

LENSES: PRINCIPAL RAYS

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- f = focal length
- ob = Object distance to lens resp. principal plane H1: >0 , <0 at left, right side of lens
- im = Image distance to lens resp. principal plane H2: >0 , <0 at right, left side of lens
- thin lens: $H1 = H2 =$ lens surface
- thick lens: $H1$ and $H2$ may change places, depending on thickness and focal lengths of curvatures
- set of two thin lenses: $H1$ and $H2$ may change places, depending on distance and focal lengths.

VARIABLES:

ob_1, ob_2, obs = object distances of lens 1, 2, s.

(position of lens 1 is set to 0.0)

(s = combination of both lenses)

(>0 resp. <0 when at left resp. right side of lens)

im_1, im_2, ims = image distances of lens 1, 2, s.

(>0 resp. <0 when at right resp. left side of lens)

f_1, f_2, f_s = focal lengths

d = distance between lenses

$mag_1, mag_2, mags$ = magnifications

h_1, h_2 = position of principal planes,
measured from lens 1 resp. lens 2.

ffl, bfl = front resp. back focal length.

CALCULATION

$$1/im_1 = 1/f_1 - 1/ob_1$$

$$ob_2 = d - ob_1$$

$$1/im_2 = 1/f_2 - 1/ob_2$$

$$1/f_s = 1/f_1 + 1/f_2 - d/f_1/f_2$$

$$h_1 = f_s * d / f_2 \text{ measured from lens 1}$$

$$h_2 = f_s * d / f_1 \text{ measured from lens 2}$$

$$obs = ob_1 + h_1$$

$$1/ims = 1/f_s - 1/obs$$

$$\text{mag1} = -\text{im1}/\text{ob1}$$

$$\text{mag2} = -\text{im2}/\text{ob2}$$

$$\text{mags} = -\text{ims}/\text{obs} = +\text{im1}*\text{im2}/\text{ob1}/\text{ob2}$$

$$\text{ffl} = f1*(d-f2) / (d-f1-f2)$$

$$\text{bfl} = f2*(d-f1) / (d-f1-f2)$$

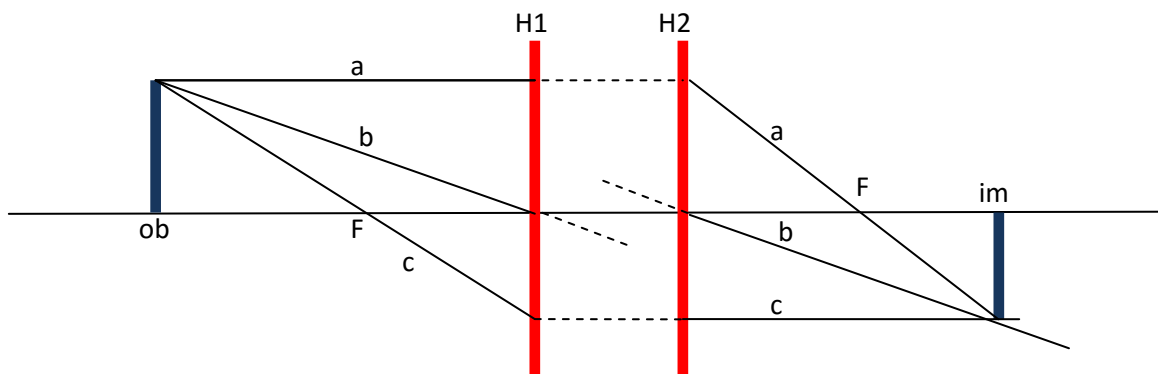
PRINCIPAL RAYS.

In combination plot, the rays travel:

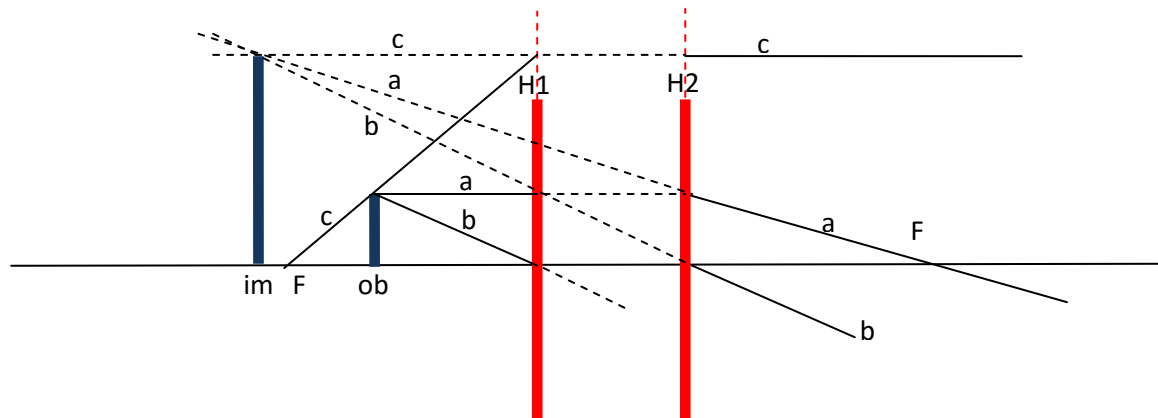
1. from obs to h1,
2. from h1 to h2 (with preserved height),
3. from h2 to ims (if ray through 0: with preserved slope).

SITUATIONS

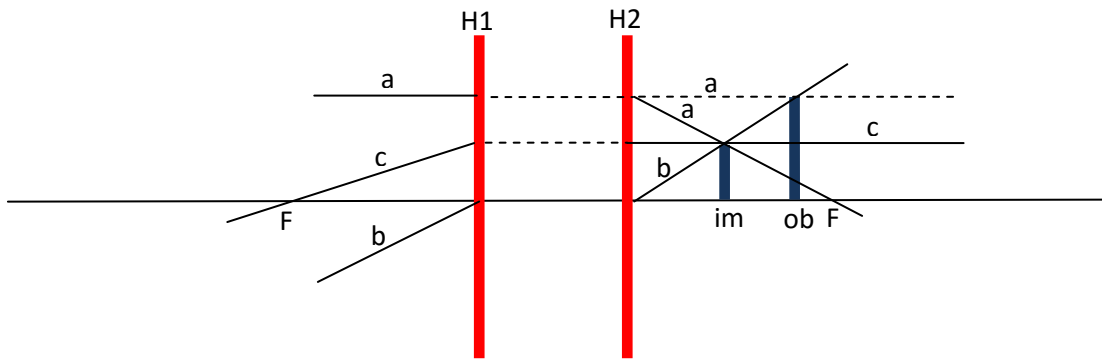
1. $f > 0, \text{ob} > 0, |\text{ob}| > f$



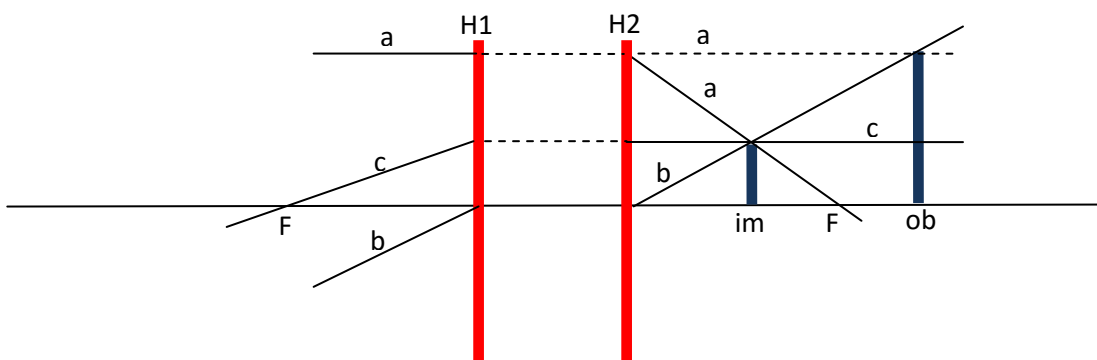
2. $f > 0, \text{ob} > 0, 0 < |\text{ob}| < f$



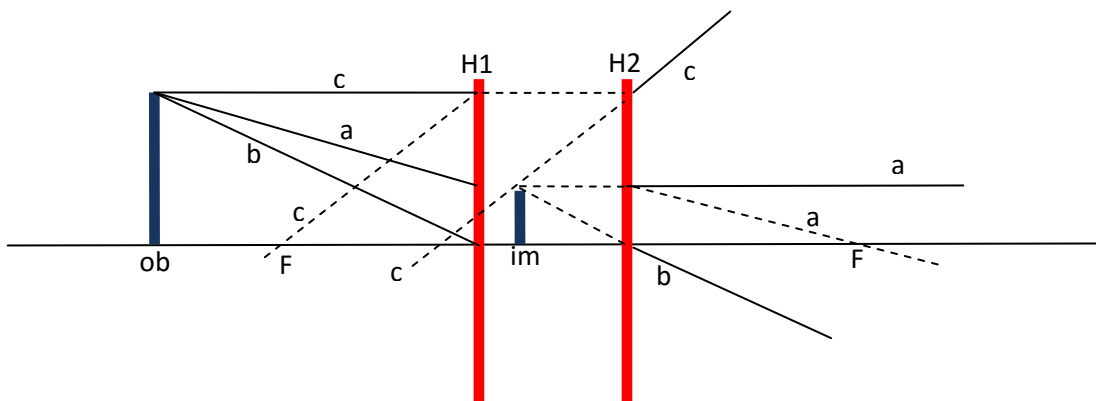
3. $f > 0, \text{ob} < 0, 0 < |\text{ob}| < f$



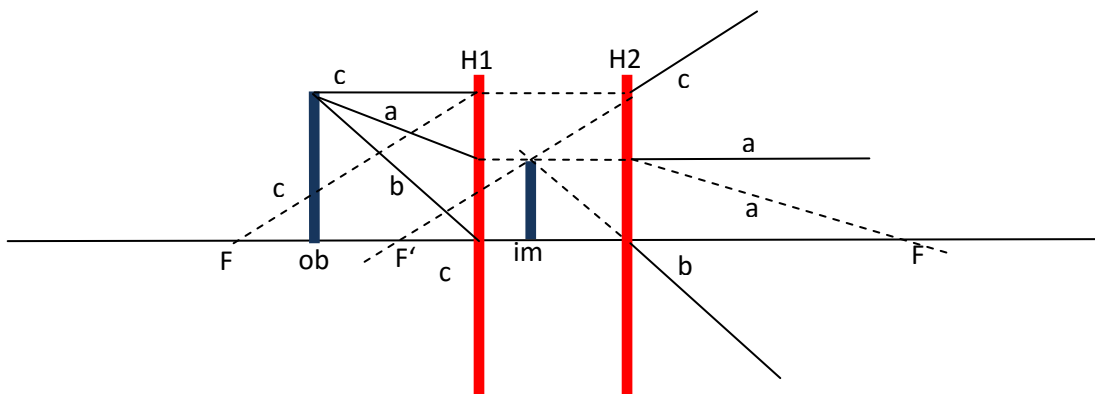
4. $f > 0, ob < 0, |ob| > f$



5. $f < 0, ob > 0, |ob| > |f|$

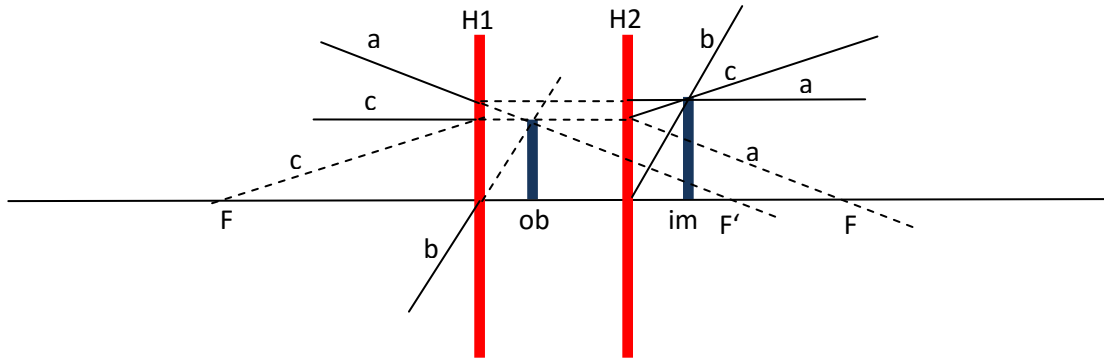


6. $f < 0, ob > 0, |ob| < |f|$



7. $f < 0, ob < 0, |ob| < |f|$

F' = virtual focus at inner side of corresponding principal plane



8. $f < 0, ob < 0, |ob| > |f|$,

F' = virtual focus at inner side of corresponding principal plane

