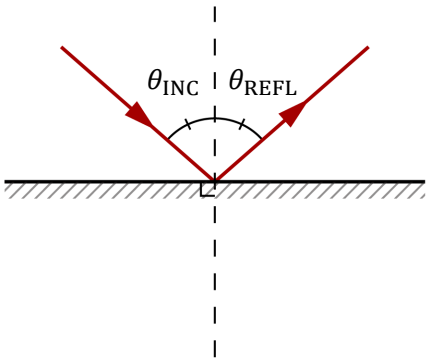
Geometric (ray) optics

Law of **reflection**

$$\theta_{\text{INC}} = \theta_{\text{REFL}}$$



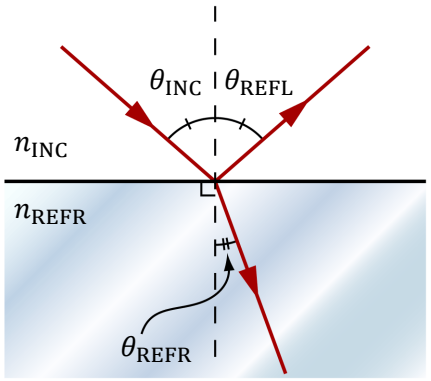
Index of refraction

$$v = \frac{c}{n}$$

Snell's law of **refraction**

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

When $n_{\text{INC}} > n_{\text{REFR}}$ and $\theta_{\text{REFR}} = 90°$, θ_{INC} is called θ_{CRIT}.
TIR



	Rays reflect **back toward original side**	Rays pass through **to other side**	Sign of focal length f
Rays **converge**	Concave mirror	Convex lens	$f > 0$
Rays **diverge**	Convex mirror	Concave lens	$f < 0$

Sketch rays to find image
1. **Parallel** to optical axis, through **focus**
2. Through **focus**, **parallel** to optical axis
3. Toward **center**, **unbent**

Relate distances from mirror/lens plane

$$\frac{1}{s_{\text{OBJ}}} + \frac{1}{s_{\text{IMG}}} = \frac{1}{f}$$

$$\frac{h_{\text{OBJ}}}{h_{\text{IMG}}} = -\frac{s_{\text{OBJ}}}{s_{\text{IMG}}}$$

$$M = -\frac{s_{\text{IMG}}}{s_{\text{OBJ}}}$$

$$R = 2f$$

Object on side of device light comes from (goes to):

$s_{\text{OBJ}} > 0$ ($s_{\text{OBJ}} < 0$)

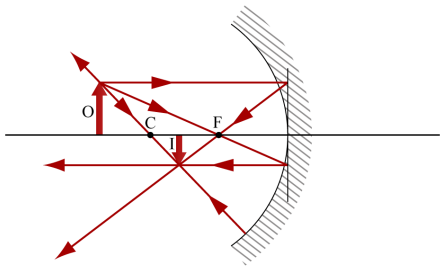
Image on side of device light goes to (comes from):

$s_{\text{IMG}} > 0$ ($s_{\text{IMG}} < 0$)

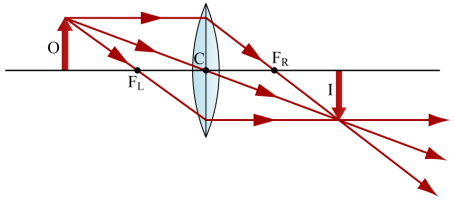
Resulting **image types**

Real ⇔ Inverted
Virtual ⇔ Upright

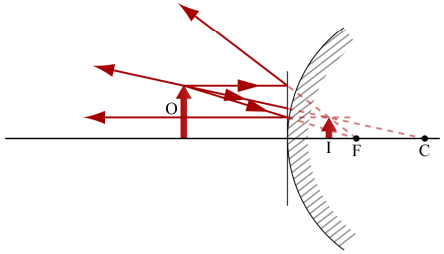
Concave mirror



Convex lens



Convex mirror



Concave lens