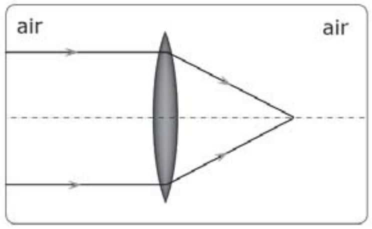
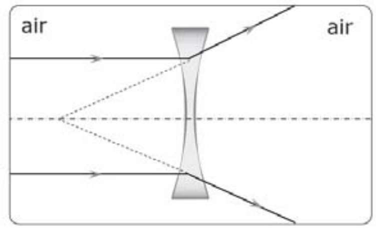
CONVERGING AND DIVERGING LENS

Converging and diverging lens

Is convex lens always converging and concave lens always diverging?





We have,

$$\frac{1}{f}=\left(\frac{n_l}{n_s}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

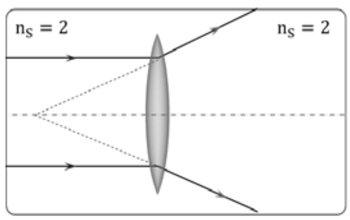
Consider a bi-convex lens kept in air ($n_s = 1$).

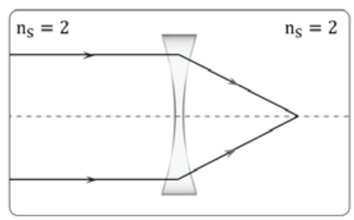
$$\frac{1}{f}=\left(\frac{n}{1}-1\right)\left(\frac{1}{R}-\left(\frac{-1}{R}\right)\right)$$

$$\frac{1}{f}=\frac{(n-1)\cdot 2}{R}$$

Thus, focal length is always positive in this case.
In air bi-convex lens is always Converging
When $n_s > n_l$, a biconvex lens becomes diverging.

Consider a bi-convex lens ($n_l = 1.5$) and bi-concave lens ($n_l = 1.5$) kept in water ($n_S = 2$).



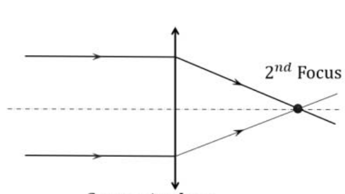


$$\frac{1}{f}=\left(\frac{1.5}{2}-1\right)\cdot\frac{2}{R}=-\text{ve}$$

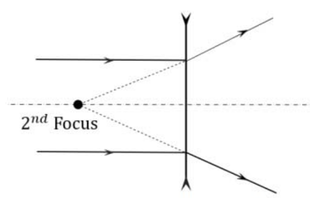
$$\frac{1}{f}=\frac{-\left(\frac{1.5}{2}-1\right)\cdot 2}{R}=+\text{ve}$$

Both concave and convex lenses can be converging or diverging, depending on the refractive index of the medium.

First focus and second focus

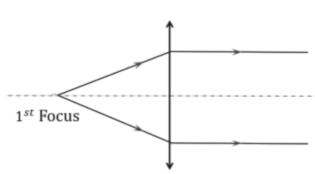


Converging Lens

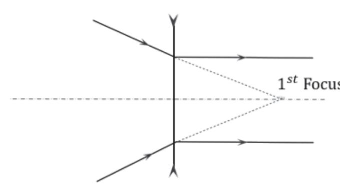


Diverging Lens

If the rays are parallel and paraxial to principal axis, then the point where they meet or appears to meet is known as second focus.



Converging Lens



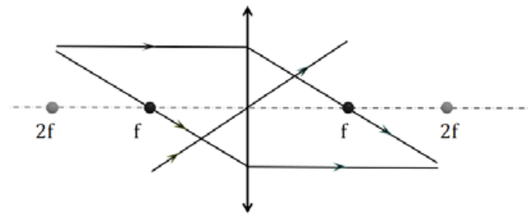
Diverging Lens

The position where object should be located or virtually situated so that rays become parallel to principal axis after refraction is known as first focus.

Standard Ray diagram

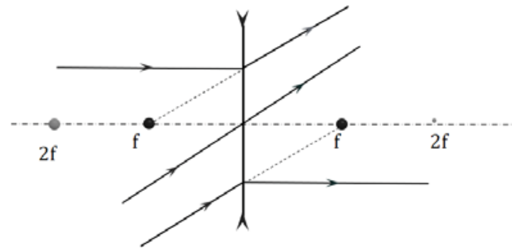
Converging Lens

Ray	Incidence	After refraction
Ray 1	Parallel to P.A.	Passes through focus
Ray 2	Passing through focus	Parallel to P.A.
Ray 3	Passing through	Undeviated



Diverging Lens

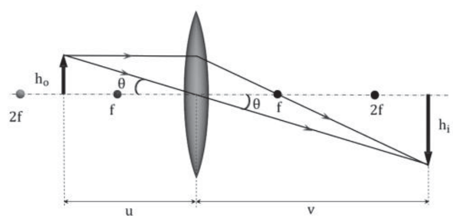
Ray	Incidence	After refraction
Ray 1	Parallel to P.A.	Passes through focus
Ray 2	Passing through focus	Parallel to P.A.
Ray 3	Passing through	Undeviated



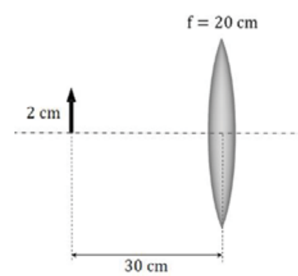
Transverse magnification

We have,
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$
$$v = \frac{u+}{u+f}$$

From figure,
$$\tan\theta = \frac{h_i}{v} = \frac{h_0}{u}$$
$$\frac{h_i}{h_0} = m = \frac{v}{u}$$
$$m = \frac{h_i}{h_0} = \frac{v}{u}$$



Ex. Find the height of the image and distance of image from the lens.



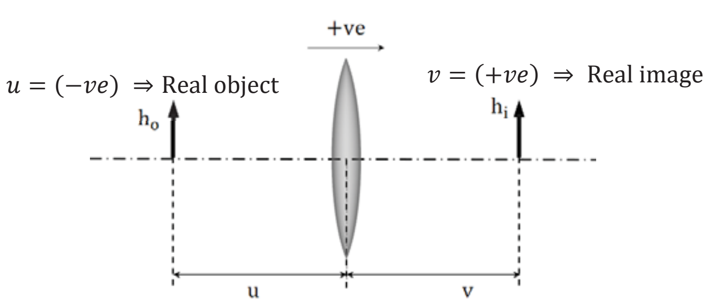
Sol. We have
$$v = \frac{uf}{u+f} = \frac{(-30)(20)}{-30+20} = \frac{-600}{-10} = 60\text{cm}$$

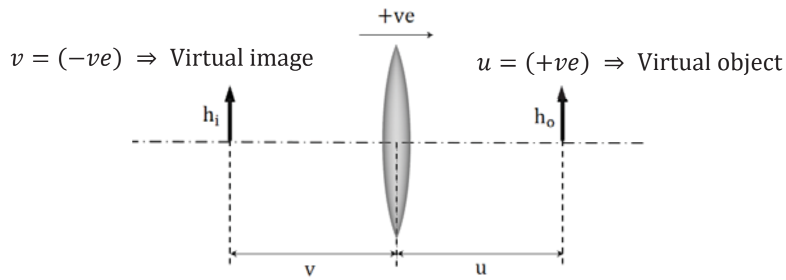
Magnification formula,
$$m = \frac{h_i}{h_o} = \frac{v}{u}$$
$$\frac{h_i}{2} = \left(\frac{+60}{-30}\right) h_i = -4\text{ cm}$$
$$v = 60\text{ cm}$$
$$h_i = -4\text{ cm}$$

Important Points

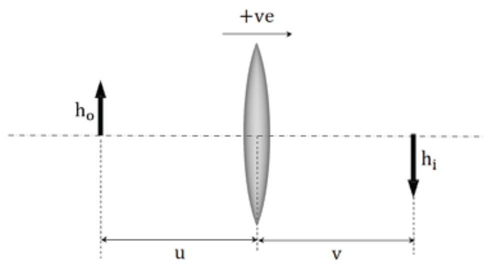
For converging lens ⇒ f (+ve)

For diverging lens ⇒ f (−ve)

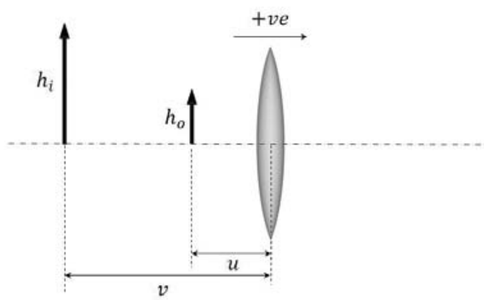




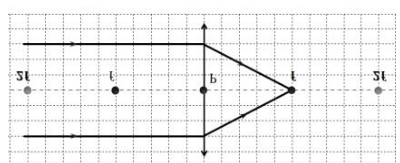
Inverted image ⇒ opposite sides ho and h_i or v_o and v_i will have opposite sign.



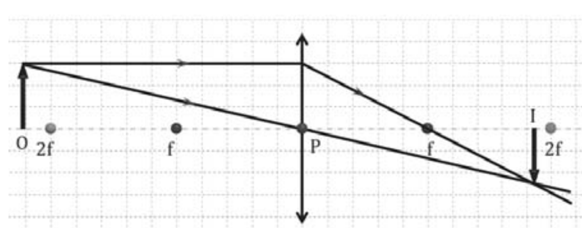
Erect image ⇒ same sides h_o and h_i or v_o and v_i will have same sign.



Cases for converging lens
Real Object



Object	Image	Nature
$O = -\infty$	$I = f$	Real, Point Image



Object	Image	Nature
$-\infty < O < -2f$	$f < I < 2f$	Real, Inverted, Smaller

When object is at centre of curvature,

$$u = -2f$$

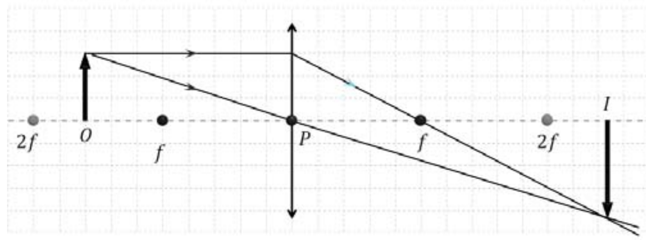
We Have

$$v = \frac{uf}{u+f}$$

$$= \frac{(-2t)\cdot f}{-2t+f}$$

$$= +2f$$

Object	Image	Nature
$O = -2f$	$I = 2f$	Real, Inverted, Same



Object	Image	Nature
$-2f < O < -\text{f}$	$2f < I < \infty$	Real, Inverted, Larger

When object is moved from slightly left to right of focus, image shifts from $+\infty$ to $-\infty$.

Object	Image	Nature
$-f < O < P$	$-\infty < I < P$	Virtual, Erect, Larger

Virtual Object

Object	Image	Nature
$P < O < \infty$	$P < I < f$	Real, Erect, Smaller

Ray diagram

We have $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

Let, $\frac{1}{f} = c,\ \frac{1}{v} = y,\ \frac{1}{u} = x$

Thus, $y - x = c$

This is an equation of straight line with slope -1.

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$