Kirkuk University

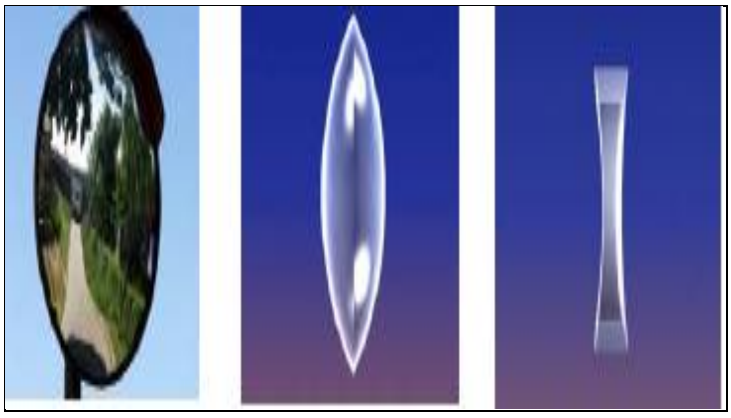
Science College

Physics Department

Lectures of

GEOMETRIC OPTICS

Lecture – 13 –



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Lecture 13: Examples for Converging (double convex) Lens

Example: A ($h_\circ = 4cm$) tall light bulb is placed a distance of ($d_\circ = 45.7cm$) from a double convex lens 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 unknown information**.**

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

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

$d_i = ?$ $\quad$ $h_i = ?$

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

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

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

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

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

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

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

The positive value of image distance indicates that the image is a real image and located on the other side of the lens**.**

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 ($h_\circ = 4cm$) tall object is placed ($d_\circ = 45.7cm$) from a double convex lens having a focal length of ($f = 15.2cm$), then the image will be real, located ($d_i = 22.8cm$) on the other side of the lens, inverted,($h_i = 1.99cm$) tall**.**

In this case, the object is located *beyond the* **2F** point (which would be two focal lengths from the lens) and the image is located between the **2F** point and the focal point **F.**

This falls into the category of **Case 1:** The object is located beyond **2F**, for a converging lens**.**

Now lets try a second sample problem**:**

Example: A ($h_\circ = 4cm$) tall light bulb is placed a distance of ($d_\circ = 8.3cm$) from a double convex lens having a focal length of ($f = 15.2cm$)**.** (**NOTE**: this is the same object and the same lens, only this time the object is placed closer to the lens.) Determine the image distance ($d_i = ?$) and the image size ($h_i = ?$)**?**

Solution:

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

$$h_\circ = 4cm \qquad d_\circ = 8.3cm \qquad f = 15.2cm$$

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

$$d_i = ? \qquad h_i = ?$$

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

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

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

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

$$0.0658\ cm^{-1} = 0.120\ cm^{-1} + 1/d_i$$

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

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

The negative value for image distance indicates that the image is a virtual image located on the object's side of the lens**.**

In the case of the image distance, a negative value always means the image is located on the object's side of the lens**.**

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**.**

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

$$h_i/(4.0\ cm) = - (-18.2\ cm)/(8.3\ cm)$$

$$h_i = - (4.0\ cm) \bullet (-18.2\ cm)/(8.3\ cm)$$

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

Note also that the image height is a positive value, meaning an upright image**.** Any image that is upright and located on the object's side of the lens is considered to be a virtual image**.**

From the calculations in the second example problem it can be concluded that if a ($h_\circ = 4cm$) tall object is placed ($d_\circ = 8.3cm$) from a double convex lens having a focal length of ($f = 15.2cm$), then the image will be virtual , located ($d_i = 18.3cm$) from the lens on the object's side , upright and ($h_\circ = 8.8cm$) 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 on the object's side of the lens**.**

This falls into the category of **Case 5:** The object is located in front of **F** (for a converging lens)**.**

Converging (double convex) Lens

H.W: An object of height ($h_o = 4cm$) is placed at ($d_o = 30cm$) in front of a convex lens of focal length ($f = 20cm$). Find:

1- The position of the image ($d_i = ?$)**? Answer :** ($d_i = 50cm$)

2- The height of the image ($h_i = ?$)**? Answer :** ($h_i = -6.67cm$)

3- The magnification of the image ($M = ?$)**? Answer :** ($M = -1.67$)

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

H.W: An object of height ($h_o = 5cm$) is placed perpendicular to the principal axis of a convex lens of focal length ($f = 10cm$) at a distance of ($d_o = 20cm$) from the lens. Find:

1- The position of the image ($d_i = ?$)**? Answer :** ($d_i = 20cm$)

2- The height of the image ($h_i = ?$)**? Answer :** ($h_i = -5cm$)

3- The magnification of the image ($M = ?$)**? Answer :** ($M = -1$)

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

H.W: An object is of ($h_o = 6cm$) height placed ($d_o = 10cm$) from a ($f = 15cm$) focal length converging lens. Determine:

1- The position of the image ($d_i = ?$)**? Answer :** ($d_i = -33.33cm$)

2- The height of the image ($h_i = ?$)**? Answer :** ($h_i = -20cm$)

3- The magnification of the image ($M = ?$)**? Answer :** ($M = -3.3$)

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