PHYSICS 534

ANSWERS

EXERCISE-49 Curved Mirrors Part-2 /2

Percy Bridgman was awarded the Nobel prize for physics in 1946 for his work on high pressure physics.

BRIDGMAN

The ***mirror equation*** is a geometrical derivation for solving problems with curved mirrors.

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

where: f = focal length (in metres)
d_o = Object distance (in metres)
d_i = Image distance (in metres)

and

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

where: M = magnification factor (no units)
h_i = height of image (in metres)
h_o = height of object (in metres)

Be sure to observe the following sign conventions when using this formula:

① All distances are measured from the vertex of a curved mirror.

② Distances of objects and ***real*** images are positive.

③ Distances of virtual images are negative.

④ Object and image heights are positive when upright and negative when inverted.

Parabolic mirrors are used as reflectors for searchlights, flashlights, projectors and automobile headlights.

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1. An object is 60 cm from a ***converging*** mirror whose radius of curvature is 30 cm. Determine the characteristics of the image.

$d_o = 60\text{ cm} \quad f = 15\text{ cm}$

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

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{15\text{ cm}} - \frac{1}{60\text{ cm}} \quad \therefore d_i = 20\text{ cm}$$

$$M = \frac{-d_i}{d_o} = \frac{-(20\text{ cm})}{60\text{ cm}} = -0.33$$

Type: Real
(real or virtual)

Location: 20 cm in front of mirror

Magnification: –0.33 (Reduced image)

Attitude: Inverted
(upright or inverted)

2. An object is 25 cm from a ***concave*** mirror whose focal length is 15 cm. Determine the characteristics of the image.

$d_o = 25\text{ cm} \quad f = 15\text{ cm}$

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

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{15\text{ cm}} - \frac{1}{25\text{ cm}} \quad \therefore d_i = 37.5\text{ cm}$$

$$M = \frac{-d_i}{d_o} = \frac{-(37.5\text{ cm})}{25\text{ cm}} = -1.5$$

Type: Real
(real or virtual)

Location: 37.5 cm in front of mirror

Magnification: –1.5 (Magnified image)

Attitude: Inverted
(upright or inverted)

3. An object is placed 7.5 cm from a ***concave*** mirror that has a focal length of 15 cm. Determine the characteristics of the image.

$d_o = 7.5\text{ cm} \quad f = 15\text{ cm}$

$\because \dfrac{1}{f} = \dfrac{1}{d_o} + \dfrac{1}{d_i}$

$\dfrac{1}{d_i} = \dfrac{1}{f} - \dfrac{1}{d_o} = \dfrac{1}{15\text{ cm}} - \dfrac{1}{7.5\text{ cm}} \quad \therefore d_i = -15\text{ cm}$

$M = \dfrac{-d_i}{d_o} = \dfrac{-(-15\text{ cm})}{7.5\text{ cm}} = 2$

[illegible]

Type: **Virtual**
(real or virtual)

Location: **15 cm behind mirror**

Magnification: **2 (Magnified image)**

Attitude: **Upright**
(upright or inverted)

4. A ***converging*** mirror has a focal length of 15 cm. Where would you place an object in front of this mirror in order to produce an upright, virtual image, ***twice*** as tall as the object? [7.5 cm]

$f = 15\text{ cm}$

$d_o = ?$

$h_i = 2h_o$

$M = 2$

$\because M = \dfrac{-d_i}{d_o}$

or $d_o = \dfrac{-d_i}{M} = \dfrac{-d_i}{2}$

$\therefore d_i = -2d_o$

$\because \dfrac{1}{f} = \dfrac{1}{d_o} + \dfrac{1}{d_i} = \dfrac{1}{d_o} + \dfrac{1}{-2d_o} = \dfrac{1}{d_o} - \dfrac{1}{2d_o} = \dfrac{1}{2d_o}$

$\because$ Since $\dfrac{1}{f} = \dfrac{1}{2d_o}$

$\therefore d_o = \dfrac{f}{2} = \dfrac{15\text{ cm}}{2} = 7.5\text{ cm}$

5. What is the focal length of a ***concave*** mirror when an object that is placed 2 cm in front of the mirror produces an image that is seen 5 cm behind the mirror? [3.3 cm]

$f = ?$

$d_o = 2\text{ cm}$

$d_i = -5\text{ cm}$

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

$= \dfrac{1}{2\text{ cm}} + \dfrac{1}{-5\text{ cm}}$

$= \dfrac{5-2}{10\text{ cm}}$

$= \dfrac{3}{10\text{ cm}}$

Thus: $f = \dfrac{10\text{ cm}}{3} = 3.3\text{ cm}$

6. A ***concave*** mirror has a focal length of 30 cm. A square object, 4 cm per edge, is situated with its center 10 cm in front of the mirror. Determine:

a) The position (center) of the image. [-15 cm]

$$f = 30 \text{ cm}$$
$$d_o = 10 \text{ cm}$$
$$d_i = ?$$

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

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

$$\frac{1}{30 \text{ cm}} - \frac{1}{10 \text{ cm}}$$

Thus: $d_i = -15 \text{ cm}$

b) The area of the image. [36 cm^2]

$$h_i = ?$$
$$h_o = 4 \text{ cm}$$
$$d_o = 10 \text{ cm}$$
$$d_i = -15 \text{ cm}$$

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

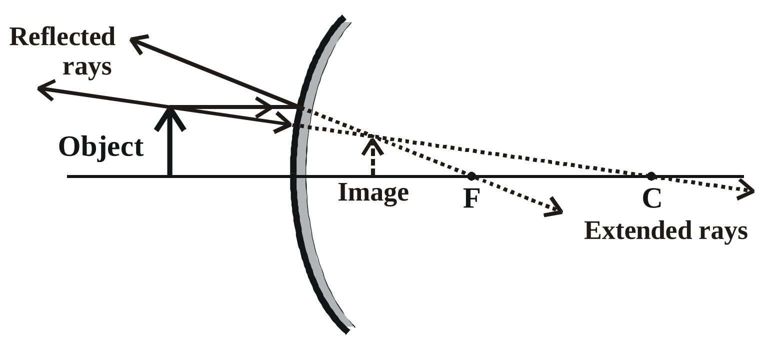
Thus: $h_i = \frac{-d_i h_o}{d_o}$

$$= \frac{-(-15 \text{ cm})(4 \text{ cm})}{10 \text{ cm}}$$

$$= 6 \text{ cm}$$

Answer: $6 \text{ cm} \times 6 \text{ cm} = 36 \text{ cm}^2$

7. Illustrated below is an object situated in front of a ***convex*** mirror. Graphically, find the image and state its characteristics.



The image is virtual, upright, reduced and located behind the mirror.

8. An object is placed 10 cm in front of a ***convex*** mirror whose focal length is 15 cm. Determine the characteristics of the image.

$f = 15\text{ cm}$
$d_o = 10\text{ cm}$
$d_i = ?$
$M = ?$

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

Thus: $$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{15\text{ cm}} - \frac{1}{10\text{ cm}}$$

$$d_i = -30\text{ cm}$$

$$M = \frac{-d_i}{d_o} = \frac{-(-30\text{ cm})}{10\text{ cm}} = 3$$

The image is virtual (since d_i is negative), upright (since M is positive), three times larger than the object (since M = 3) and located behind mirror.

9. When an object is 30 cm in front of a ***concave*** mirror, its image is real and situated 15 cm from the mirror. Determine the location of the image if the object is placed 6.0 cm from the mirror. [15 cm]

$d_o = 30\text{ cm}$
$d_i = 15\text{ cm}$
$f = ?$

Since: $$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{30\text{ cm}} + \frac{1}{15\text{ cm}}$$

Thus: $f = 10\text{ cm}$

$d_o = 6.0\text{ cm}$
$d_i = ?$
$f = 10\text{ cm}$

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

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{10\text{ cm}} - \frac{1}{6\text{ cm}}$$

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

10. Fill in the four (4) missing quantities:

MIRROR TYPE	FOCAL LENGTH	OBJECT DISTANCE	IMAGE DISTANCE	OBJECT HEIGHT	IMAGE HEIGHT
Concave	**4 cm**	① 3 cm	**-12 cm**	**2 cm**	② **8 cm**
Convex	③ **23.3 cm**	**10 cm**	**-7 cm**	**1 cm**	④ **0.7 cm**

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