CH # 13 RECTILINEAR PROPAGATION OF LIGHT

Some important formulae:

$i)\ \frac{1}{f} = \frac{1}{P} + \frac{1}{q} \qquad ii)\ M = \frac{q}{P} = \frac{hi}{ho} \qquad iii) f = \frac{R}{2}$

Nature of image:

If 'q' is +ve image will be REAL.

If 'q' is –ve image will be VIRTUAL.

Nature of mirror:

If 'f' is +ve given mirror is CONCAVE.

If 'f' is –ve given mirror is CONVEX.

13.1: An object is placed at a distance of 30cm from a concave mirror of focal length 5cm. If the object is 5cm is high, find the position and size of image.

GIVEN:

Object distance = P = 30cm

Focal length = f = 5cm

Size of object = h_o = 5cm

REQUIRED:

Position of image = q = ?

Size of image = hi = ?

SOLUTION:

By using mirror formula,

$$\frac{1}{f} = \frac{1}{P} + \frac{1}{q}$$

$$\frac{1}{5} = \frac{1}{30} + \frac{1}{q}$$

$$\frac{1}{5} - \frac{1}{30} = \frac{1}{q}$$

$$\frac{1}{q} = \frac{6-1}{30}$$

$$\frac{1}{q} = \frac{5}{30}$$

$$\frac{1}{q} = \frac{1}{6}$$

q = 6cm

We know that,

$$\frac{hi}{ho} = \frac{q}{P}$$

$$\frac{hi}{5} = \frac{6}{30}$$

$$hi = \frac{6}{30} \times 5$$

hi = 1cm

13.2: If an object is placed at a distance of 10cm from a spherical mirror and its virtual image is formed at a distance of 5cm from the mirror. Find the focal length and the nature of mirror.

GIVEN:

Object distance = P = 10cm

Image distance = q = -5cm (Virtual image)

REQUIRED:

Focal length = f = ?

SOLUTION:

By using mirror formula,

$$\frac{1}{f} = \frac{1}{P} + \frac{1}{q}$$

$$\frac{1}{f} = \frac{1}{10} + \frac{1}{(-5)}$$

$$\frac{1}{f} = \frac{1}{10} - \frac{1}{5}$$

$$\frac{1}{f} = \frac{1-2}{10}$$

$$\frac{1}{f} = -\frac{1}{10}$$

f = -10cm since f is –ve therefore given mirror is CONVEX MIRROR

13.3: An object is situated at a distance of 20cm from a concave mirror. Find the nature and the position of the image if the focal length of the mirror is 15cm.

GIVEN:

Object distance = P = 20cm

Focal length = f = 15cm

REQUIRED:

Image distance = q = ?

Nature of image = ?

SOLUTION:

By using mirror formula,

$$\frac{1}{f} = \frac{1}{P} + \frac{1}{q}$$

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

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

$$\frac{1}{q} = \frac{4-3}{60}$$

$$\frac{1}{q} = \frac{1}{60}$$

q = 60cm 'q' is positive therefore image is real.

Position of image is 60cm from the mirror.

13.4: An object is situated at a distance of 24.0cm from a concave mirror. The focal length of concave mirror is 6cm. Determine the size of the image and its distance from the mirror if the object is 12cm high.

GIVEN:

Object distance = P = 24cm

Focal length = f = 6cm

Size of object = h_o = 12cm

REQUIRED:

Image distance = q = ?

Size of image = hi = ?

SOLUTION:

By using mirror formula,

$$\frac{1}{f} = \frac{1}{P} + \frac{1}{q}$$

$$\frac{1}{6} = \frac{1}{24} + \frac{1}{q}$$

$$\frac{1}{6} - \frac{1}{24} = \frac{1}{q}$$

$$\frac{1}{q} = \frac{4-1}{24}$$

$$\frac{1}{q} = \frac{3}{24}$$

$$\frac{1}{q} = \frac{1}{8}$$

q = 8cm

We know that,

$$\frac{hi}{ho} = \frac{q}{P}$$

$$\frac{hi}{12} = \frac{8}{24}$$

$$hi = \frac{8}{24} \times 12$$

hi = 4cm

13.5: The focal length of concave mirror is 40cm. Where an object should be placed so as to gets its real image magnified twice.

GIVEN:

Focal length = f = 10cm

Magnification = M = 2

REQUIRED:

Object distance = P = ?

SOLUTION:

$$Magnification = M = \frac{q}{P}$$

$$M = \frac{q}{P}$$

$$2 = \frac{q}{P}$$

2P = q

By using mirror formula,

$$\frac{1}{f} = \frac{1}{P} + \frac{1}{q}$$

$$\frac{1}{10} = \frac{1}{P} + \frac{1}{2P}$$

$$\frac{1}{10} = \frac{2+1}{2P}$$

$$\frac{1}{10} = \frac{3}{2P}$$

2P = 3 x 10

2P = 30

$$P = \frac{30}{2}$$

P = 15cm

13.6: The radius of curvature of concave mirror is 40cm. where should an object be placed as to gets its real image magnified four times.

GIVEN:

Radius of curvature = R = 40cm

Magnification = M = 4

REQUIRED:

Object distance = P = ?

SOLUTION:

$f = \frac{R}{2}$

$f = \frac{40}{2}$

f = 20cm

$Magnification = M = \frac{q}{P}$

$M = \frac{q}{P}$

$4 = \frac{q}{P}$

4P = q

By using mirror formula,

$\frac{1}{20} = \frac{1}{P} + \frac{1}{4P}$

$\frac{1}{20} = \frac{4+1}{4P}$

$\frac{1}{20} = \frac{5}{4P}$

4P = 5 x 20

4P = 100

$P = \frac{100}{4}$

P = 25cm

13.7: An object is situated at a distance of 20cm from convex mirror of radius of curvature 20cm. Find the position and the nature of image.

GIVEN:

Object distance = P = 20cm

Radius of curvature = R = 20cm

REQUIRED:

Image distance = q = ?

Nature of image = ?

SOLUTION:

$f = \frac{R}{2}$

$f = \frac{20}{2}$

f = 10cm

f = -10cm (Since mirror is convex)

By using mirror formula,

$\frac{1}{f} = \frac{1}{P} + \frac{1}{q}$

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

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

$\frac{1}{q} = \frac{-2-1}{20}$

$\frac{1}{q} = -\frac{3}{20}$

$q = -\frac{20}{3}$

q = - 6.67 cm

q is negative therefore nature of image is VIRTUAL

13.8: Focal length of concave mirror is 10cm, if the object is situated at a distance of (i) 60cm (ii) 20cm (iii) 5cm from the mirror, find the distance of image in each case.

GIVEN:

Focal length = f = 10cm

i) P = 60cm

ii) P = 20cm

iii) P = 5cm

REQUIRED:

Image distance in each case = q = ?

SOLUTION:

By using mirror formula,

$i)\ \frac{1}{f} = \frac{1}{P} + \frac{1}{q}$

$\frac{1}{10} = \frac{1}{60} + \frac{1}{q}$

$\frac{1}{10} - \frac{1}{60} = \frac{1}{q}$

$\frac{1}{q} = \frac{6-1}{60}$

$\frac{1}{q} = \frac{5}{60}$

$\frac{1}{q} = \frac{1}{12}$

q = 12 cm

$ii)\ \frac{1}{f} = \frac{1}{P} + \frac{1}{q}$

$\frac{1}{10} = \frac{1}{20} + \frac{1}{q}$

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

$\frac{1}{q} = \frac{2-1}{20}$

$\frac{1}{q} = \frac{1}{20}$

q = 20 cm

$iii)\ \frac{1}{f} = \frac{1}{P} + \frac{1}{q}$

$\frac{1}{10} = \frac{1}{5} + \frac{1}{q}$

$\frac{1}{10} - \frac{1}{5} = \frac{1}{q}$

$\frac{1}{q} = \frac{1-2}{10}$

$\frac{1}{q} = -\frac{1}{10}$

q = -10 cm