# Mirror and Magnification Equations

# Mirror and Magnification Equations

- The characteristics of an image can be predicted by using two equations:
  - **Mirror Equation:**
    - Allows us to determine the **focal point**, **distance of the image**, or **the distance of the object**
    - Must know two of the three variables in order to solve the third
  - **Magnification Equation:**
    - Allows us to determine the **height of the object** or the **height of the image**.
    - This equation is usually used following the mirror equation

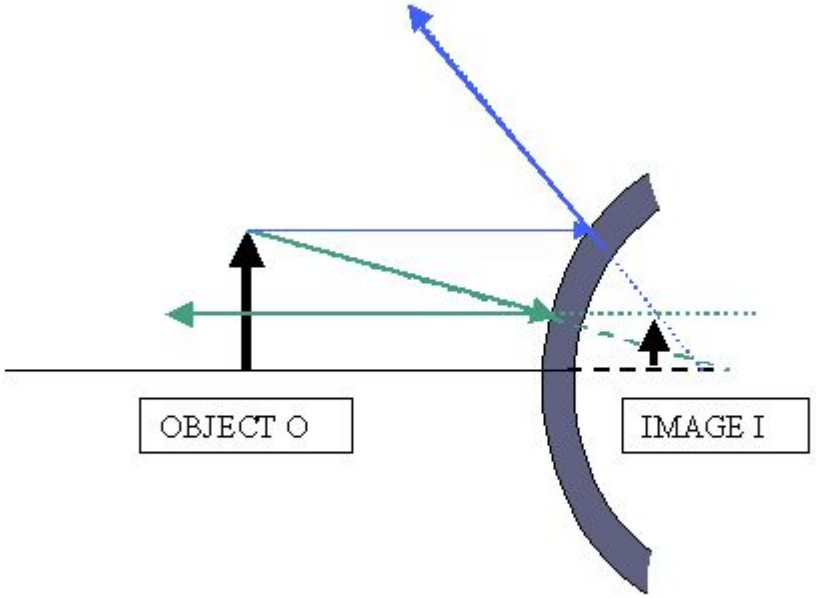
# Mirror Equation

- The mirror equation is seen below
  - $d_o$ represents the distance of the **object**
  - $d_i$ represents the distance of the **image**
  - $f$ represents **focal length**

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

# Mirror Equation

- **If the image distance $d_i$ is negative, then the image is behind the mirror (a virtual image)**




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

# Positive or Negative

Be sure to follow these sign conventions when using curved mirror equations:

| | Sign | |
|---|---|---|
| **Quantity** | **Positive (+)** | **Negative (-)** |
| Focal length *f* | Concave mirror | Convex mirror |
| Object distance $d_o$ | Real object | n/a |
| Image distance $d_i$ | Real image | Virtual image |
| Magnification *m* | Upright image | Inverted image |

- **Example 1:** A concave mirror has a focal length of 12 cm. An object with a height of 2.5 cm is placed 40.0 cm in front of the mirror. Calculate the image distance using GRASP. Is the image in front of the mirror or behind? How do you know?

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- **Given:**
  $f = 12$ cm
  $h_o = 2.5$ cm
  $d_o = 40.0$ cm

- **Required:**
  $d_i = ?$

- **Analysis:**

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

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

- **Example 1:** A concave mirror has a focal length of 12 cm. An object with a height of 2.5 cm is placed 40.0 cm in front of the mirror. Calculate the image distance. Is the image in front of the mirror or behind? How do you know?

- Use GRASP …
- **Given:**
  $f = 12$ cm
  $h_o = 2.5$ cm
  $d_o = 40.0$ cm
- **Required:**
  $d_i = ?$
- **Analysis:**

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

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

**Solution:**

$$\frac{1}{d_i} = \frac{1}{12\text{cm}} - \frac{1}{40.0\text{cm}}$$

$$\frac{1}{d_i} = \frac{10}{120\text{cm}} - \frac{3}{120\text{cm}}$$

$$\frac{1}{d_i} = \frac{7}{120\text{ cm}}$$

$$d_i = \frac{120\text{ cm}}{7}$$

$$d_i = 17.14\text{ cm}$$

$$d_i = 17\text{ cm}$$

**Paraphrase**

The image is 17 cm from the mirror. The sign is positive so the image is in front of the mirror.

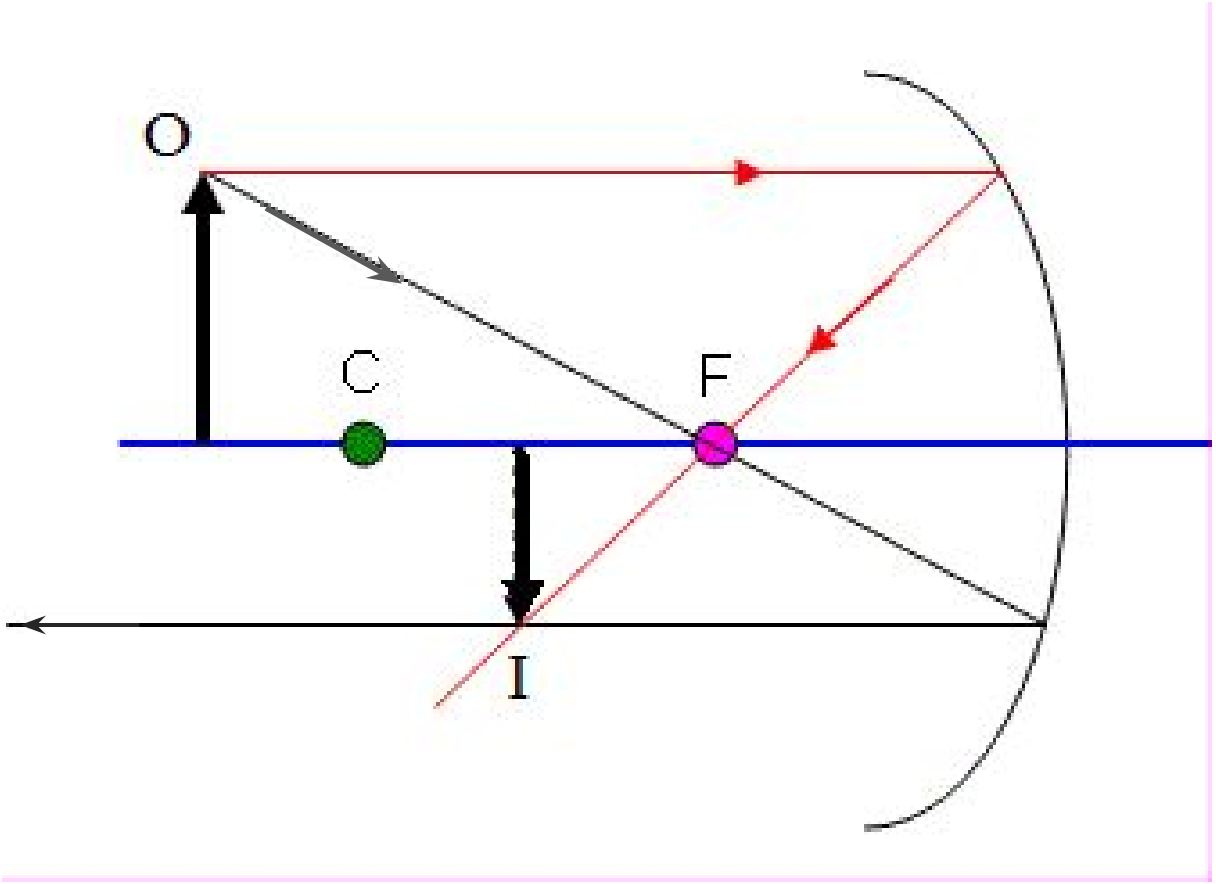
# Magnification Equation

- The magnification (m) tells you **the size**, or **height** of the image relative to the object, using object and image distances.
  - Therefore, in order to use this equation the **distance** of the object and image must be known.

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

# Magnification Equation

- If the image height $h_i$ is negative, the image is inverted relative to the object.



- **Example 2:** A concave mirror has a focal length of 12 cm. An object with a height of 2.5 cm is placed 40.0 cm in front of the mirror. The image distance has been calculated to be 17.14 cm. What is the height of the image? Is the image inverted? Explain.

- **Example 2:** A concave mirror has a focal length of 12 cm. An object with a height of 2.5 cm is placed 40.0 cm in front of the mirror. The image distance has been calculated to be 17.14 cm. What is the height of the image? Is the image inverted? Explain.

- Use GRASP …
- **Given:**

  $f = 12$ cm

  $h_o = 2.5$ cm

  $d_o = 40.0$ cm

  $d_i = 17.14$ cm

- **Required:**

  $h_i = ?$

- **Analysis:**

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

- **Example 2:** A concave mirror has a focal length of 12 cm. An object with a height of 2.5 cm is placed 40.0 cm in front of the mirror. The image distance has been calculated to be 17.14 cm. What is the height of the image? Is the image inverted? Explain.

- Use GRASP …
- **Given:**
  $f = 12$ cm
  $h_o = 2.5$ cm
  $d_o = 40.0$ cm
  $d_i = 17.14$ cm

- **Required:**
  $h_i = ?$

- **Analysis:**
  $$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

**Solution:**

$$\frac{h_i}{2.5\text{ cm}} = \frac{-17.14\text{ cm}}{40.0\text{cm}}$$

$$h_i = \frac{(-17.14\text{ cm})(2.5\text{ cm})}{40.0\text{cm}}$$

$$h_i = -1.07\text{ cm}$$

$$h_i = -1.1\text{ cm}$$

**Paraphrase**

The height of the image is 1.1 cm. The sign is negative , so the image is inverted.

- **Example 3:** A convex surveillance mirror in a convenience store has a focal length of -0.40 m. A customer, who is 1.7 m tall, is standing 4.5 m in front of the mirror.
  - a) Calculate the image distance.
  - b) Calculate the image height.

Answers:
$d_i$ = -0.37 m
$h_i$ = 0.14 m