Optic 7

The Newtonian Lens Equation

We have been using the "Gaussian Lens Formula;

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

An alternate lens formula is known as the Newtonian Lens Formula;

$X_1 X_2 = f^2$

Which can be verified by substituting;

$P = f + X_1$ & $q = f + X_2$

Into the Gaussian Lens Formula, Here, ***x_1*** and ***x_2*** are the distances to the object and image respectively from the focal points. (*f* is negative for a diverging lens)

$X_1 = p - f$ & $X_2 = q - f$

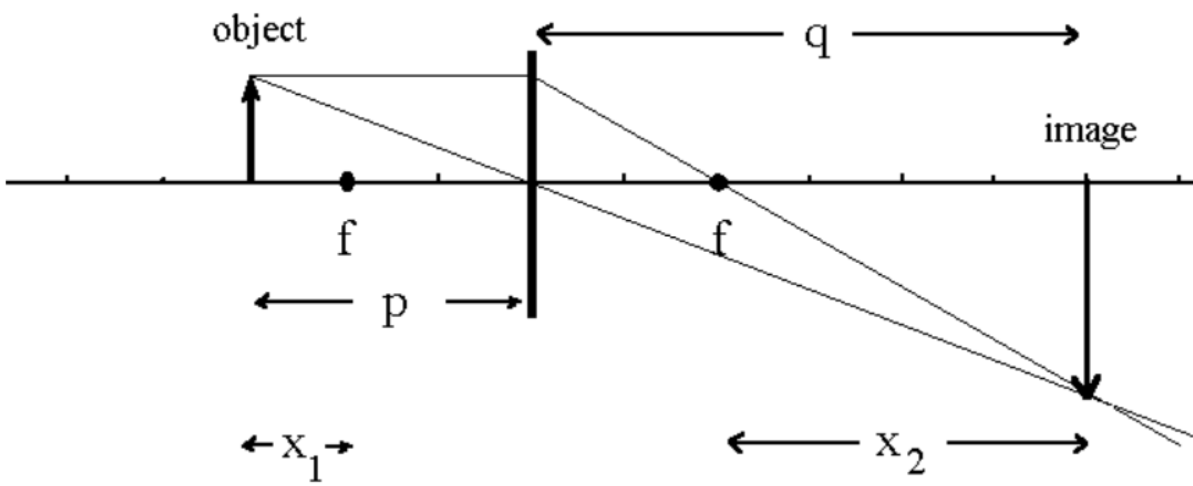


Figure 18. Gaussian &Newtonian Lens Equations Relation

Example1:

An object is 15 cm from a converging lens which has a focal length of 10 cm, where is the image?

$X_1 = p - f = 15 - 10 = 5$ cm

$X_2 = \frac{X1}{f2} = \frac{100}{5} = 20$cm

So the image is *(*10+20*) cm =* 30 *cm* to the right of the lens.

Example2:

An object is 15 cm from a diverging lens which has a focal length of -10 cm, where is the image?

$$X_1 = p\text{-}f = 15\text{-}(-10) = 25 \text{ cm}$$

$$X_2 = \frac{X1}{f2} = \frac{100}{25} = 4 \text{ cm}$$

So the image is ((-10) +4) cm = -6 cm to right of lens, which is 6 cm to left of lens

Lens maker's Equation

The lens maker's equation is another formula used for giving a relationship between the (focal length, refractive index and radii of curvature of the two spheres) used in the lens. Each face of a lens is part of a sphere where the thickness of the lens must be considered.

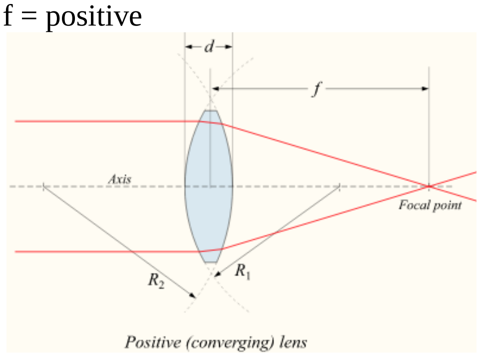
For a thin lens,

$$P = \frac{1}{f} = (n_{Lens} - 1)\left[\frac{1}{R1} - \frac{1}{R\,2}\right]$$

P is the power of the lens,
f is the focal length of the lens,
n is the refractive index of the lens material,
R_1 is the radius of curvature of the face closest to the object

R_2 is the radius of curvature of other face

For a Convex (converging) Lens
R1 = positive
R2 = negative
f = positive



For a Concave (diverging) Lens
R1 = negative
R2 = positive
f = negative

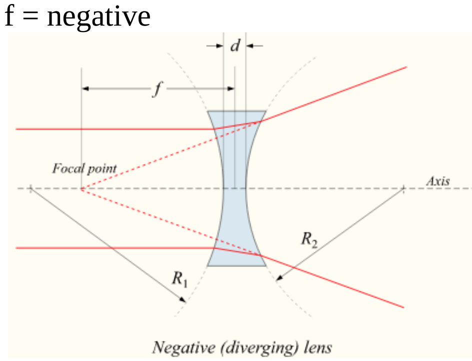


Figure 19. Thickness of the lens effect **Example:**

The refractive index of a lens is given as 1.5, two curved surfaces have radius of curvature 10cm and -15cm respectively. Calculate the focal length of the given lens?

n=1.50*,* R_1 =10 cm and R_2 = -15 cm Lens maker's formula is given as,

$$P=\frac{1}{f} = (n_{Lens} - 1)\left[\frac{1}{R1} - \frac{1}{R\,2}\right]$$

$$P=\frac{1}{f} =(1.5-1)\left[\frac{1}{10} + \frac{1}{15}\right] =$$

0.5x (0.1 + 0.0666) =

0.5 x 0.1666 =

0.0833

f = 1/0.0833=12cm