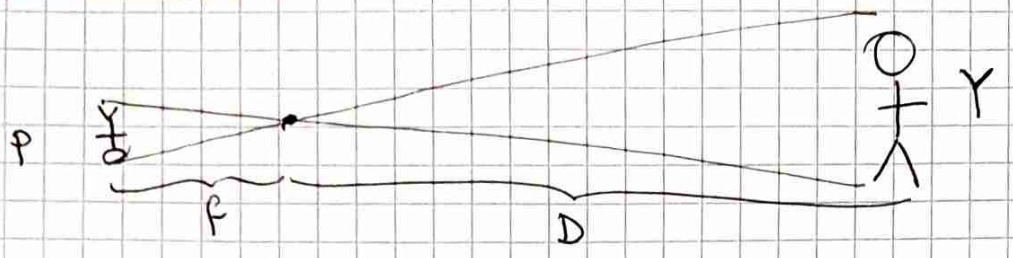
- Pinhole model



- p & f are in pixels, D and Y in meters, for example.
- P is to f as Y is to D:

$$\frac{P}{f} = \frac{Y}{D} \qquad (1)$$

~~Problem:~~

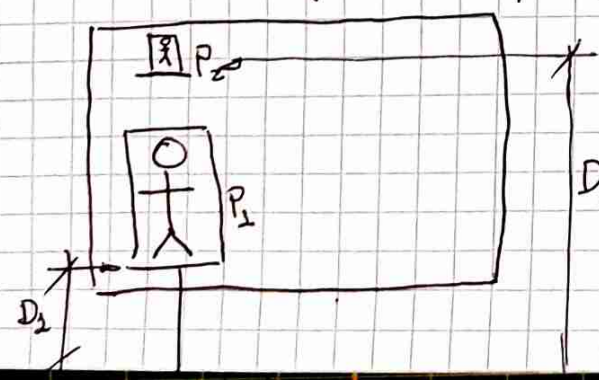
Example intrinsics matrix for Samsung S8 @ 1280x720:

$$K = \begin{vmatrix} 986.58 & 0 & 656.44 \\ 0 & 921.43 & 356.22 \\ 0 & 0 & 1 \end{vmatrix} = \begin{vmatrix} f_u & 0 & c_u \\ 0 & f_v & c_v \\ 0 & 0 & 1 \end{vmatrix}$$

- The value 986.58 is the ~~vertical~~ horizontal focal distance $(0,0)$
- The value 921.43 is the vertical focal distance $(1,1)$
- Both can be calculated manually, using (1)

Problem:

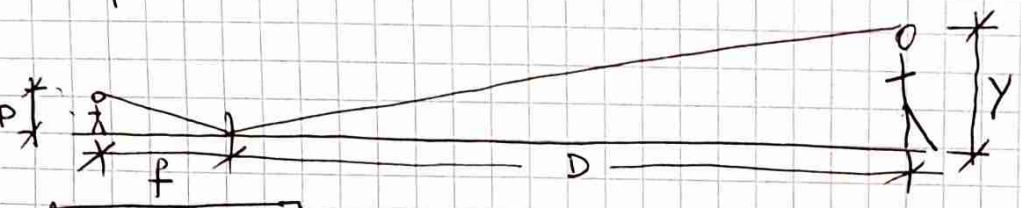
a) Having P (person height, in pixels), f (focal distance, in pixels, which can be obtained from the matrix K or Sy using (1)) and Y (person height, in meters), calculate D.



- use the foot line, for verticals,
- use the center, for horizontals:
  → ⊥

a) Camera on the floor.

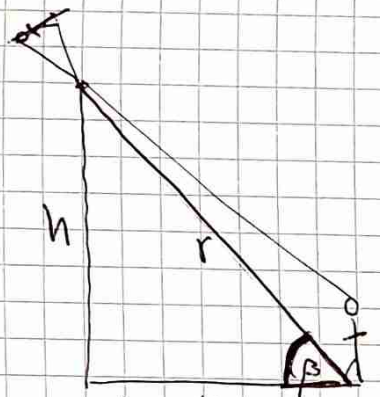
- This image is equivalent to the first one:

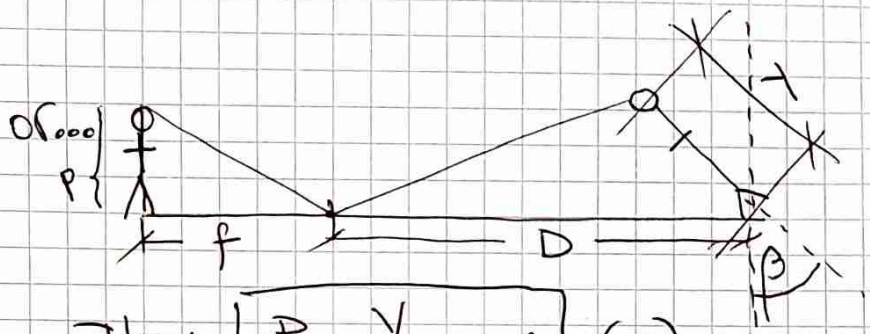


- given (1), then, $\boxed{D = \frac{Yf}{P}}$ (2); Example: $D = \frac{1.74m \times 921.43px}{120px}$

$\Rightarrow \boxed{D = 13.36m}$ (R1)

b) Camera on a pole:





Then, $\boxed{\frac{P}{f} = \frac{Y}{D}\cos\beta}$ (3)

$\boxed{\cos\beta = \frac{D}{r} = \frac{D}{\sqrt{D^2+h^2}}}$ (4)

So, from (3) and (4): $\frac{P}{f} = \frac{Y}{D} \cdot \frac{D}{\sqrt{D^2+h^2}} \Rightarrow$

$\Rightarrow D^2 + h^2 = \left(\frac{Yf}{P}\right)^2$ and $\boxed{D = \sqrt{\left(\frac{Yf}{P}\right)^2 - h^2}}$ (5)

final solution!

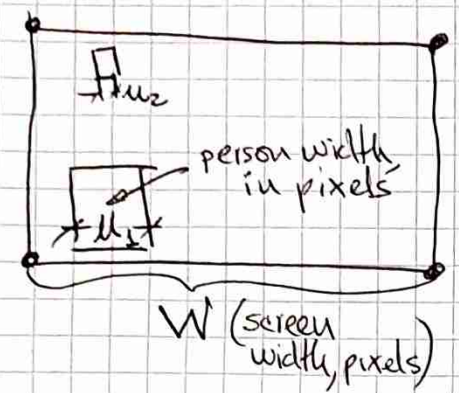
Example: Pole has Øm: $D = \frac{Yf}{P}$ (same as (1)) ✓

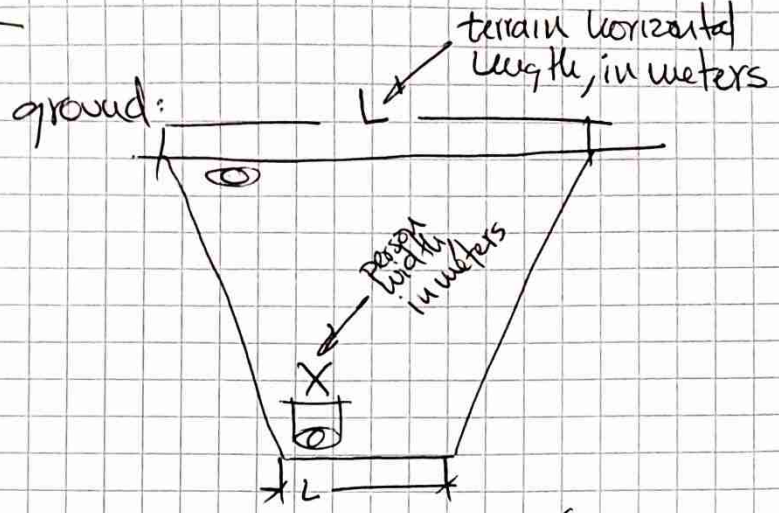
Pole has 5m: $D =$ (from (R1))

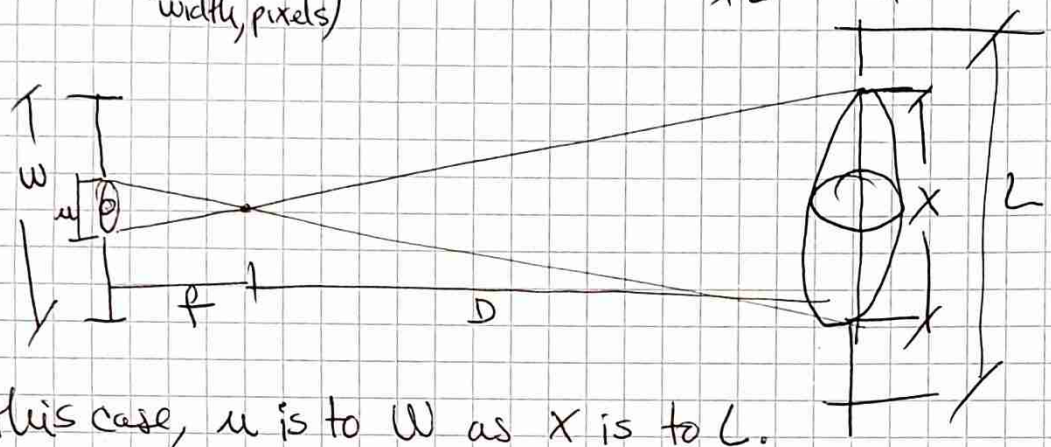
$D = \sqrt{(13.36m)^2 - (5m)^2}$

$D = 12.39m$ ✓ (seems right!)

c) Horizontal measurement







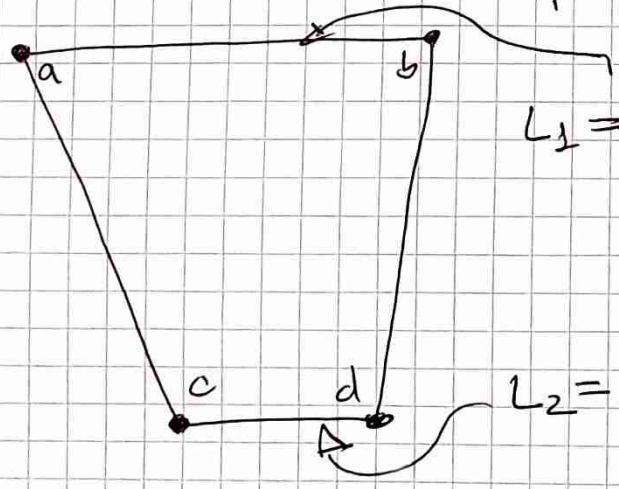
In this case, u is to W as X is to L.

$$\frac{u}{w} = \frac{X}{L} \quad (6), \text{ then } \boxed{L = \frac{X\,W}{u}} \quad (7)$$

- no need of rotations!

Example:

- The physical average width of this person is 0.5m.
  Width = ~~18~~ 1280px and, when near the camera, the person detection measures 35px. On the farthest point, she measures 3px.



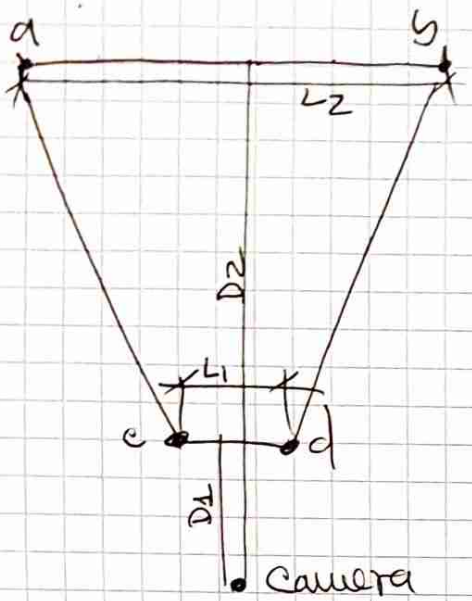
$$L_1 = \frac{0.5m \cdot 1280px}{3px} = 213.33$$

$$L_2 = \frac{0.5m \cdot 1280px}{35px} = 18.29m$$

- Now, we have ~~a~~ a, b, c, d, relative to the camera!

d) to WGS84.

Now, we have the four points relative to the camera:



~~Having~~ Problem: given the heading angle of the camera, convert it to WGS84 coords. them

Solution 1: Having the equivalence LAT/size in meters and LON/size in meters, calculate the positions one by one.

solution 2: Stackoverflow 7222382