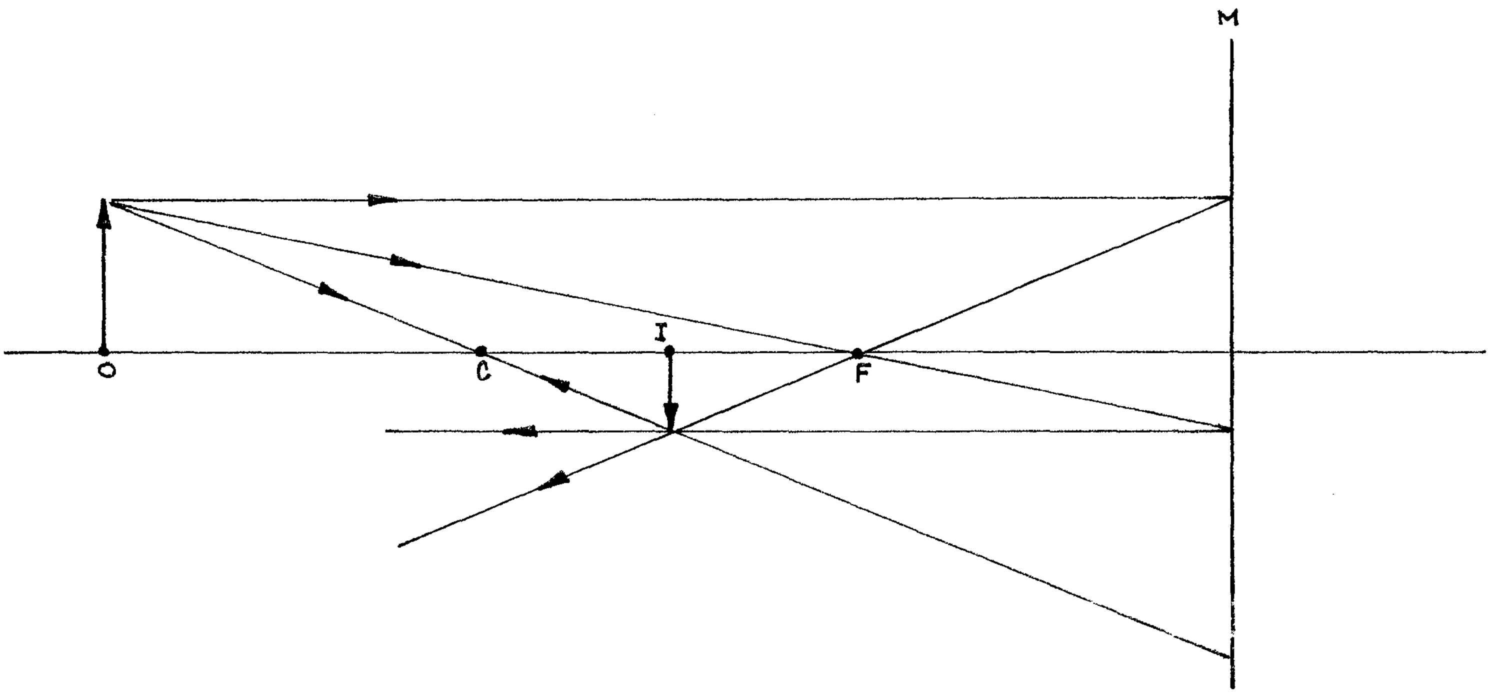
$\beta = 90° - \alpha = 25°$ (complementary angle)

$\gamma = 180° - 120° - \beta = 35°$ (there are 180° in a triangle)

$\delta = 90° - \gamma = 55°$ (complementary angle)

$\theta = \delta = \boxed{55°}$ (law of reflection)

25.10



Conclusions:

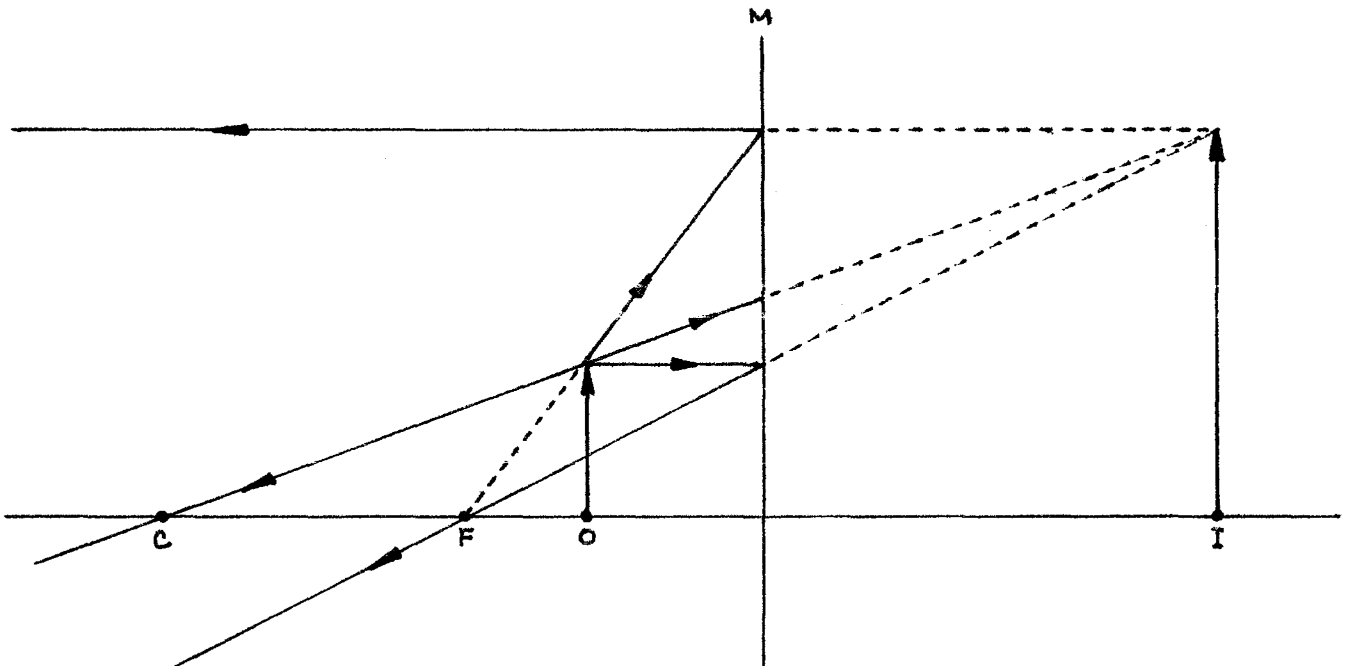
This ray tracing is actual size. According to the drawing, the image is $\boxed{-1.0 \text{ cm high}}$ (inverted) and $\boxed{7.5 \text{ cm in front of the mirror}}$.

Notice that any two of the three rays drawn could have located the image.

Because there really is light where the image appears, the image is said to be "real."

$\boxed{25.11}$

In order to fit my drawing on this paper, I will reduce the horizontal dimensions given by a ratio of 5:1. That means the focal length (20.0cm) will be drawn 4.00cm long; and the object (12.0 cm from the mirror) will be drawn 2.40 cm away. It is not necessary to use the same reduction ratio (or any reduction at all) for the vertical dimensions. In this case, I will draw my object 2.0cm high, just as it was described.



Conclusions:

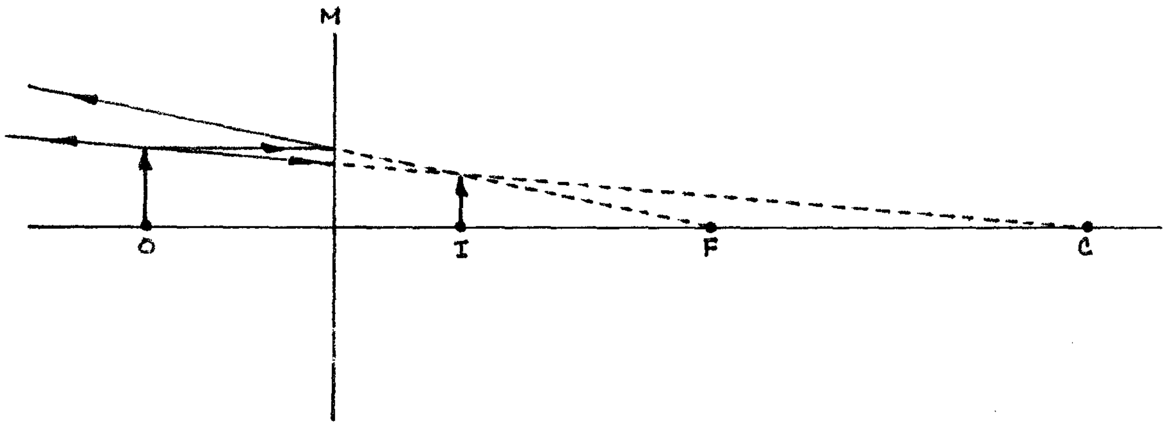
Since my vertical scale is actual size, the image really is $\boxed{\text{5.0cm high}}$ just as it appears in the drawing.

Because I scaled the horizontal dimensions with a ratio of 5:1, the image, which in the drawing is −6.00 cm away from the mirror, is really −30.0 cm away from the mirror or $\boxed{\text{30.0cm behind the mirror.}}$ and is upright.

Also, because there really is no light where the image appears, the image is said to be "virtual".

25.13

The lengths described in this problem can not all fit on this paper. However, they fit well when scaled down (reduced) by a factor of 10:1. So I'll draw the center of curvature 10.0 cm away (not 100 cm away) from the mirror; the object distance is 2.50cm (not 25.0cm); and the object is 1.00cm high (not 10.0cm).



Conclusions

From the ray tracing above, the image is −1.67 cm from the mirror and is 0.67cm high. Since my drawing was done with a 10:1 ratio, the actual image is −16.7 cm from the mirror or $\boxed{\text{16.7 cm behind the mirror}}$ and is actually $\boxed{\text{6.7 cm high \& upright}}$.

I used two rays to locate the image. Can you see how a third ray, initially headed for F, confirms the location of the image?

Because there is no light where the image appears, the image is said to be "virtual".

$\boxed{25.16}$

$d_i = -34.0\,\text{cm}.$
$d_o = 7.50\,\text{cm}.$
$f = ?$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{7.50\,\text{cm}} - \frac{1}{34.0\,\text{cm}} = 0.10392\,\text{cm}^{-1}$$

$$\therefore f = \frac{1}{0.10392\,\text{cm}^{-1}} = 9.6226\,\text{cm}$$

Rounded to three significant figures, $f = \boxed{9.62\,\text{cm}}$

Because the focal length is positive, the mirror is $\boxed{\text{concave}}$

$\boxed{25.17}$

$R = -68\text{ cm}$ (this is negative for a convex mirror.)
$d_i = -22\text{ cm}$ (while it is possible for a convex mirror to produce an image in front of it, I believe we are to assume that the image location is behind the mirror — so d_i is negative.)

a. Since $f = \frac{R}{2}$, $f = -34\text{cm}$. And with $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$,

$$d_o = \frac{d_i f}{d_i - f} = \frac{(-22\text{cm})(-34\text{cm})}{-22\text{cm} - (-34\text{cm})} = 62\,{}^1\!/\!_3\text{ cm}$$

Because d_o is positive, the object is $\boxed{62\,{}^1\!/\!_3\text{ cm in front of the mirror.}}$

b. $$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o} \quad \#1$$

$$\therefore\ m = \frac{-d_i}{d_o} = \frac{-(-22\text{cm})}{62\,{}^1\!/\!_3\text{cm}} = 0.3529411 = \boxed{0.35} \text{ (two significant figures)}$$

From eq #1, $\frac{h_i}{h_o} = 0.35$ or $h_i = (0.35)h_o$ #2

Eq #2 implies that h_i is oriented in the same direction as h_o and is only 35% as high as h_o. Thus, the image is

c. $\boxed{\text{upright}}$ and

d. $\boxed{\text{smaller}}$ than the object.

$\boxed{25.18}$

$f = 12\text{ cm}$
$d_i = 36\text{ cm}$
$m = ?$

Since magnification $m = \frac{-d_i}{d_o}$, we first must determine d_o.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \longrightarrow \frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = \frac{1}{12\text{ cm}} - \frac{1}{36\text{ cm}} = \frac{2}{36\text{ cm}}$$

$$d_o = \frac{36\text{ cm}}{2} = 18\text{ cm}$$

$$\therefore\ m = \frac{-36\text{ cm}}{18\text{ cm}} = \boxed{-2.0}$$

$\boxed{25.19}$

$R = 56.0\text{ cm.} \longrightarrow f = \frac{R}{2} = 28.0\text{cm.}$
$d_o = 31.0\text{ cm.}$
$d_i = ?$

a. Since $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \longrightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$ #1

$\therefore \frac{1}{d_i} = \frac{1}{28.0\text{cm}} - \frac{1}{31.0\text{cm}} = 0.0034562212\text{ cm}^{-1}$

$\therefore d_i = \frac{1}{0.0034562212}\text{ cm.} = 289.3333\cdots\text{ cm.}$

Rounded to three significant figures, $d_i = \boxed{289\text{ cm}}$

An alternate approach is to rewrite eq. #1 as $\frac{1}{d_i} = \frac{d_o - f}{d_o f}$

$\therefore d_i = \frac{d_o f}{d_o - f} = \frac{(31.0\text{cm})(28.0\text{cm})}{31.0\text{cm} - 28.0\text{cm}} = 289.3333\cdots\text{ cm.}$

b. Since $m \equiv \frac{h_i}{h_o} \longrightarrow h_i = m h_o$ #2.

Also $m = \frac{-d_i}{d_o} = \frac{-(289.3333\cdots\text{ cm})}{31.0\text{cm}} = -9.3333\cdots$

when this result is used in eq #2 along with $h_o = 0.95\text{ cm}$,

$h_i = (-9.3333\cdots)(0.95\text{ cm}) = -8.8666\cdots\text{ cm.}$

Rounded to two significant figures, $h_i = -8.9\text{ cm.}$

c. The negative magnification means that the image is inverted relative to the object. Thus, for the image to appear "normal" (i.e. right-side up) the slide (i.e. the object) will need to be upside down.

25.21

$f = \frac{R}{2}$ (this is positive because the mirror is concave.)

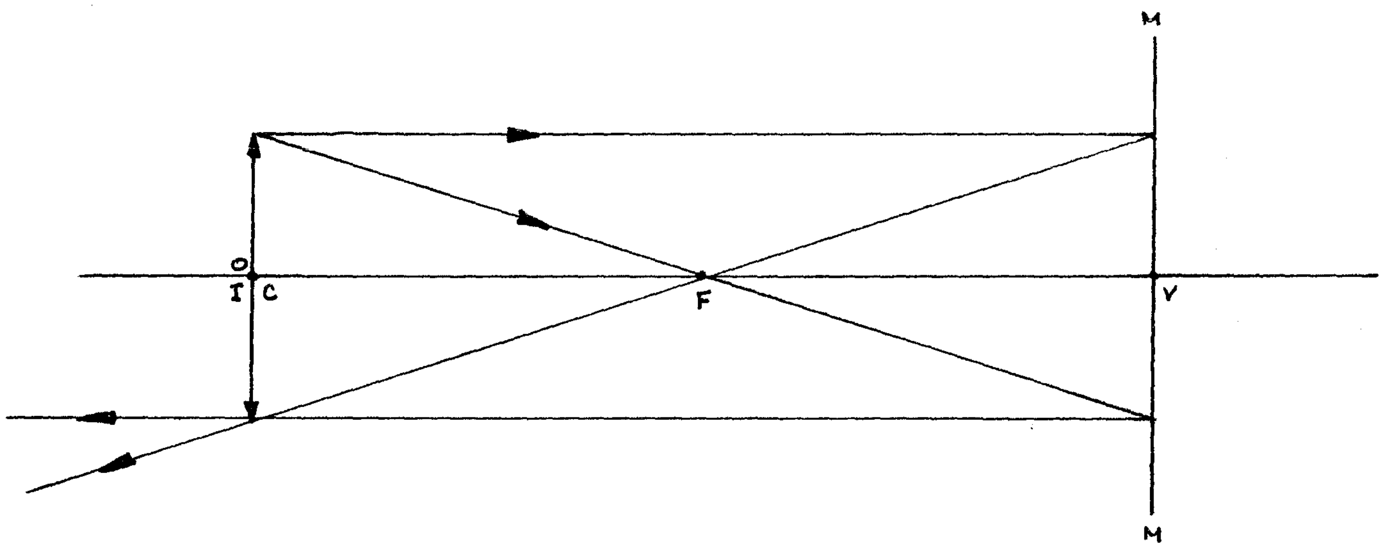
$d_i = d_o$ ("the image distance equals the object distance")

a. Since $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \longrightarrow \frac{1}{d_o} + \frac{1}{d_o} = \frac{2}{d_o} = \frac{1}{R/2} = \frac{2}{R}$

$\therefore \frac{2}{d_o} = \frac{2}{R} \longrightarrow d_o = \boxed{R}$

b. Since $m = \frac{-d_i}{d_o}$ and $d_i = d_o \longrightarrow m = \frac{-d_o}{d_o} = \boxed{-1}$

c. Since m is negative, the image is $\boxed{\text{inverted}}$



$\boxed{25.23}$

$d_i = -12.0\text{ cm}$ (negative because it's behind the mirror)
$d_o = \infty$ (assumed)

Since $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ and $d_o = \infty$,

$\frac{1}{d_i} = \frac{1}{f} \longrightarrow d_i = f = -12.0\text{ cm}.$

and since $f = R/2 \longrightarrow R = 2f = \boxed{-24.0\text{ cm}.}$

Therefore this is a $\boxed{\text{convex mirror}}$ because the center of curvature is behind the mirror.

$\boxed{25.35}$

$f = 42\text{ cm}$ (concave mirrors have positive focal lengths)
$d_i = 97\text{ cm}$. (this is positive because the image is in front of the mirror.)
$d_o = ?$

Since $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \longrightarrow \frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i}$ #1

You can substitute the values for f and d_i given above into eq #1 and solve for $1/d_o$; and then invert this value to get d_o.

An alternative approach to eq #1 is to rearrange it in a way similar to that shown in problem 25.16:

$$\frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = \frac{d_i - f}{d_i f}$$

$$\therefore\ d_o = \frac{d_i f}{d_i - f} = \frac{(97\text{cm})(42\text{cm})}{55\text{cm.}} = \boxed{74\text{ cm}}$$