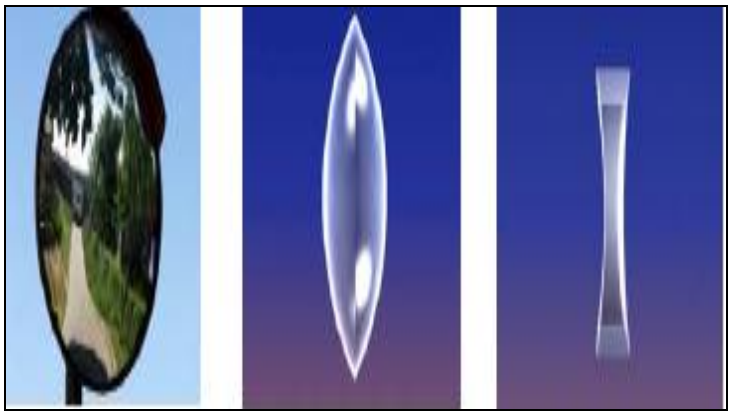
Kirkuk University

Science College

Physics Department

Lectures of GEOMETRIC OPTICS Lecture – 4 –



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Lecture 4: Examples for Concave Mirrors

Example: A ($h_o = 4cm$) tall light bulb is placed a distance of ($d_o = 45.7cm$) from a concave mirror having a focal length of ($f = 15.2cm$). Determine the image distance ($d_i = ?$) and the image size ($h_i = ?$)**?**

Solution:

Like all problems in physics, begin by the identification of the known information**.**

$$h_\circ = 4cm,\ d_\circ = 45.7cm,\ f = 15.2cm$$

Next identify the unknown quantities that you wish to solve for**.**

$$d_i = ?,\ h_i = ?$$

To determine the image distance, the mirror equation must be used**.**

The following lines represent the solution to the image distance; substitutions and algebraic steps are shown**.**

$$\mathbf{1/f = 1/do + 1/d_i}$$

$$1/(15.2\text{ cm}) = 1/(45.7\text{ cm}) + 1/d_i$$

$$0.0658\text{ cm}^{-1} = 0.0219\text{ cm}^{-1} + 1/d_i$$

$$0.0439\text{ cm}^{-1} = 1/d_i$$

$$\mathbf{d_i = 22.8\text{ cm}}$$

The positive value of image distance indicates that the image is a real image and located on the object's side of the mirror**.**

To determine the image height, the magnification equation is needed**.** Since three of the four quantities in the equation (disregarding the **M**) are known, the fourth quantity can be calculated**.**

The solution is shown below**.**

$$\mathbf{h_i/h_o = - d_i/d_o}$$

$$h_i/(4\ cm) = -(22.8\ cm)/(45.7\ cm)$$

$$h_i = -(4\ cm) \bullet (22.8\ cm)/(45.7\ cm)$$

$$\mathbf{h_i = -1.99\ cm}$$

The negative values for image height indicate that the image is an inverted image**.**

As is often the case in physics, a negative or positive sign in front of the numerical value for a physical quantity represents information about direction**.**

In the case of the image height, a negative value always indicates an inverted image**.**

From the calculations in this problem it can be concluded that if a ($h_o = 4cm$) tall object is placed ($d_o = 45.7cm$) from a concave mirror having a focal length of ($f = 15.2cm$), then the image will be **real**, **located** ($d_i = 22.8cm$) on the object's side of the mirror, **inverted**, ($h_i = 1.99cm$) **tall.**

In this case, the object is located *beyond* the center of curvature (which would be two focal lengths from the mirror), and the image is located between the center of curvature and the focal point**.**

This falls into the category of **Case 1**: The object is located beyond **C.**

Now let's try a second example problem**:**

Example: A ($h_o = 4cm$) tall light bulb is placed a distance of ($d_o = 8.3cm$) from a concave mirror having a focal length of ($f = 15.2cm$)**.** (**NOTE**: this is the same object and the same mirror, only this time the object is placed closer to the mirror.) Determine the image distance and the image size**?**

Solution:

Again, begin by the identification of the known information**.**

$$h_\circ = 4cm\,,\ d_\circ = 3.8cm\,,\ f = 15.2cm$$

Next identify the unknown quantities that you wish to solve for**.**

$$d_i = ?\,,\ h_i = ?$$

To determine the image distance, the mirror equation will have to be used**.**

The following lines represent the solution to the image distance; substitutions and algebraic steps are shown**.**

$$\mathbf{1/f = 1/do + 1/d_i}$$

$$1/(15.2\ cm) = 1/(8.3\ cm) + 1/d_i$$

$$0.0658\ cm^{-1} = 0.1205\ cm^{-1} + 1/d_i$$

$$-0.0547\ cm^{-1} = 1/d_i$$

$$\mathbf{d_i = -18.3\ cm}$$

The negative value for image distance indicates that the image is a virtual image located behind the mirror**.**

In the case of the image distance, a negative value always means behind the mirror**.**

To determine the image height, the magnification equation is needed**.** Since three of the four quantities in the equation (disregarding the **M**) are known, the fourth quantity can be calculated**.**

The solution is shown below**.**

$$\mathbf{h_i/h_o = - d_i/d_o}$$

$$h_i/(4.0\ cm) = -\ (-18.3\ cm)/(8.3\ cm)$$

$$h_i = -\ (4.0\ cm) \bullet (-18.3\ cm)/(8.3\ cm)$$

$$\mathbf{h_i = 8.8\ cm}$$

Note also that the image height is a positive value, meaning an upright image**.**

Any image that is upright and located behind the mirror is considered to be a virtual image**.**

From the calculations in the second example problem it can be concluded that if a ($h_o = 4cm$) tall object is placed ($d_o = 8.3cm$) from a concave mirror having a focal length of ($f = 15.2cm$), then the image will be **virtual**, **located** ($d_i = 18.3cm$) behind the mirror, **upright** and ($h_i = 8.8cm$) **tall.**

In this case, the object is located in front of the focal point (i.e., the object distance is less than the focal length), and the image is located behind the mirror**.**

This falls into the category of **Case 5**: The object is located in front of **F.**

Concave Mirrors

H.W: If an object of height ($h_o = 4cm$) is placed at distance of ($d_o = 12cm$) from a concave mirror having focal length ($f = 24cm$).

Find:-

1- The position of the image ($d_i = ?$)**? Answer:** ($d_i = -24.04cm$)

2- The height of the image ($h_i = ?$)**? Answer:** ($h_i = 8.01cm$)

3- The magnification of the image ($M = ?$)**? Answer:** ($M = 2.003$)

4- The nature of the image ($L.O.S.T$)**?**

5- The radius of curvature of the mirror ($R = ?$)**? Answer:** ($R = 48cm$)

H.W: An object of ($h_o = 5cm$) height is placed at a distance of ($d_o = 15cm$) from a concave mirror, if the focal length of the mirror is ($f = 10cm$).

Find:-

1- The position of the image ($d_i = ?$)**? Answer:** ($d_i = 30.03cm$)

2- The height of the image ($h_i = ?$)**? Answer:** ($h_i = -10.01cm$)

3- The magnification of the image ($M = ?$)**? Answer:** ($M = -2.002$)

4- The nature of the image ($L.O.S.T$)**?**

5- The radius of curvature of the mirror ($R = ?$)**? Answer:** ($R = 20cm$)

H.W: An object of ($h_o = 6cm$) height is placed at a distance of ($d_o = 30cm$) from a concave mirror of focal length ($f = 10cm$).

Find:

1- The position of the image ($d_i = ?$)**? Answer:** ($d_i = 14.925cm$)

2- The height of the image ($h_i = ?$)**? Answer:** ($h_i = -12.060cm$)

3- The magnification of the image ($M = ?$)**? Answer:** ($M = -0.498$)

4- The nature of the image ($L.O.S.T$)**?**

5- The radius of curvature of the mirror ($R = ?$)**? Answer:** ($R = 20cm$)