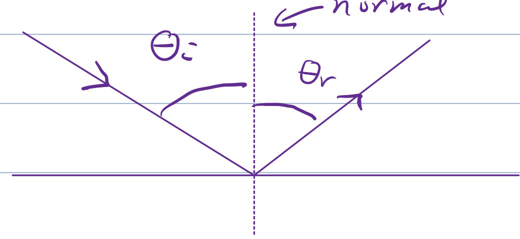
18.1 The Ray Model of Light

- See pre-lecture video.
- Read
  - Ray diagrams only show a few representative rays, out of the infite number that travel in all directions.
- Ray model is relevant when $\lambda \ll$ objects.

Flat surface, e.g. a mirror



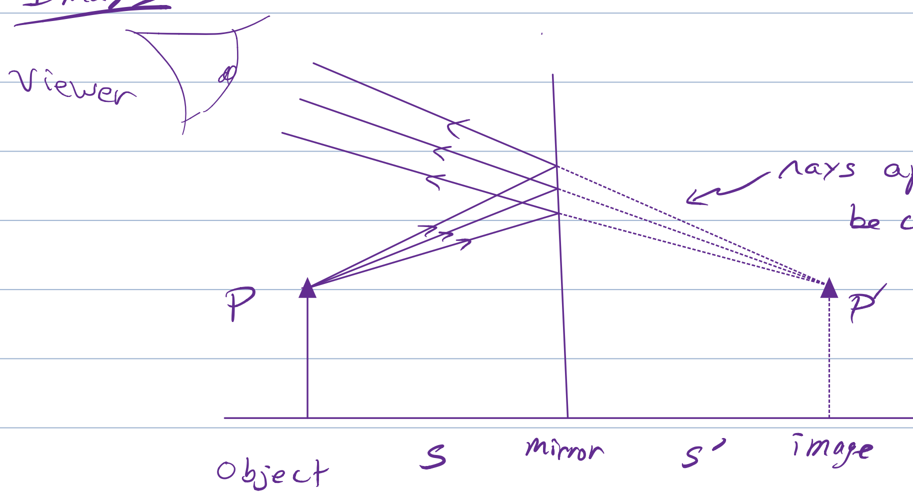
θ_i = incident angle

θ_r = reflected angle

① Measure all angles from the surface normal

② $\theta_i = \theta_r$

Images

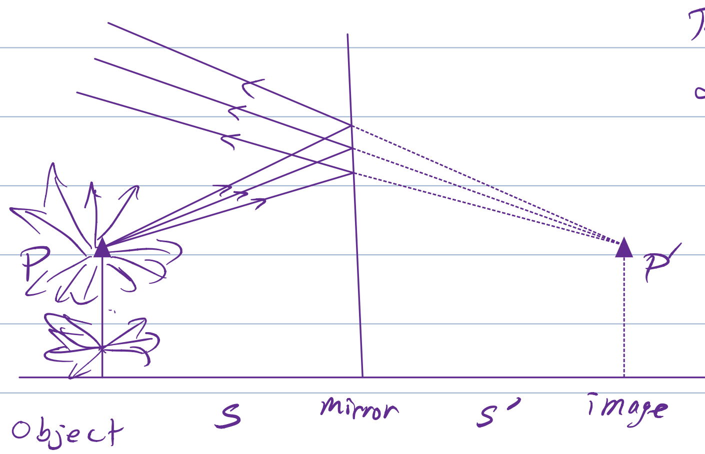


S = object distance (mirror to object)

S' = image distance (mirror to image)

Do the geometry. For a plane mirror, get

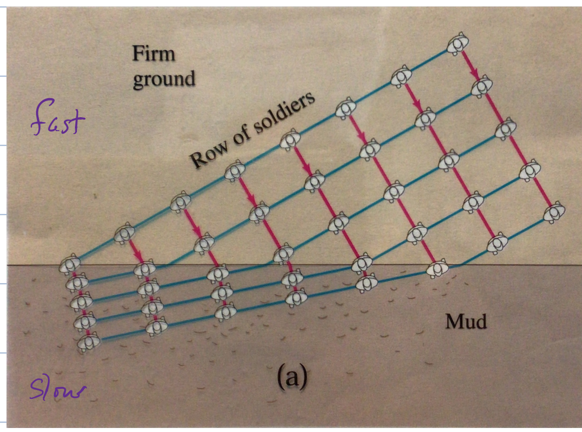
$$S' = S \quad . \quad \text{(plane mirror)}$$

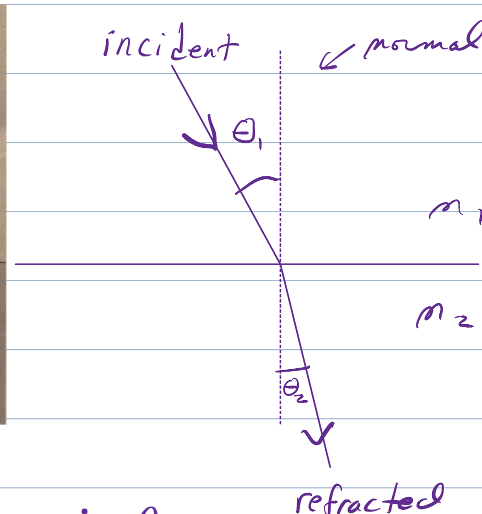


There are actually an ∞ number of rays.
We show a useful few

18.2 Refraction

Light slows down when it enters a medium
n = index of refraction. $v = c/n$.
Saw this with thin films. It also will cause rays to bend when they encounter an interface at an angle.





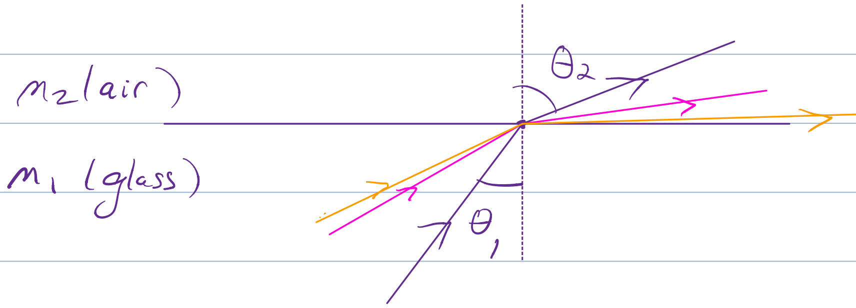
Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

If $n_2 > n_1$, bends towards the normal.

Applications
1) Simple example Ch18-refraction
2) Apparent depth and other "geometry" problems. SKIP! (18.4)
3) Total internal reflection (below)
4) Thin lenses (sections 18.5 and 18.7)

Total Internal Reflection

assume $n_1 > n_2$ (e.g. glass and air)



Since $n_1 > n_2$, and $n_1 \sin\theta_1 = n_2 \sin\theta_2$,

$\theta_2 > \theta_1$, it bends away from the normal.

Question: what is the largest θ_1 you can have?

Answer: Max θ_2 is $90°$, so

$$n_1 \sin\theta_{1,max} = n_2 \sin 90^0$$

$$n_1 \sin\theta_{1,max} = n_2$$

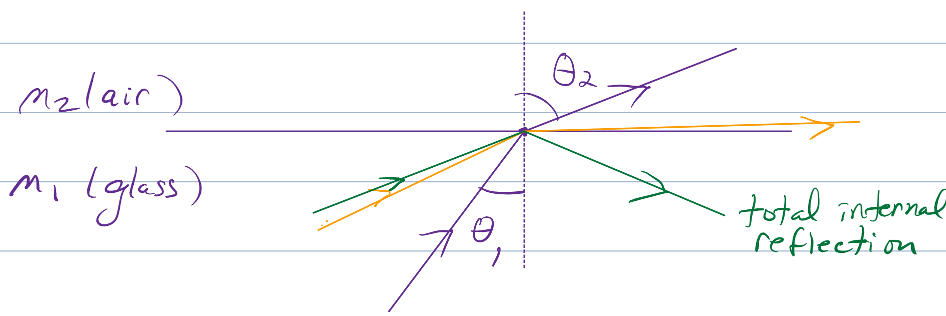
$$\theta_{1,max} = \sin^{-1}(n_2/n_1)$$

e.g. $n_1 = 1.5 \quad n_2 = 1.0$

$$\theta_{1,max} = \sin^{-1}(1/1.5) \simeq 41.8°$$

What happens if $\theta_1 > 41.8°$?

Get <u>reflection</u>!



This is essentially what happens inside a fiber optic cable.