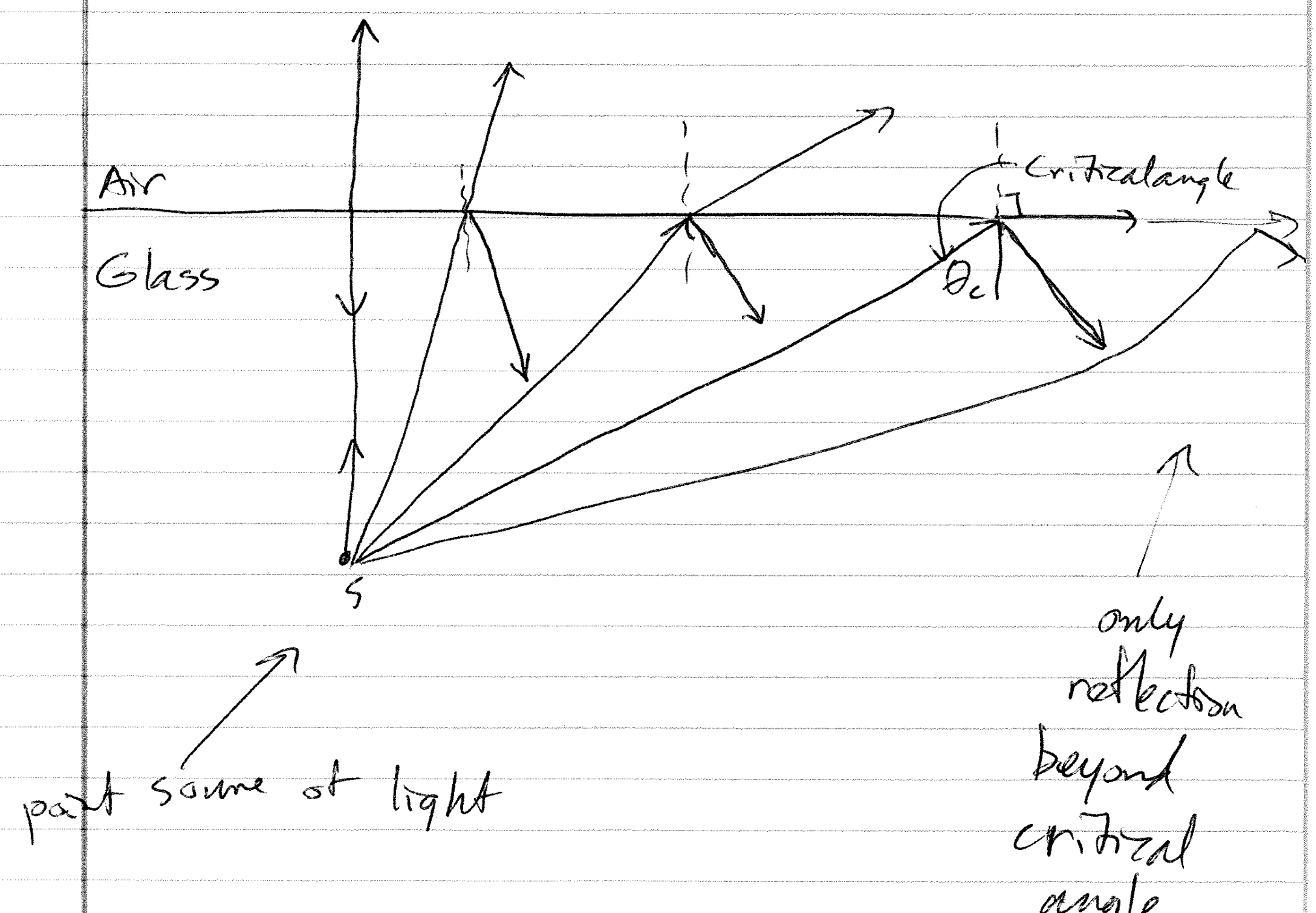
Lecture 22

Total Internal Reflection

situation where light does not refract but only reflects back

suppose the following situation:



recall Snell's law is

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

take n_1 to be for glass & n_2 for air

How to calculate critical angle?

it occurs when $\theta_2 = 90°$ or $= \pi/2$ (radians)

$$\Rightarrow \quad n_1 \sin\theta_c = n_2 \sin \pi/2$$

$$= n_2$$

$$\Rightarrow \sin\theta_c = \frac{n_2}{n_1}$$

$$\Rightarrow \quad \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

the fact that $\sin\theta_c = \frac{n_2}{n_1}$

& $|\sin\theta_c| \leq 1$

$\Rightarrow$ total internal reflection cannot occur if $n_2 > n_1$

so this only happens if $n_2 < n_1$ (as is the case for glass & air)

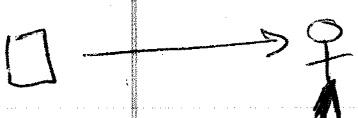
- total internal reflection is used in medical technology.
- During surgery, can view interior of artery by running two thin bundles of optical fibers through it. one is used to illuminate inside of artery & the other is used for producing an image.

Ch. 34 - Images

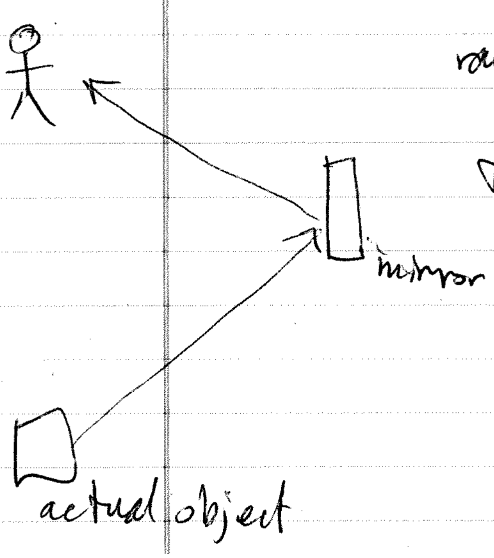
physics of mirrors, lenses, & optical instruments

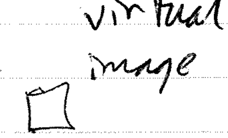
two kind of images

- when you see an object, your eye intercepts light rays coming from it, & then this gets processed by your retina, visual cortex, & brain.

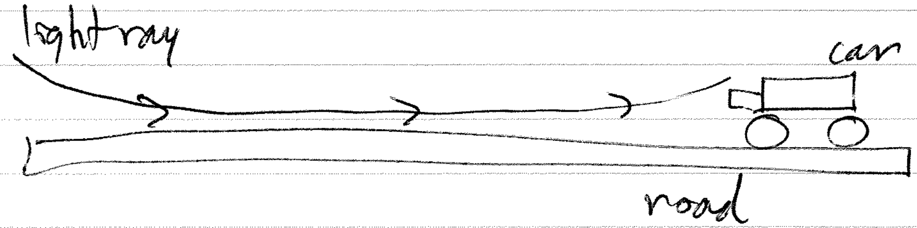


- another way is if the light rays from the object reflect from a mirror & then reach you.





Other kind of virtual image: mirage

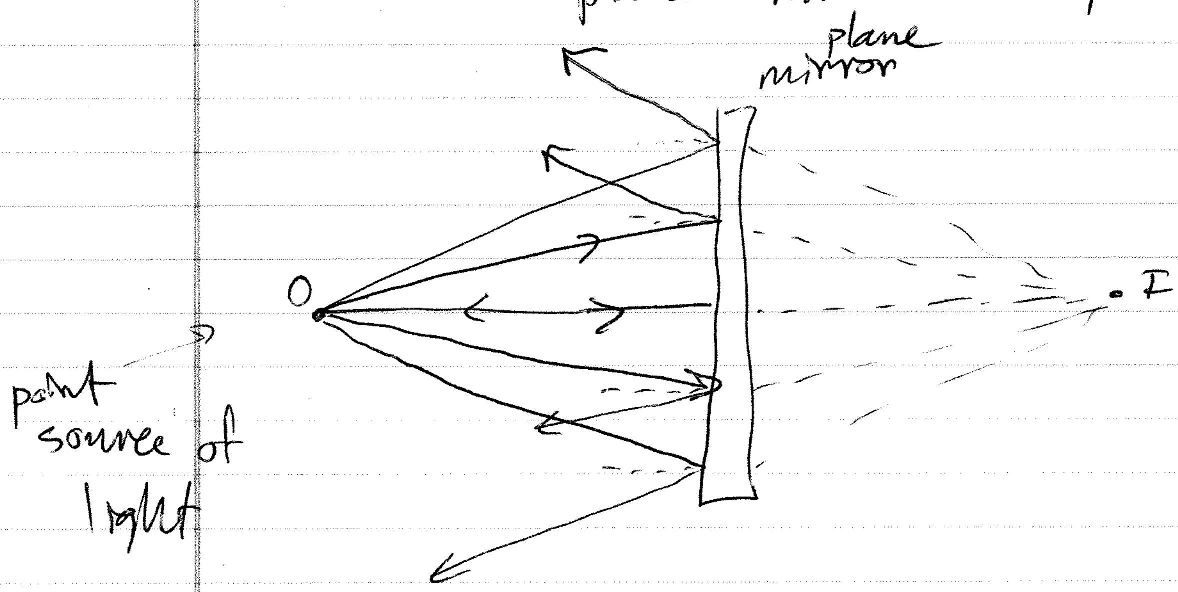


due to refraction, looks like there is a pool of water in front of you

- happens b/c light travels through progressively warmer air heated by the road, & index of refraction changes. light is blue colored coming from sky & turbulence of air gives appearance of a shimmy, like a pool of water.

Plane Mirrors

- Mirror is a surface that can reflect a beam of light in one direction instead of scattering it wildly in many directions or absorbing it.
- Here we consider images that a plane mirror can produce.



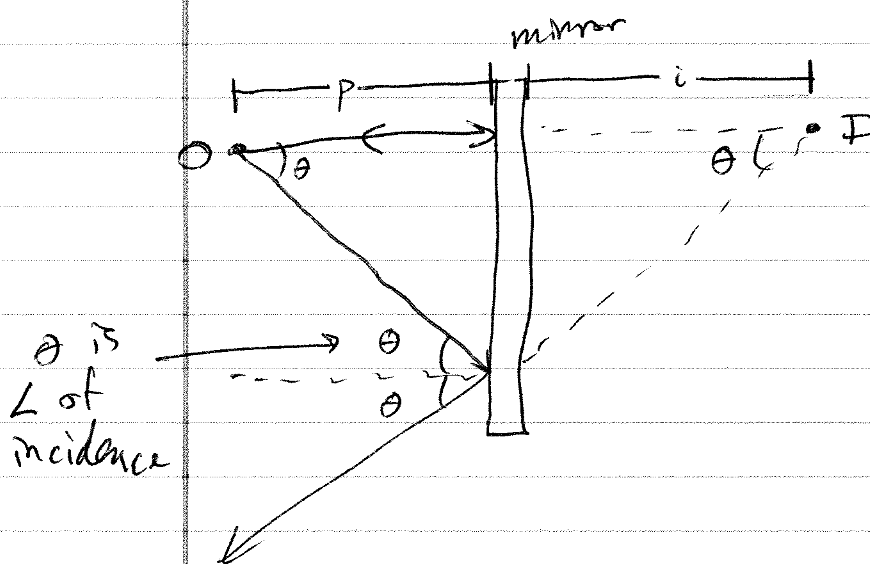
O is a point source of light.

What your eye perceives when looking @ mirror is that there is a point source @ I.

Your eye sees a <u>virtual image</u>
b/c light rays do not actually go through point I,

can do ray tracing to analyze this situation.

Consider two of the beams:



triangle on left & right are congruent (all sides & angles are equal)

measure distance of physical object to mirror as positive &

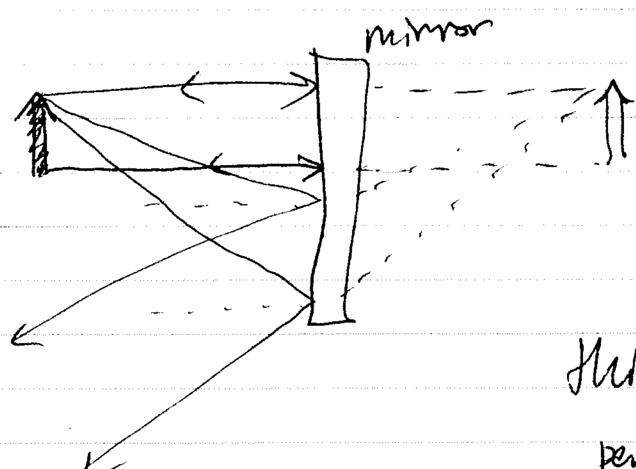
& image distances from mirror as negative.

$\Rightarrow \quad i = -p$

or $\quad |i| = p$

Extended Objects

rather than a point source, suppose we have an extended object

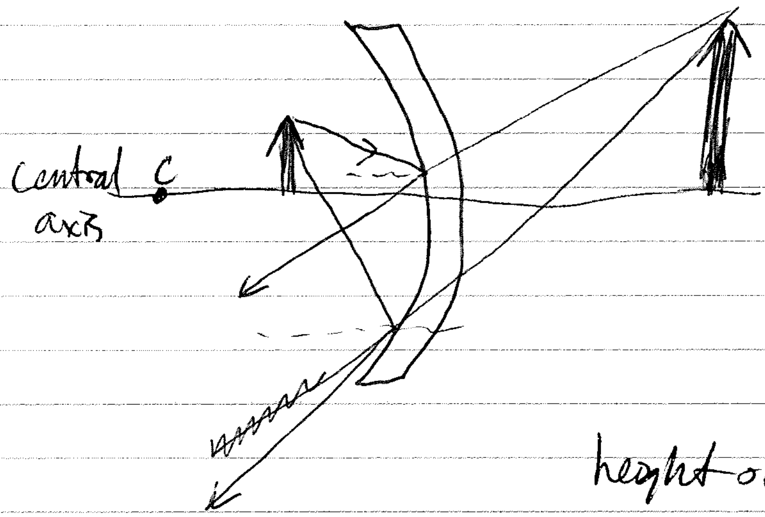


This is how you perceive a virtual image of an extended object.

Also explains why you see reflection of yourself in mirror.

spherical mirrors

concave mirror ("caved in toward source")



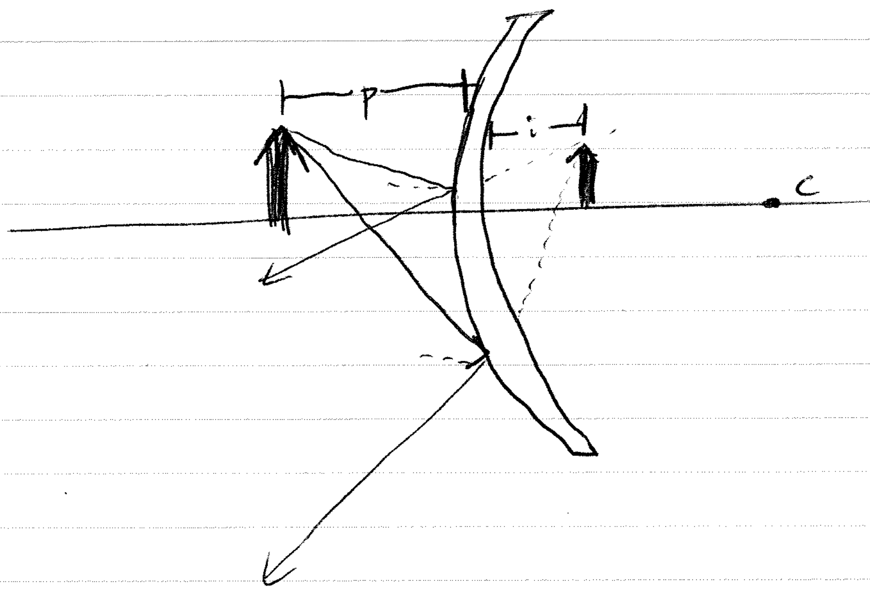
height of image is bigger

some key differences w/ previous case

center of curvature is @ center of sphere.

1. center of curvature C - not infinitely far away & in front of mirror
2. field of view is now smaller
3. image is farther behind mirror
   |i| is greater
4. height of image bigger

Convex mirror "flexed out"



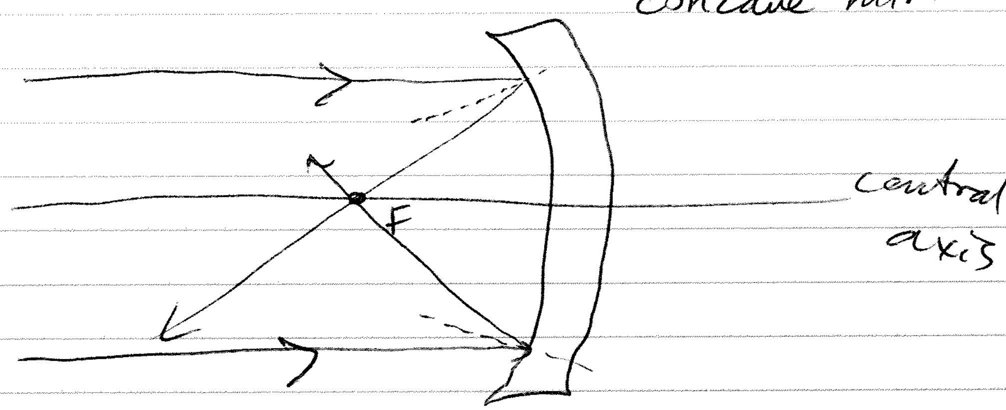
1. center of curvature behind mirror now
2. increases field of view
3. moves image of object closer to mirror
4. image height decreases.

Focal points of spherical mirrors

- For plane mirror, $|i| = p$
- to determine relation for spherical mirror consider object @ ∞ distance away on central axis

rays from this far away source are parallel when they reach the mirror

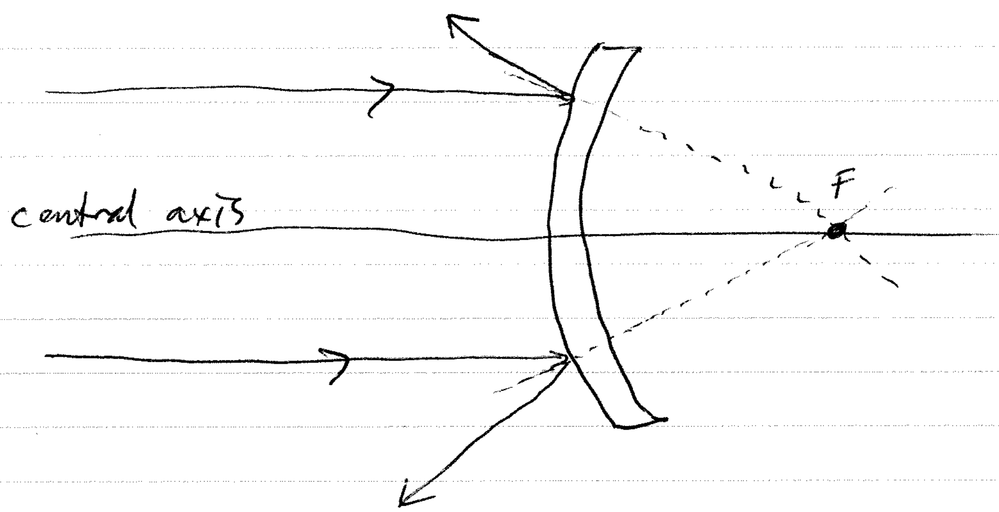
- picture is



- parallel rays reflect through a common point called focal point F

- distance from center of mirror is called focal length f

for convex mirror



for convex mirror, looks like parallel rays originate from point source @ F (virtual focal point)

focal length f is negative & behind mirror

can find f w/

$f = \frac{1}{2} r$ where

r is radius of curvature of sphere ($r > 0$ for concave, $r < 0$ for convex) can prove that

$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$$

relation between

physical distance p

image distance i

& focal length f

of mirror.