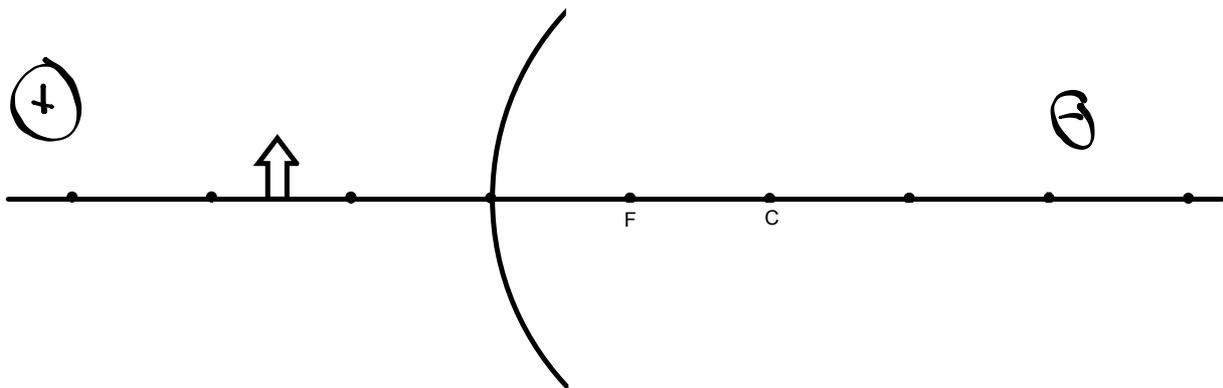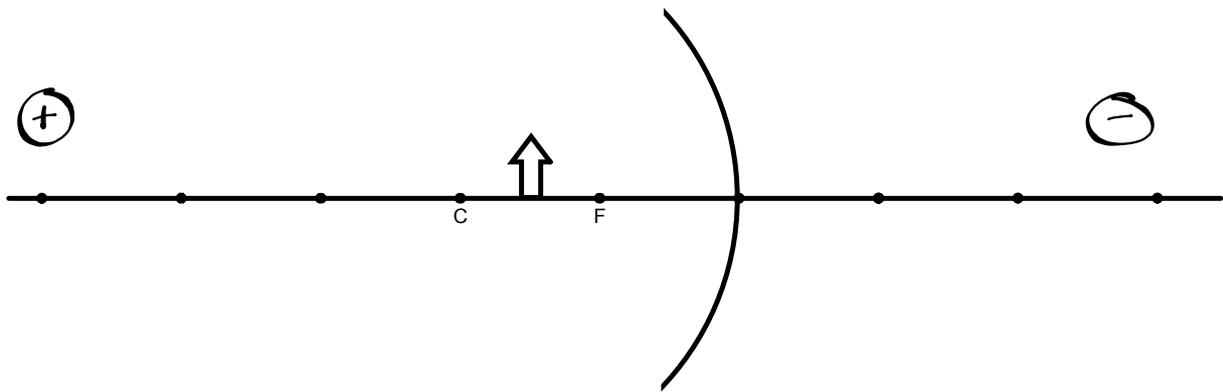# *L04 – Mirror Equations*

Symbols:
- h_0 is the height of the object
- h_i is the height of the image
- d_0 is the distance of the object
- d_i is the distance of the image

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

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

Sign convention (ours... not the Interwebs):
- Real images have positive distances (virtual negative)
- Erect (positive height), Inverted (negative height)
- Erect (positive magnification), Inverted (negative magnification)
- Concave (focal length positive)
- Convex (focal length negative)
- Objects *always* have a positive distance

Q1: An object is located 20.0 cm from a converging mirror that has a focal length of 15.0 cm.

a) Draw the ray diagram.

Enlarged
Inverted
Real

$d_i \approx 50$ cm
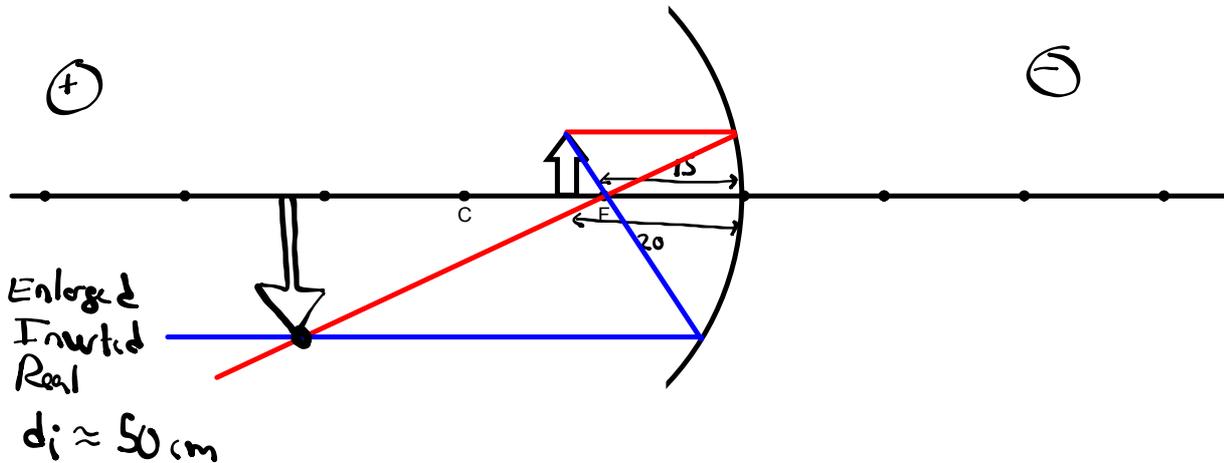
b) Where will the image form relative to the mirror vertex?

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

$$\frac{1}{15} = \frac{1}{20} + \frac{1}{d_i}$$

$$-\frac{1}{20} \quad -\frac{1}{20}$$

$$\frac{1}{15} - \frac{1}{20} = \frac{1}{d_i}$$

$$0.01\overline{6} = \frac{1}{d_i}$$

$$d_i = \frac{1}{0.01\overline{6}} = 60 \text{ cm}$$

c) If the object is 5.00 cm high, determine the attitude, height and magnification of the image.

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$h_o = 5$ cm

$$m = \frac{-60}{20}$$

$$m = -3$$

Inverted   3x bigger

$$m = \frac{h_i}{h_o}$$

$$-3 = \frac{h_i}{5}$$

$$h_i = -15 \text{ cm}$$

Inverted   Enlarged by 3x

.

If enlarged, $m = 2$ (m>1)
diminished, $m = 0.4$ (m<1)
If erect, $m = +2$ or $+0.4$
inverted, $m = -2$ or -0.4

Q2: A diverging mirror of focal length 10.0 cm produces an image of an object located 20.0 cm from the mirror. Determine the image distance and the magnification. Is the image real or virtual?

Erect
Diminished
Virtual

$\ominus$

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

F   C

Guess

$d_i \approx -7cm$
$M \approx +0.3$

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$d_o = +20$
$f = -10$

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

$$\frac{1}{-10} = \frac{1}{20} + \frac{1}{d_i}$$

$$\frac{1}{-10} - \frac{1}{20} = \frac{1}{d_i}$$

$$-0.15 = \frac{1}{d_i}$$

$$d_i = \frac{1}{-0.15}$$

$$d_i = -6.6 \, cm$$

Virtual

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$m = \frac{-d_i}{d_o} = \frac{-(-6.\overline{6})}{20}$$

$$\boxed{m = +0.\overline{3}}$$

Erect   Diminished

Use the following information to answer Q3 to Q5.

A convex mirror has a focal point 8cm away from the vertex. An object that is 10cm tall is placed 12cm from the vertex.
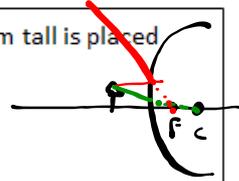
Image Characteristics

1 – Real   ③ Erect   5 – Enlarged

② Virtual   4 – Inverted   ⑥ Diminished

Q3: Using the **Image Characteristics** above, the image can best be described as:

Type: __2__   Attitude: __3__   Magnification: __6__

*(Record your **three-digit** answer in the numerical response boxes below.)*

| 2 | 3 | 6 | |

Q4: How far from the vertex is the image located, in centimeters?

*(Record your **three-digit** answer in the numerical response boxes below.)*

| 4 | . | 8 | 0 |

$$f = -8$$
$$d_o = 12$$
$$h_o = 10$$

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

$$\frac{1}{-8} = \frac{1}{12} + \frac{1}{d_i}$$

$$-0.208\overline{3} = \frac{1}{d_i}$$

$$\boxed{d_i = -4.80 cm}$$

Q5: What is the height of the image, in centimeters?

*(Record your **three-digit** answer in the numerical response boxes below.)*

| 4 | . | 0 | 0 |

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$\frac{h_i}{10} = \frac{-(-4.80)}{12}$$

$$\boxed{h_i = +4.00 cm}$$

Use the following information to answer Q6 to Q8.

A convex mirror has a focal point 8cm away from the vertex. An object that is 7cm tall is placed 6cm from the vertex.

Image Characteristics

1 – Real	③ Erect	5 – Enlarged
② Virtual	4 – Inverted	⑥ Diminished

Q6: Using the **Image Characteristics** above, the image can best be described as:

Type: _____   Attitude: _____   Magnification: _____

(Record your three-digit answer in the numerical response boxes below.)

2	3	6	

Q7: How far from the vertex is the image located, in centimeters?

(Record your three-digit answer in the numerical response boxes below.)

3	.	4	3

$$f = -8$$
$$d_o = +6$$

$$d_i = -3.42857\ldots$$

$$\boxed{d_i \approx -3.43 \text{cm}}$$

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

$$\frac{1}{-8} = \frac{1}{6} + \frac{1}{d_i}$$

Q8: What is the height of the image, in centimeters?

(Record your three-digit answer in the numerical response boxes below.)

4	.	0	0

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$\frac{h_i}{7} = \frac{-(-3.42857\ldots)}{6}$$

$$\boxed{h_i = 4.00 \text{ cm}}$$