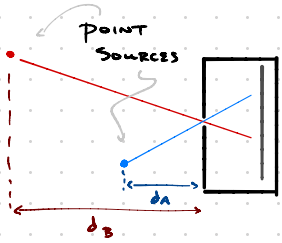
LECTURE 25
MIRRORS & LENSES

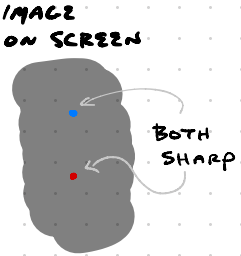
FOCUSING

- RECAP: PINHOLE CAMERA

PROS

- OBJECTS @ ALL DEPTHS FORM SHARP IMAGE [i.e. INFINITE "DEPTH OF FOCUS"]





CONS

- IMAGES ARE DIM:
  - NEED SMALL APERTURE FOR SHARP FOCUS, ONLY SMALL FRACTION OF EMITTED RAYS STRIKE SCREEN.

- HOW CAN WE GET A BRIGHTER IMAGE WHILE PRESERVING SHARPNESS OF IMAGE?

- TRADEOFF:
  - CAN ACCOMPLISH THIS, BUT ONLY FOR OBJECTS @ A CERTAIN DEPTH:

BRIGHT, SHARP

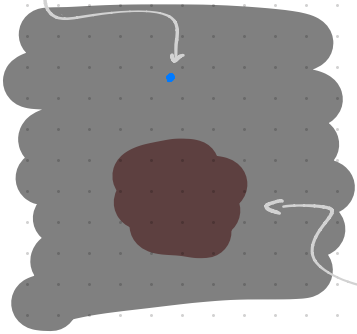
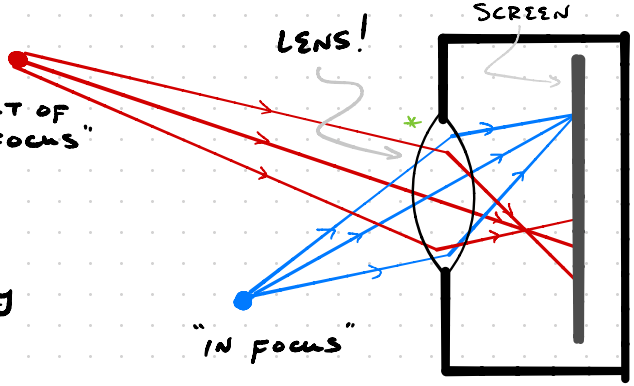


IMAGE ON SCREEN



* RAYS ACTUALLY REFRACT TWICE (FRONT & BACK SURFACES)

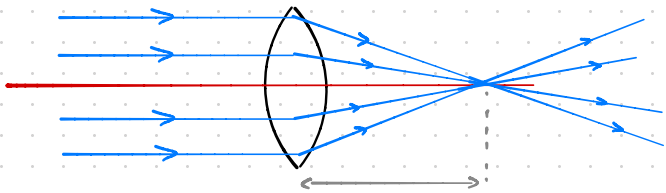
- How do lenses form images?

- For thin lenses we have two simple rules:

#1: Rays traveling parallel to the lens' axis of symmetry appear to cross the axis a distance f away from lens:

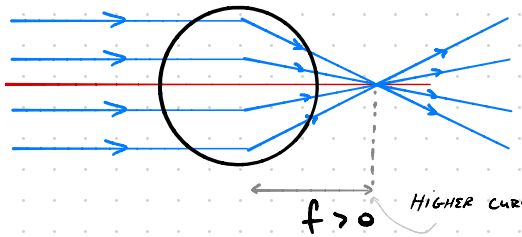
* "axis" for short
* f: "focal length" of lens

Eg. converging lens, long focal length:



f > 0

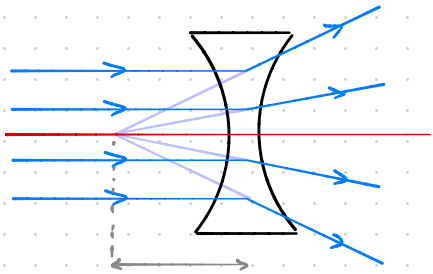
converging lens, short focal length:



f > 0

higher curvature, shorter focal length

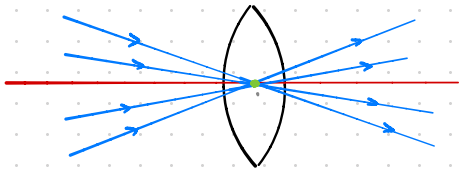
Diverging lens:



f < 0

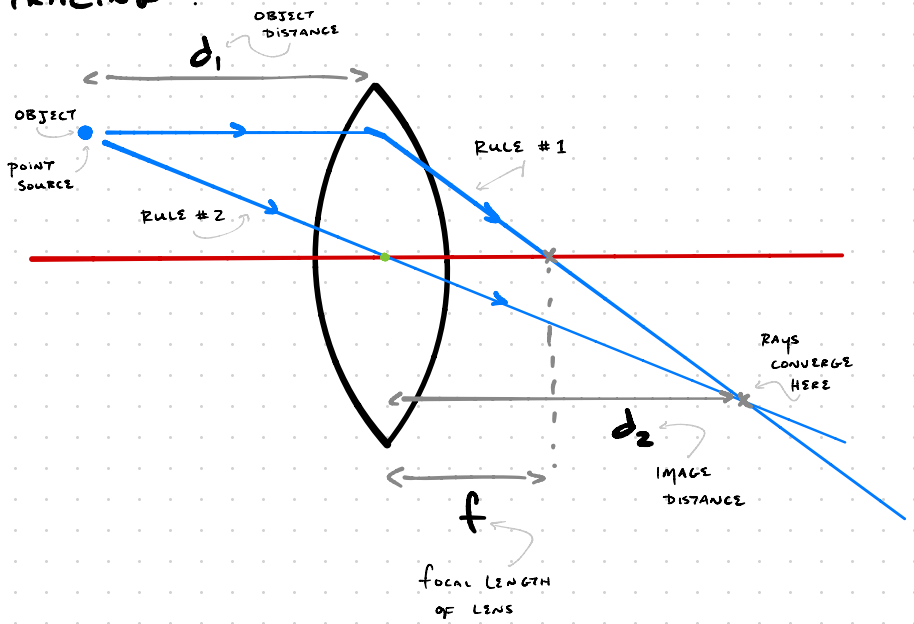
- Rays appear to cross axis a distance f behind lens! f is negative!

#2 : RAYS TRAVELING THRU CENTER OF LENS AREN'T DEFLECTED :



FROM THESE TWO RULES WE CAN DETERMINE AT WHAT DEPTH AN OBJECT'S IMAGE IS IN FOCUS :

"RAY TRACING" :



- FROM GEOMETRY CAN SHOW :

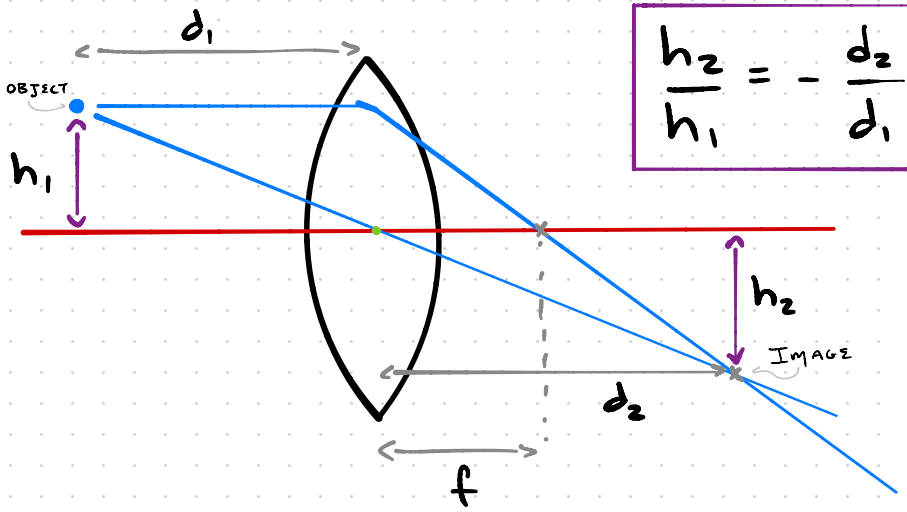
$$\frac{1}{d_1} + \frac{1}{d_2} = \frac{1}{f}$$

"THIN LENS EQUATION"

MAGNIFICATION:

By GEOMETRY WE ALSO HAVE:

$$\frac{h_2}{h_1} = -\frac{d_2}{d_1}$$



- THEN BY THIN LENS EQUATION:

"MAGNIFICATION"

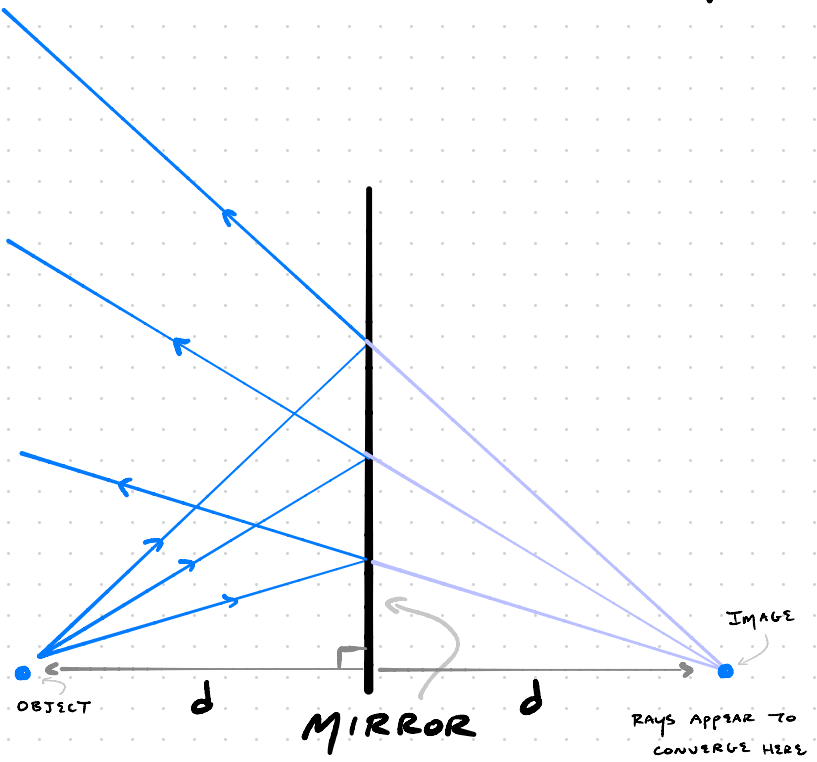
$$M \equiv \frac{h_2}{h_1} = -\frac{d_2}{d_1} = -\frac{\left[\frac{1}{f} - \frac{1}{d_1}\right]^{-1}}{d_1}$$

$$= -\left[d_1/f - 1\right]^{-1}$$

$\longrightarrow$ CAN SHRINK / MAGNIFY IMAGE BY CHANGING OBJECT DISTANCE d_1!

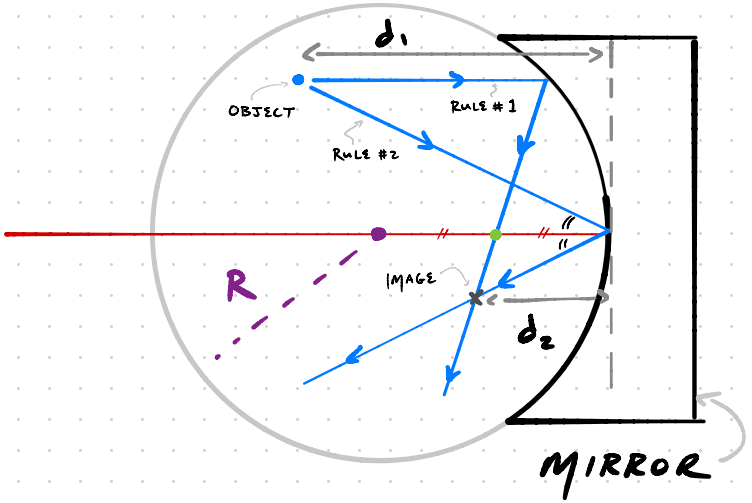
MIRRORS

- FLAT MIRRORS:
  - RAYS FROM POINT SOURCE APPEAR TO ORIGINATE FROM "MIRROR IMAGE" OF POINT:



- CURVED MIRRORS:

  OBEYS LAW SIMILAR TO THIN LENS EQUATION:



$$\frac{1}{d_1} + \frac{1}{d_2} = \frac{1}{f}$$

$$f = \frac{R}{2}$$

R: RADIUS OF CURVATURE