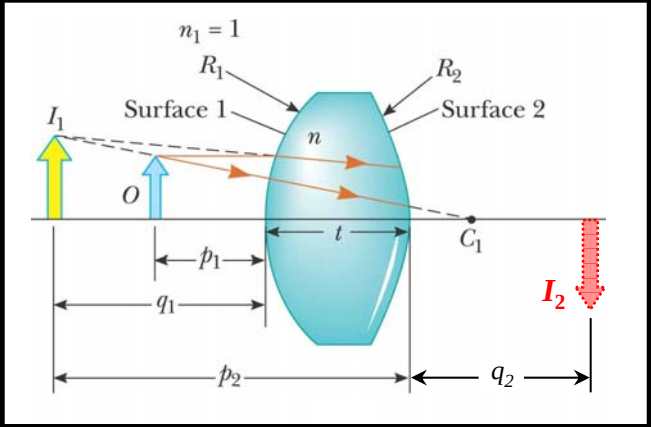
36.4 Thin lenses

2) A lens with *two spherical surfaces* with radii of curvature R_1 and R_2.

→ The image formed by one refracting surface serves as the object for the second surface.



$$\frac{n_1}{p} + \frac{n_2}{q} = \frac{(n_2 - n_1)}{R}$$

$$1/f = (n - 1)\,(\,1/R_1 - 1/R_2\,)$$

(Lens Makers' Equation)

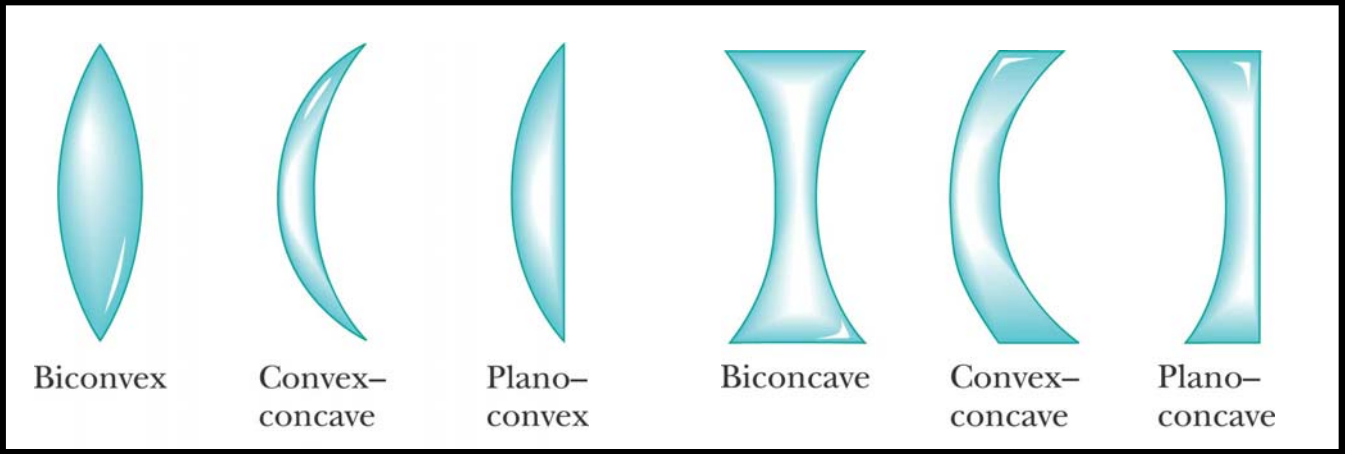
$$1/p + 1/q = 1/f$$

(Thin Lens Equation)

- Sign conventions for thin lenses :

	p	q	R_1 & R_2	f
+	real object (*front of lens*)	real image (*back of lens*)	C is in back of lens	converging
–	virtual object (*back of lens*)	virtual image (*front of lens*)	C is in front of lens	diverging

3) Various lens shapes :



2) A lens with two spherical surfaces with radii of curvature R_1 and R_2.

$$1/f = (n - 1)\,(\,1/R_1 - 1/R_2\,)$$ (Lens Makers' Equation)

$$1/p + 1/q = 1/f$$ (Thin Lens Equation)

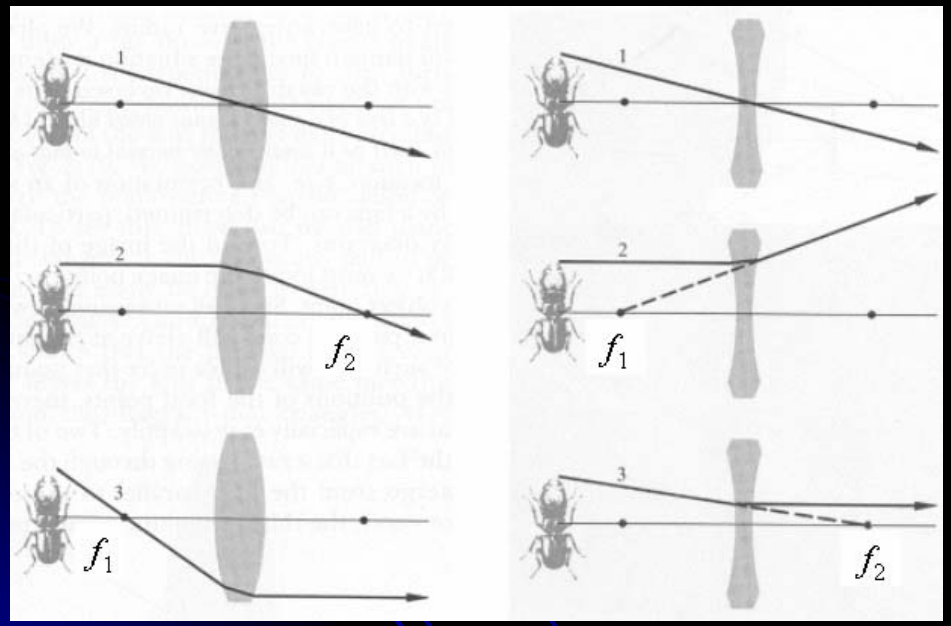
	p	q	R_1 & R_2	f
+	real object (*front of lens*)	real image (*back of lens*)	C is in back of lens	converging
–	virtual object (*back of lens*)	virtual image (*front of lens*)	C is in front of lens	diverging

4) Ray diagrams by using principal rays for convex (*and* concave) lens.

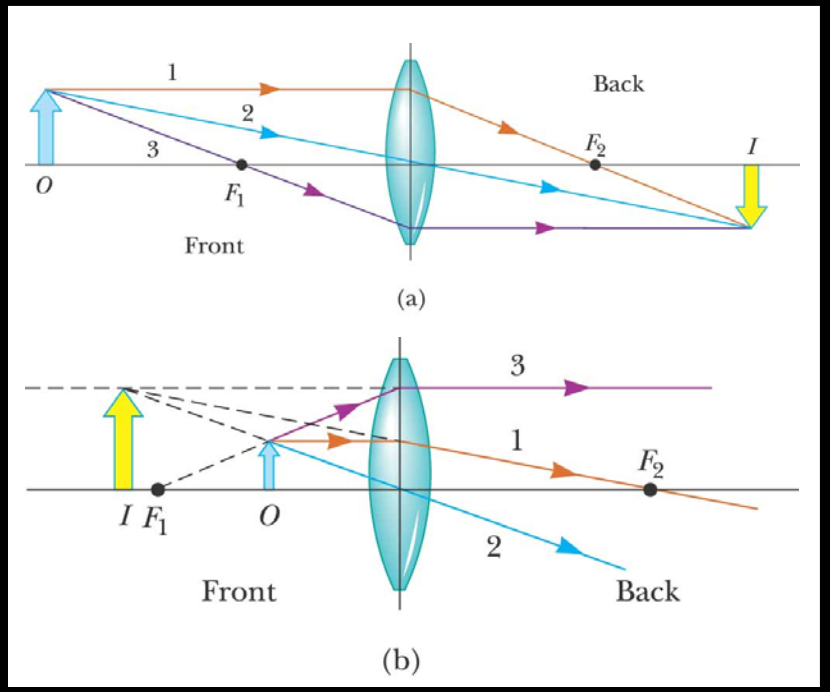
(1) a ray passing through the center of the lens continues in a straight line.
(*cf*. same for concave lens.)

(2) a ray initially // to the principal axis passes through f_2.
(*cf*. appears from f_1 for concave lens.)

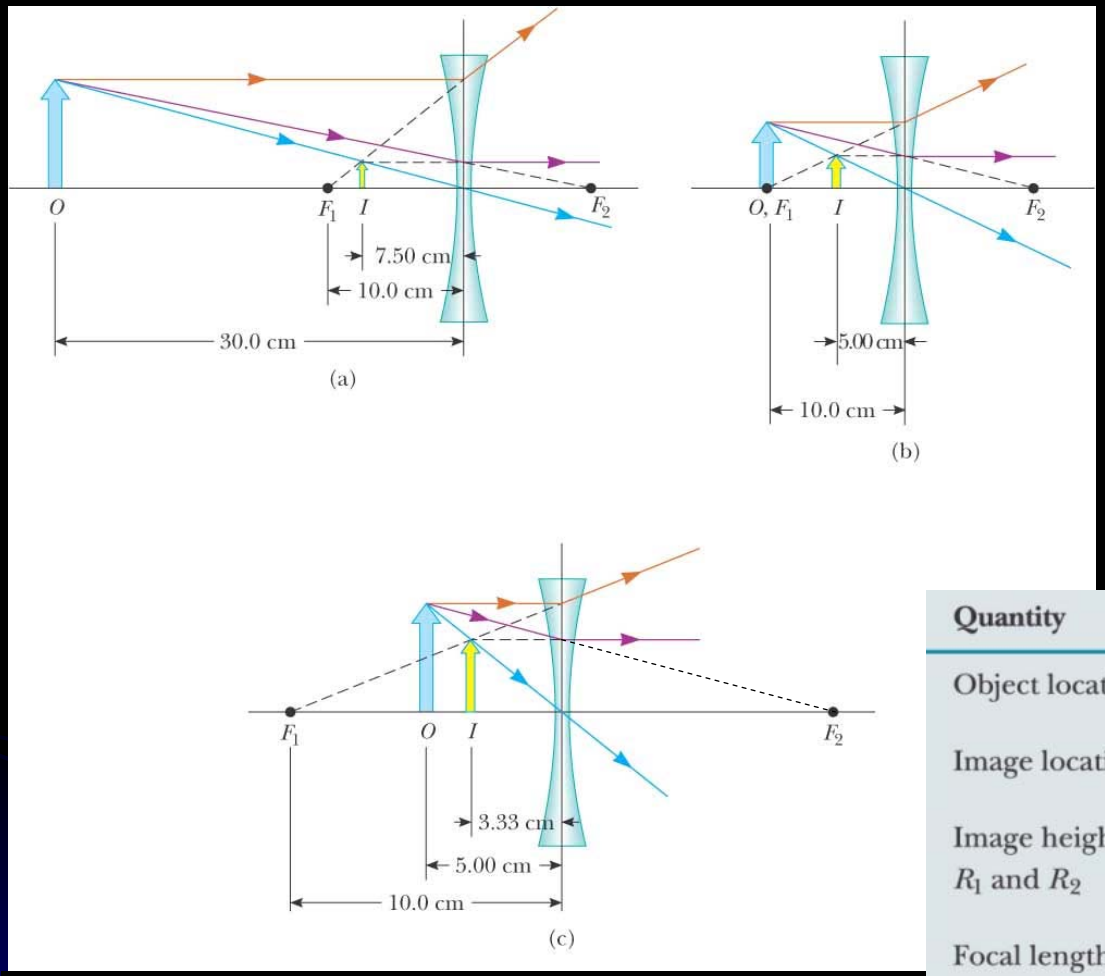
(3) a ray passing through f_1 continues // to the principal axis.
(*cf*. drawn toward f_2 continues // to the principal axis for concave lens.)



(A) Convex lens



(B) Concave lens



Quantity	Positive When	Negative When
Object location (p)	Object is in front of lens (real object)	Object is in back of lens (virtual object)
Image location (q)	Image is in back of lens (real image)	Image is in front of lens (virtual image)
Image height (h')	Image is upright	Image is inverted
R_1 and R_2	Center of curvature is in back of lens	Center of curvature is in front of lens
Focal length (f)	Converging lens	Diverging lens

(Example 36.10) Images formed by a diverging lens.

(a) The object is farther from the lens than the focal point.
(b) The object is at the focal point.
(c) The object is closer to the lens than the focal point.

5) Combination of thin lenses :

(1) The image formed by the 1st lens acts as a *real object* for the 2nd lens.

(2) The image formed by the 1st lens acts as a *virtual object* for the 2nd lens.

$$1/p + 1/q = 1/f$$ (Thin Lens Equation)

	p	q	R_1 & R_2	f
+	real object (*front of lens*)	real image (*back of lens*)	C is in back of lens	converging
–	virtual object (*back of lens*)	virtual image (*front of lens*)	C is in front of lens	diverging