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)

$$x_1 = p - f$$

$$x_2 = q - f$$

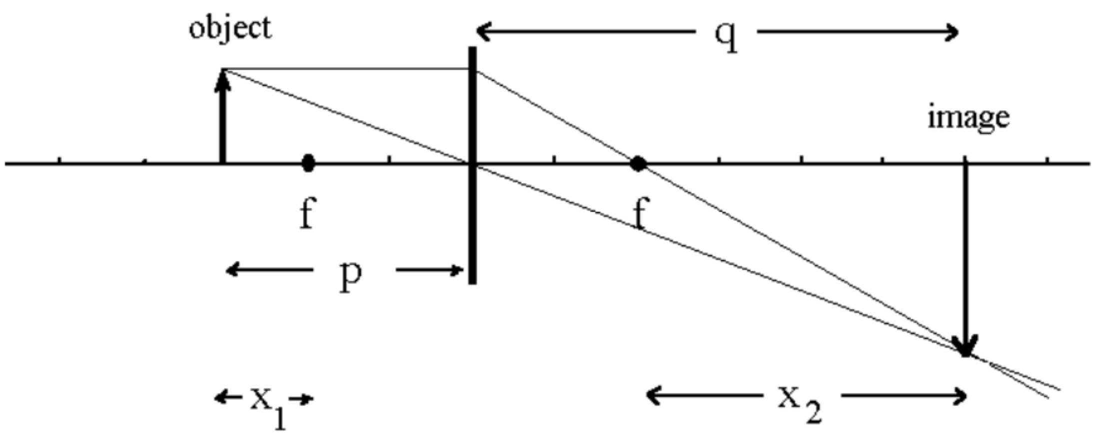

Figure 18. Gaussian &Newtonian Lens Equations Relation

Example1:

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

$$x_1 = p - f = 15 - 10 = 5\ cm$$

$$x_2 = \frac{f^2}{x_1} = \frac{100}{5} = 20cm$$

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?

$$x_1 = p - f = 15 - (-10) = 25\ cm$$

$$x_2 = \frac{f^2}{x_1} = \frac{100}{25} = 4cm$$

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,

$$p = \frac{1}{f} = (n_{Lens} - 1)[\frac{1}{R_1} - \frac{1}{R_2}]$$

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

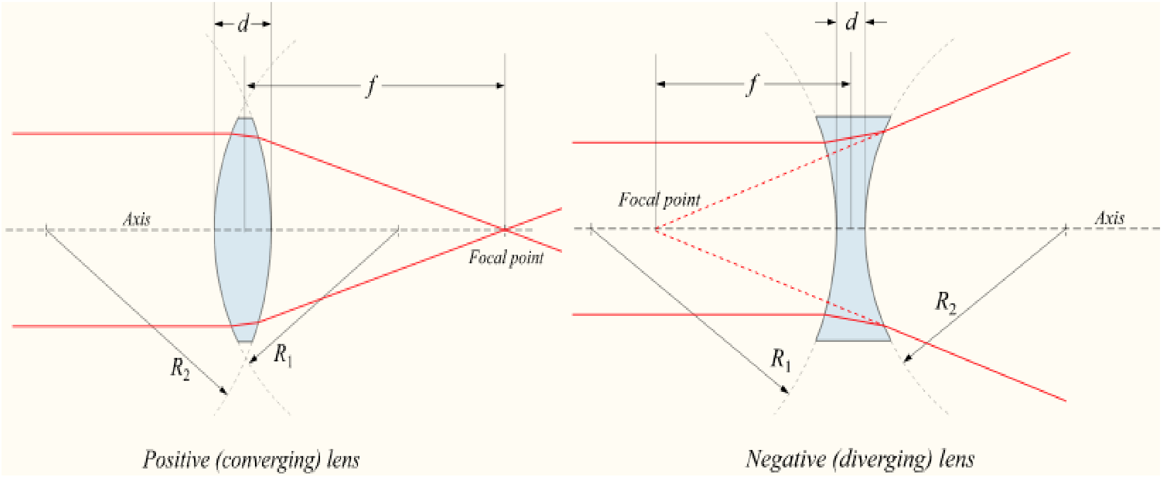

Figure 19. Thickness of the lens effect

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,

$$\frac{1}{f} = (n_{Lens} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

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

$= 0.5\times\times(0.1+0.0666) = 0.5\times\times0.1666 = 0.0833$

$$f = \frac{1}{0.0833} = 12\ cm$$