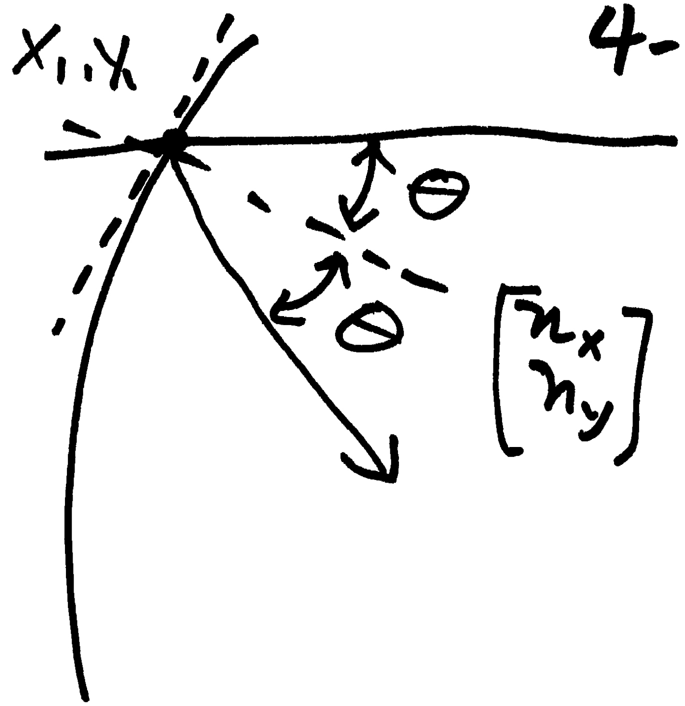
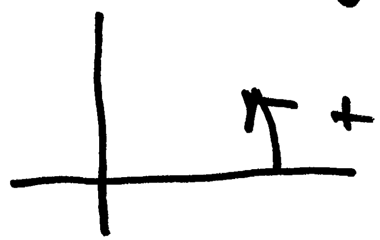
1. intersect ray + surface
2. find surface tangent + normal
3. find incidence angle
4. find equation reflected ray



2 D

bearing/angle



$$\beta_{ray} = \tan^{-1}\left(\frac{n_y}{n_x}\right) - \Theta$$

(atan2(n_y, n_x))

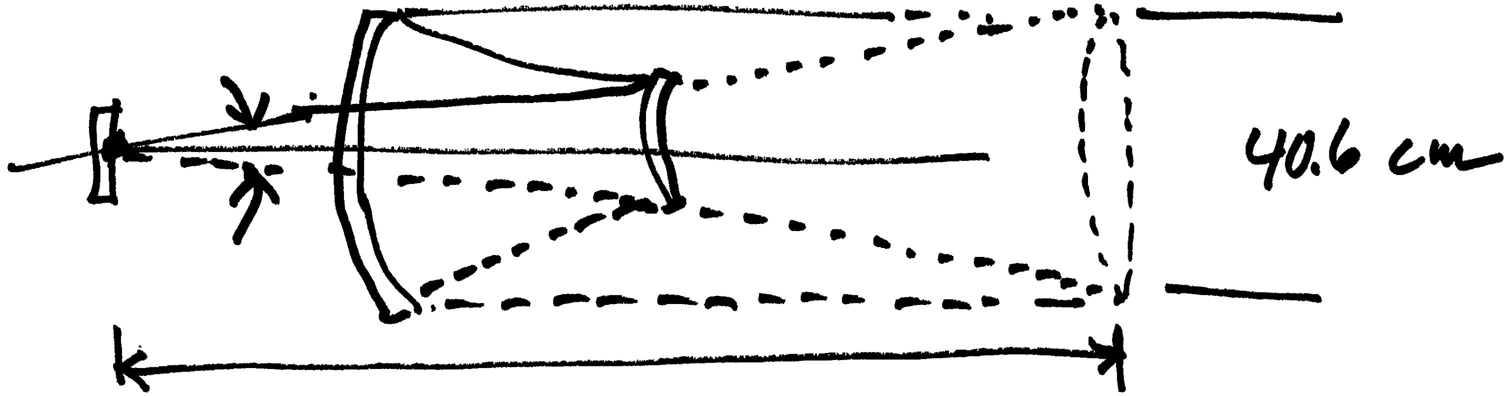
$$\text{slope} = m = \tan(\beta)$$

Ray Trace Steps

for homework 1

have m, x_1, y_1 $\Rightarrow$ $y = mx + (y_1 - m x_1)$

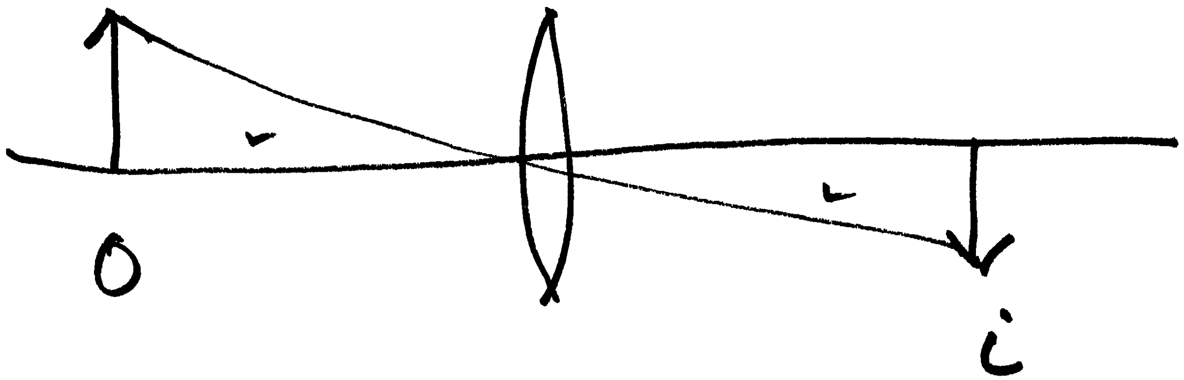
5. do again



dot product

$$\hat{r} \cdot \hat{n} = r_x n_x + r_y n_y$$

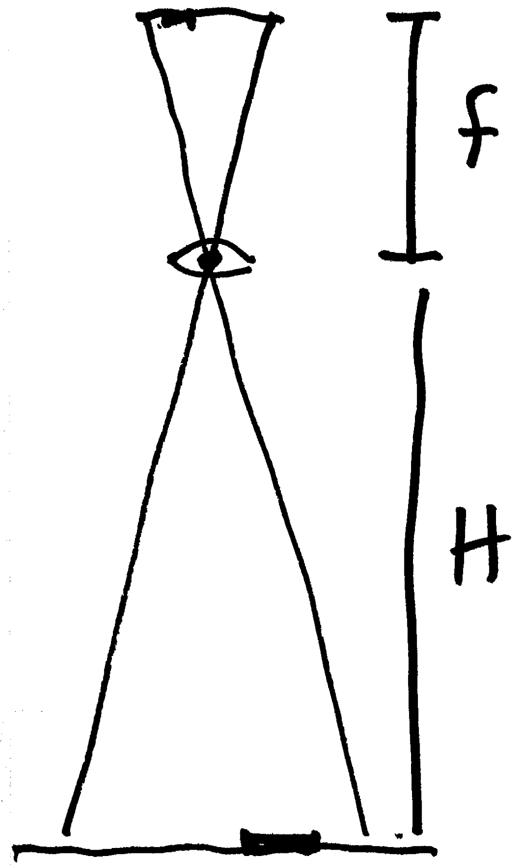
dot(r, n)



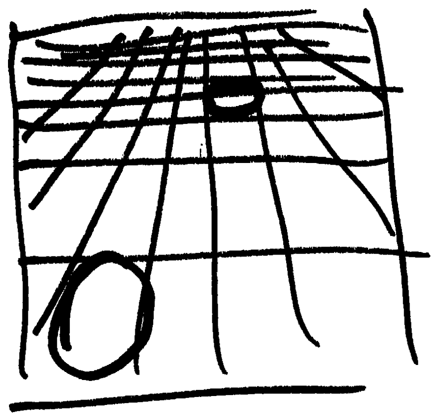
magnification

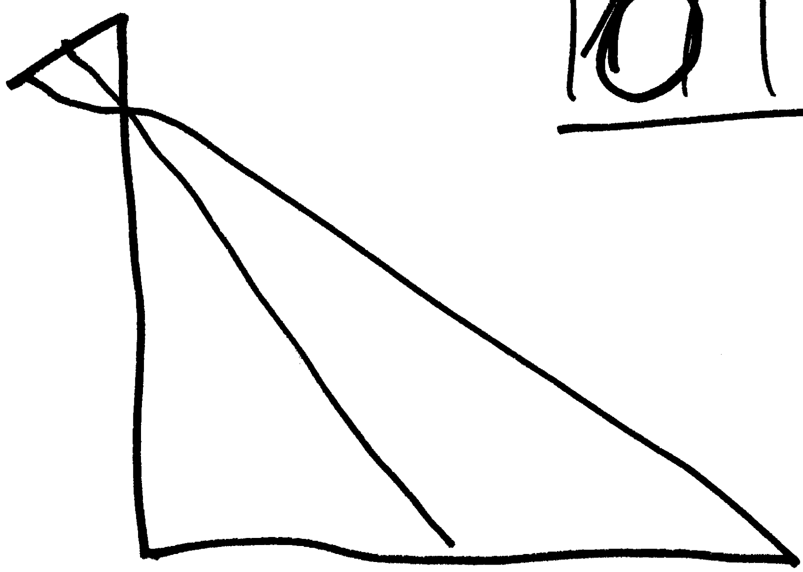
Scale $\dfrac{\text{image size}}{\text{object size}} = \dfrac{i}{o}$

meas. ⊥ to optical axis



Scale = $\dfrac{f}{H}$





vertical photo ~ constant scale

oblique photo ~ scale different everywhere
different every direction

example for scale: $f = 152.4$ mm (6")

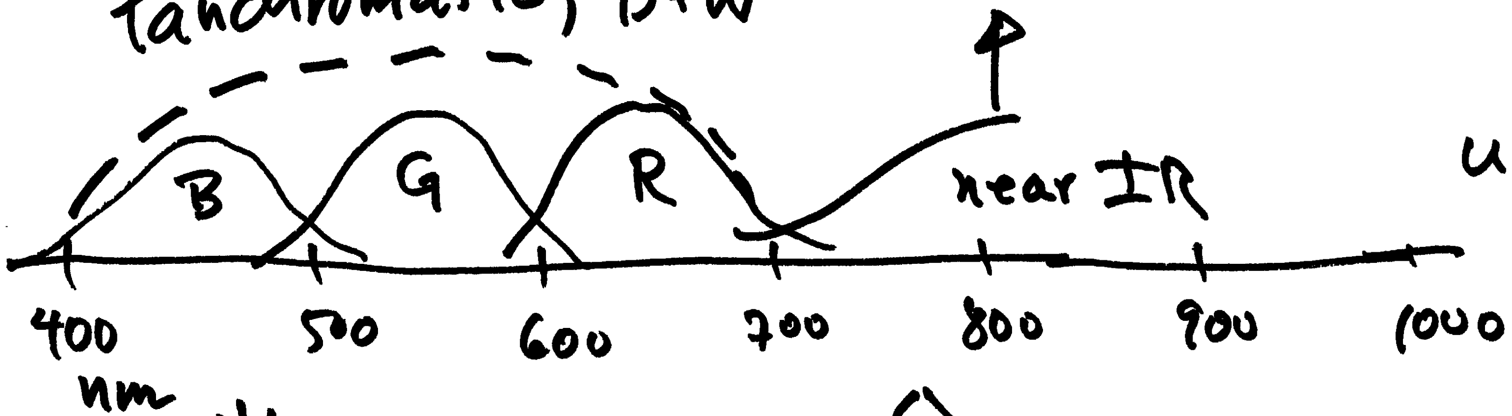
$H = 700$ m

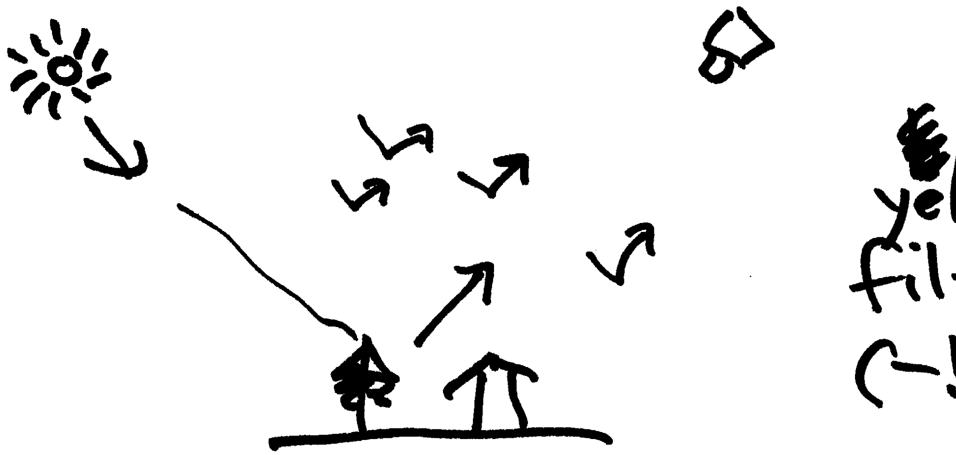
scale: $\frac{0.1524}{700} = 2.177 \times 10^{-4} = \frac{1}{4593}$

1:4593

unitless ratio

Panchromatic, B+W

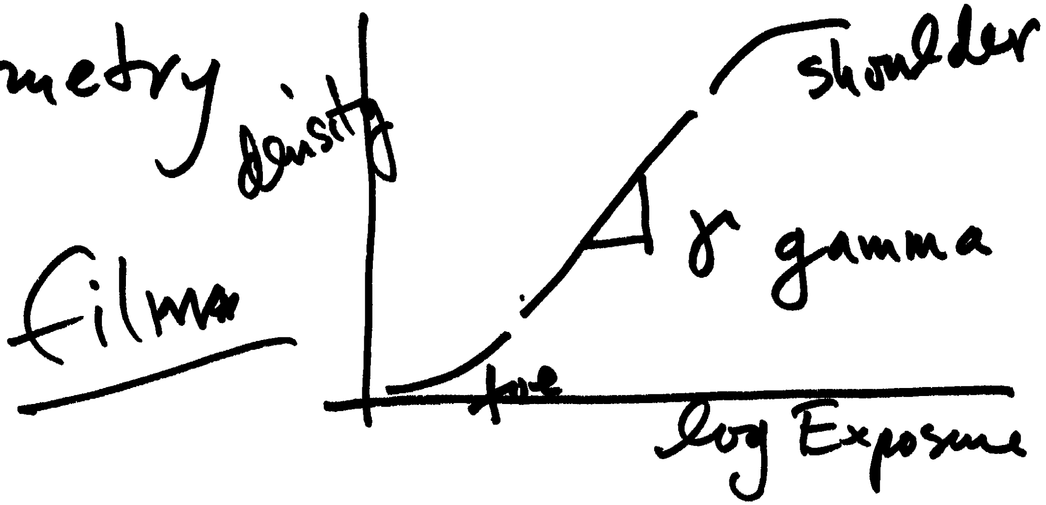


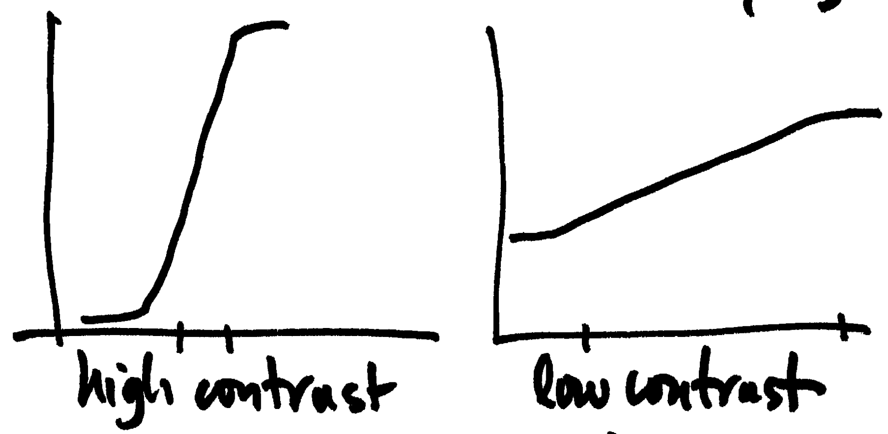


yellow filter (−blue)

Sensitometry

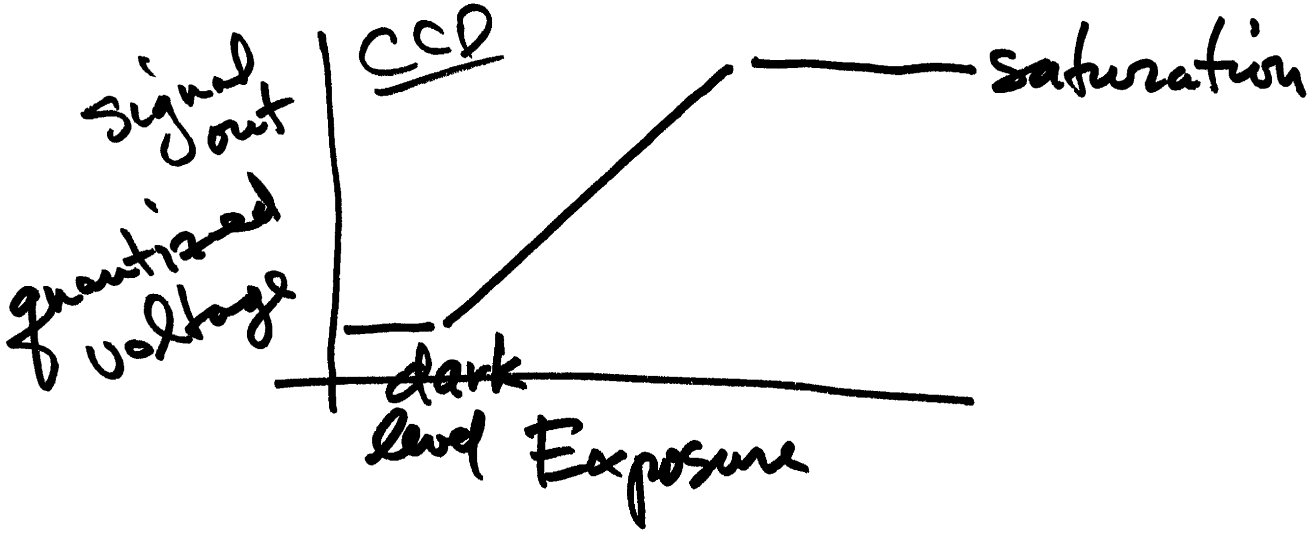
film





wide "latitude"

forgiving of wrong exposure



CCD benefits

more linear response
higher dynamic range
geometrically stable
QE proportion of photons which produce electron
extra images are "free"

geometry:

relief displacement

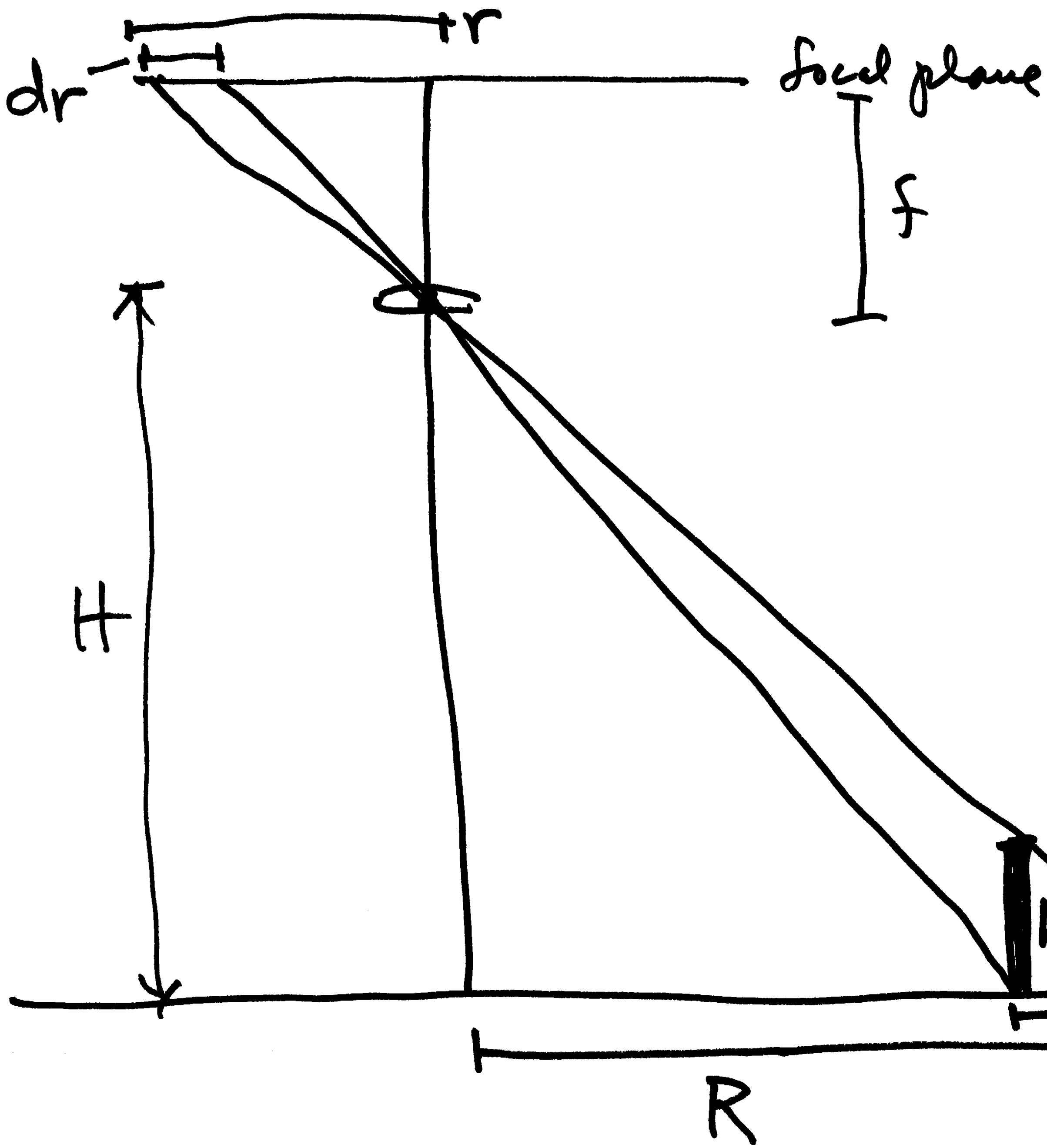
(frame)

radar (SAR)

layover

Relief Displacement

determine height of object



$$\frac{h}{H} = \frac{dR}{R}$$

$$\frac{dR}{R} = \frac{dr}{r}$$

$$\frac{h}{H} = \frac{dr}{r}$$

$$h = \frac{dr}{r} H$$

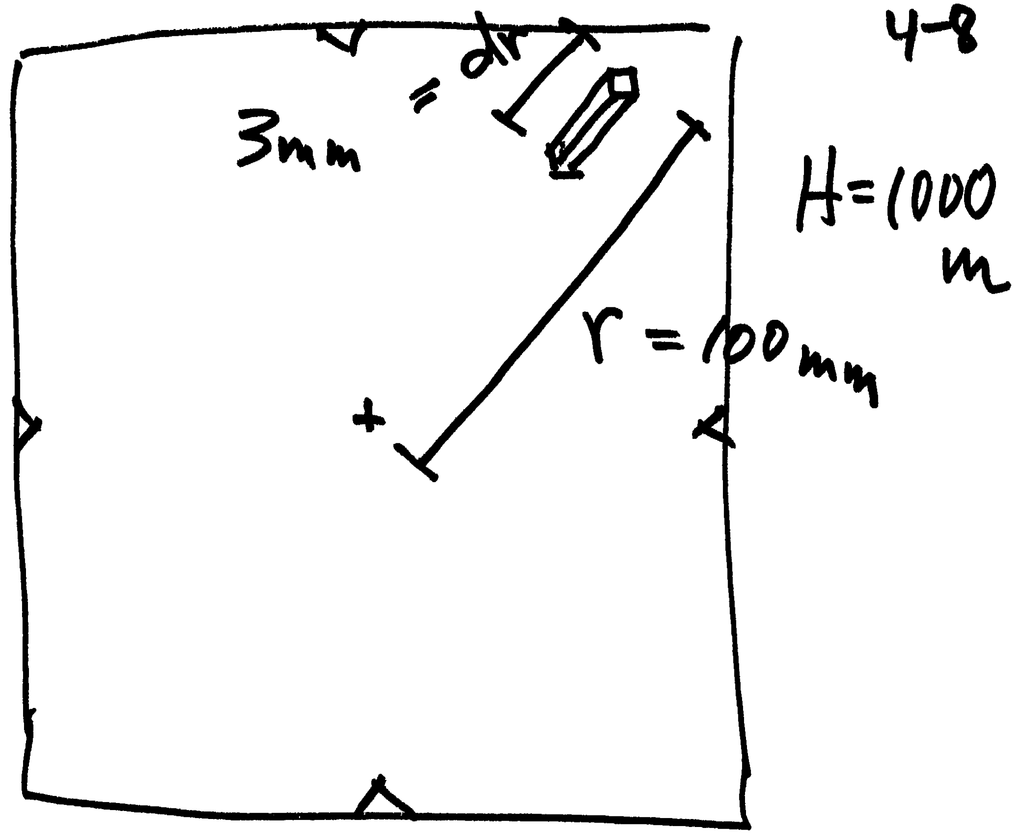
height of object from single photograph

assumed: Vertical photo
PP = Nadir point

$$h = \frac{dr}{r} H$$

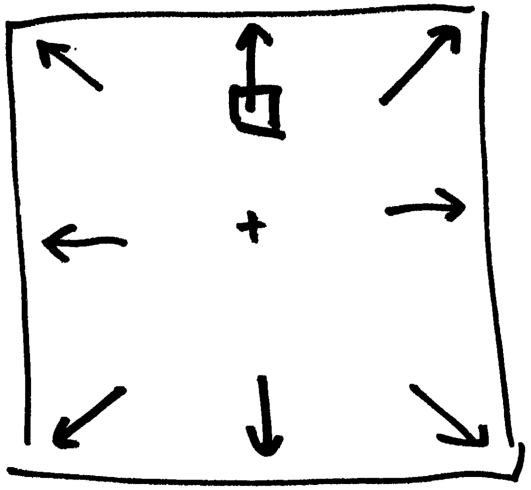
r ← measure

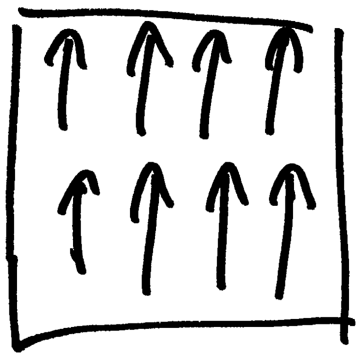
H ← auxilliary sensor (infer from scale)

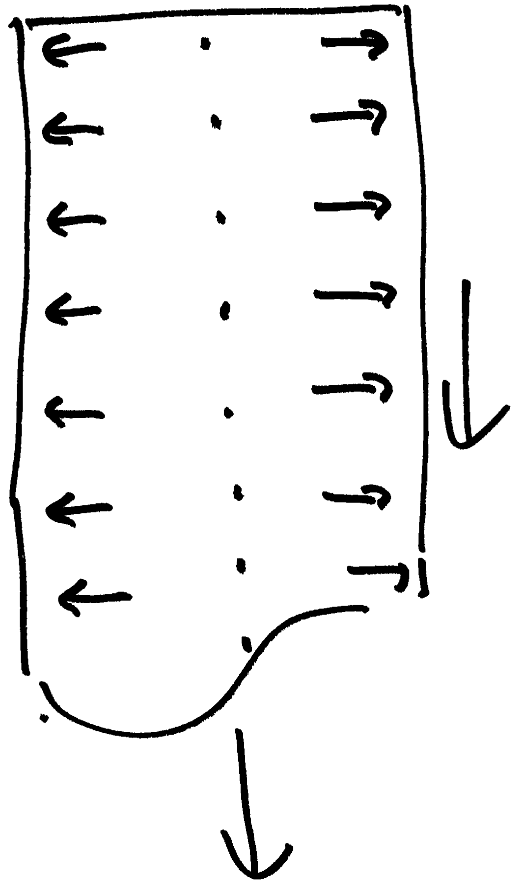


$$h = \frac{3}{100} \cdot 1000 = \underline{30\,m}$$

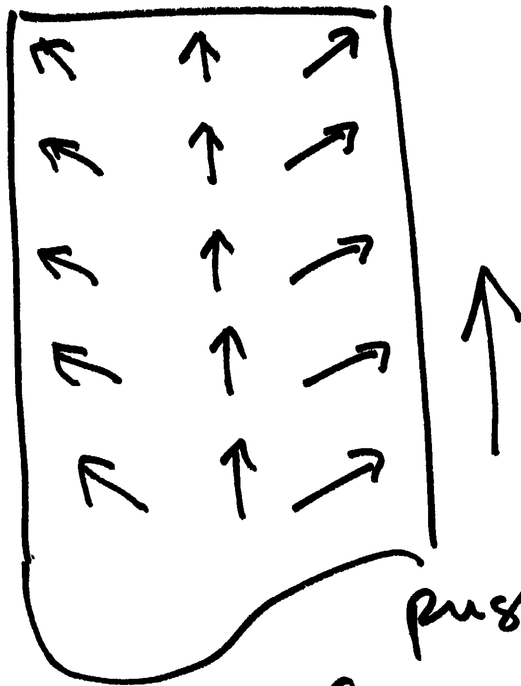
example for relief displacement







pushbroom
nadir
view

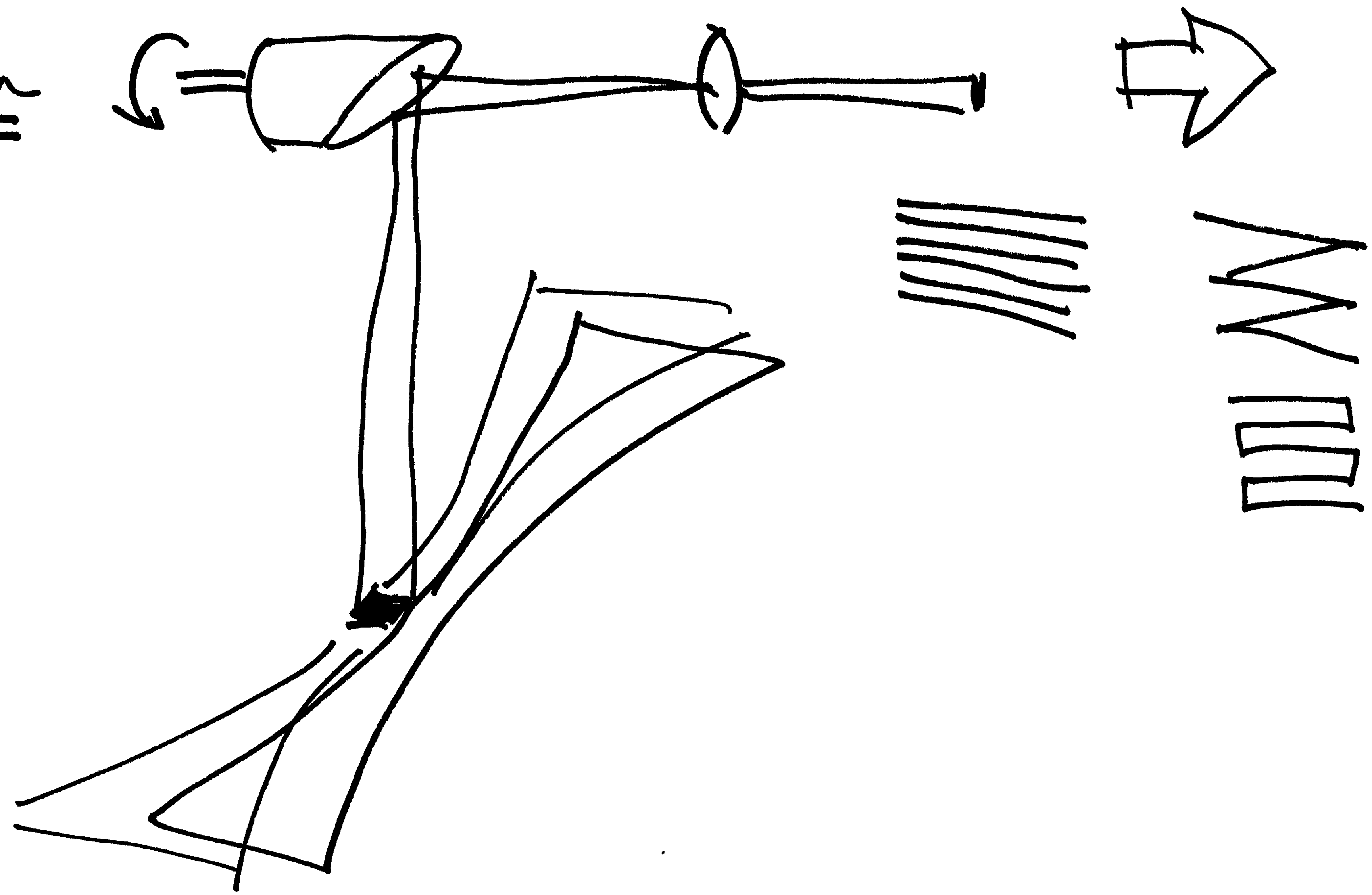


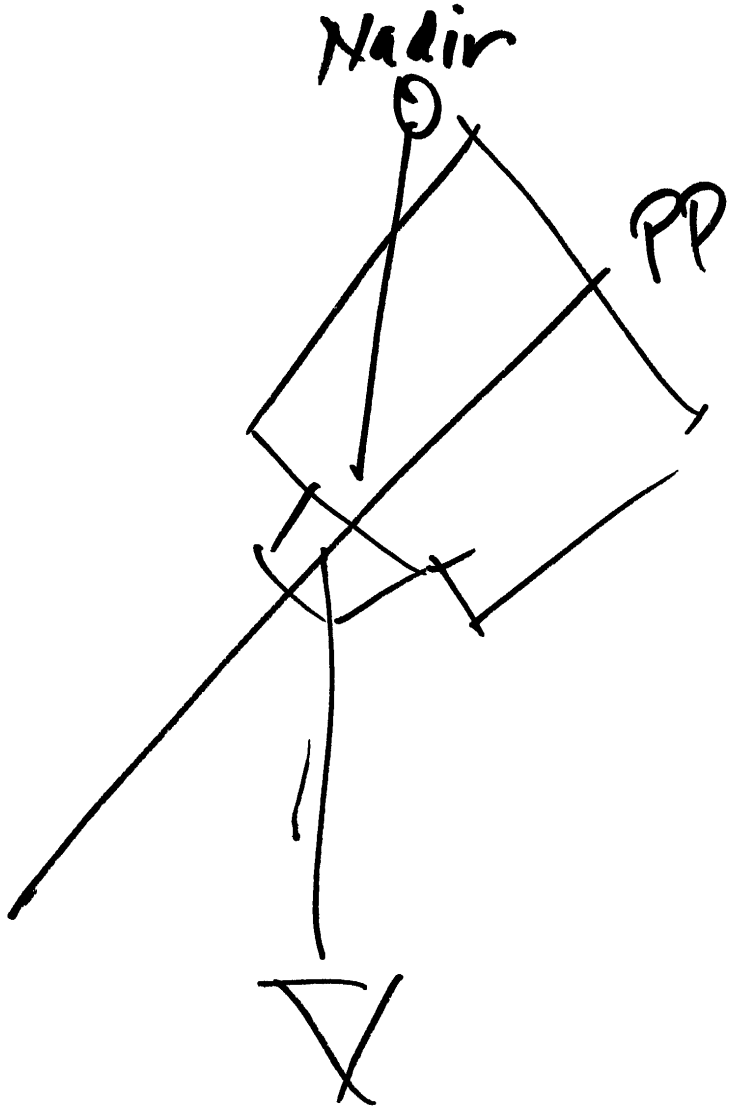
pushbroom
forward looking
view

relief displacement in

- frame
- pushbroom

frame (pinhole) ✓
pushbroom
whiskbroom




Nadir
PP