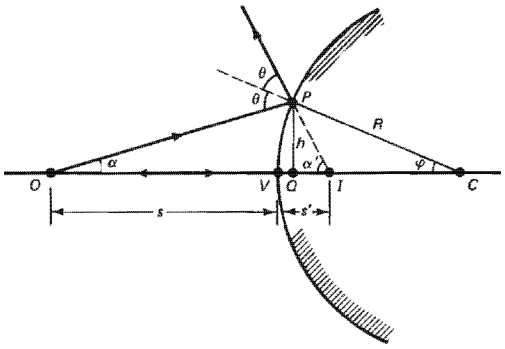
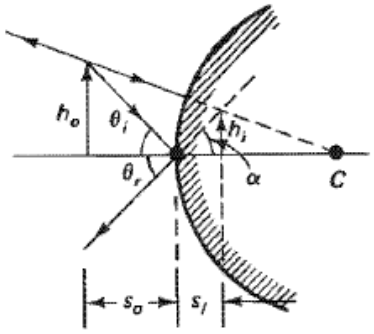
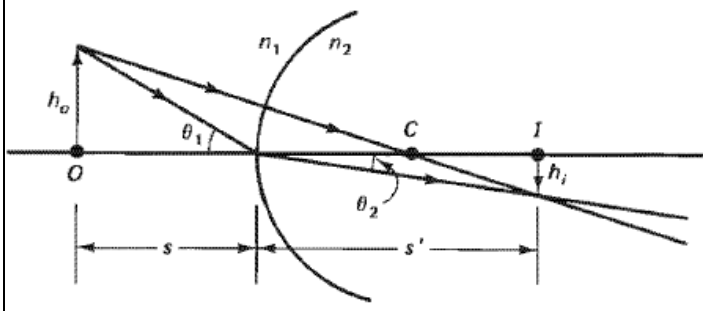
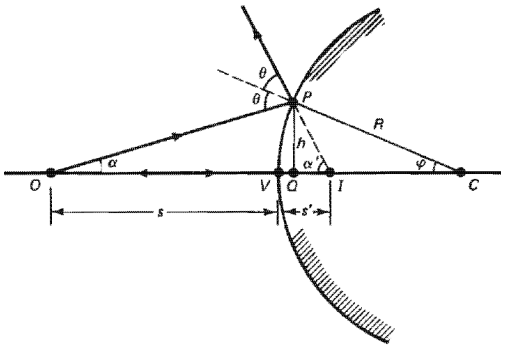
Sign Convention: Mirrors and Lenses

Object Distance (S)	
S>0 (Real)	"O" to the Left of "V"
S<0 (Virtual)	"O" to the Right of "V"
Image Distance (S')	
S'>0 (Real)	"O" to the Left of "V" (Mirror) "O" to the Right of "V" (Lens, Refractive Surface)
S'<0 (Virtual)	"O" to the Right of "V" (Mirror) "O" to the Left of "V" (Lens, Refractive Surface)
Radios of Curvature (R)	
R>0 (Convex)	"C" to the Right of "V"
R<0 (Concave)	"C" to the Left of "V"
S.- Object Distance S'.- Image Distance R .- Radios of Curvature O.- Object Point V.- Vertex C.- Center of Curvature F.- Focal point f.- Focal distance	

Mirror	
Convex	**Concave**
	

Refractive surface

Convex	Concave
	

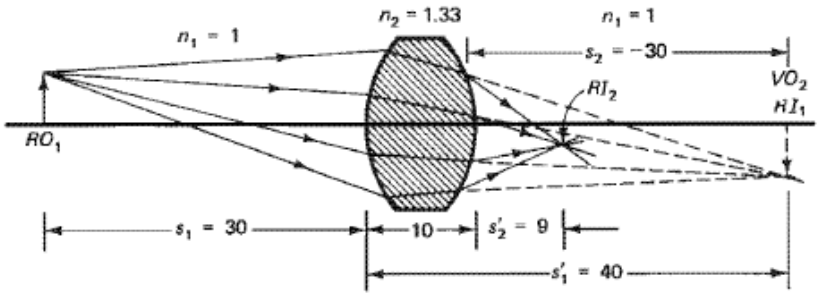
Imaging Equation: Mirror	Magnification: $\boldsymbol{m = \frac{h_i}{h_o} = -\frac{n_1 s'}{n_2 s}}$
$$\frac{1}{s} + \frac{1}{s'} = -\frac{2}{R} = \frac{1}{f}$$	Object height h_o Image height h_o Erected image $m > 0$ Inverted image $m < 0$
Imaging Equation: Refractive Surface $n_1 \rightarrow n_2$	
$$\frac{n_1}{s} + \frac{n_2}{s'} = -\frac{n_2 - n_1}{R} = \frac{1}{f}$$	

Ray Tracing: Mirrors

Ray leaving a point P at the tip of object

Ray 1. Ray Parallel to the Optic Axis (OA)**.** After Reflection: - Concave: Passes through the Focal Point - Convex: propagates as if it cam from focal Point
Ray 2. Leaves P in a direction towards or from F - Concave: Passes trough F→ Reflects and propagates parallel to OA - Convex: Leaves P as it came from F→ Reflects and emerges parallel to OA
Ray 3. Leaves P and propagates along the line joining P and C (Center of curvature) Reflects along the same line.

Thin Lens: $n_1 \rightarrow n_2 \rightarrow n_1$



Thin Lens Equation:

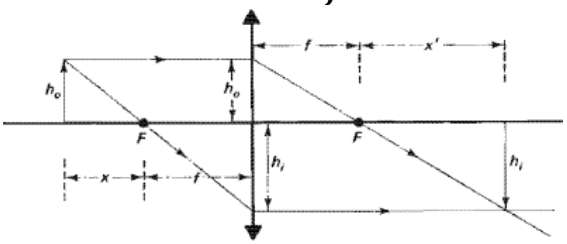
$$\frac{n_1}{s}+\frac{n_2}{s'}=\frac{n_2-n_1}{n_1}\left(\frac{1}{R1}-\frac{1}{R2}\right)=\frac{1}{f}$$

Lens Maker Formula

$$\frac{n_2-n_1}{n_1}\left(\frac{1}{R1}-\frac{1}{R2}\right)=\frac{1}{f}$$

Newton Equation for Thin Lens

$$xx'=f^2$$



x .- Object distance from Focal Point
x' .- Image distance Focal Point
Focal Distance f

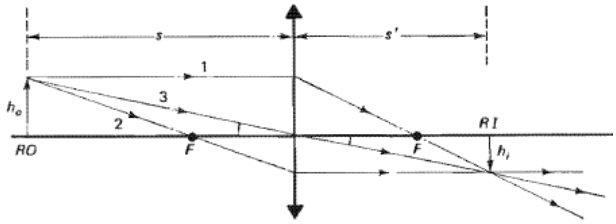
Ray Tracing: Thin Lens
Ray leaving a point "P" at the tip of object

Ray 1. Ray leaving P parallel to OA
- Converging lens: After Refraction ray passes through right focal point F
- Diverging lens: comes from left focal point F

Ray 2. Leaves P
- Converging lens: passes though Focal Point F → emerges parallel to OA
- Diverging lens: propagates toward (right) Focal Point F → emerges parallel to OA

Ray 3. Leaves P and propagates along the line joining P and center of the lens in Optical Axis, then it emerges without deviation.

Convergent Lense



Divergent Lense