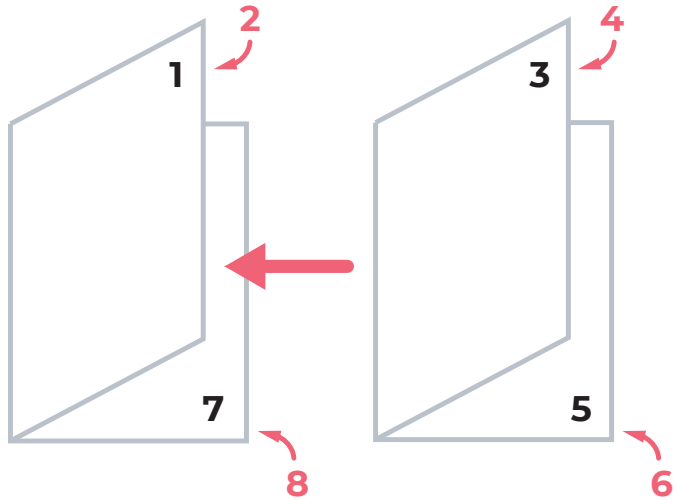




## To assemble the booklet:



Print on two A4 sheets using both sides (select short-edge binding), then assemble the booklet by folding the sheets in two.

## To do measurements with your smartphone:

Install Phyphox app on your phone. This app is developed by Aachen University, it's free and open-source, translated in English and available for Android and iOS. Phyphox allows to conduct measurements using your smartphone built-in sensors.



Precision: high



Difficulty: low

# Nº54. Number of Pixels

## Formula

$$H \propto \frac{1}{\sqrt{N}}$$

## Material

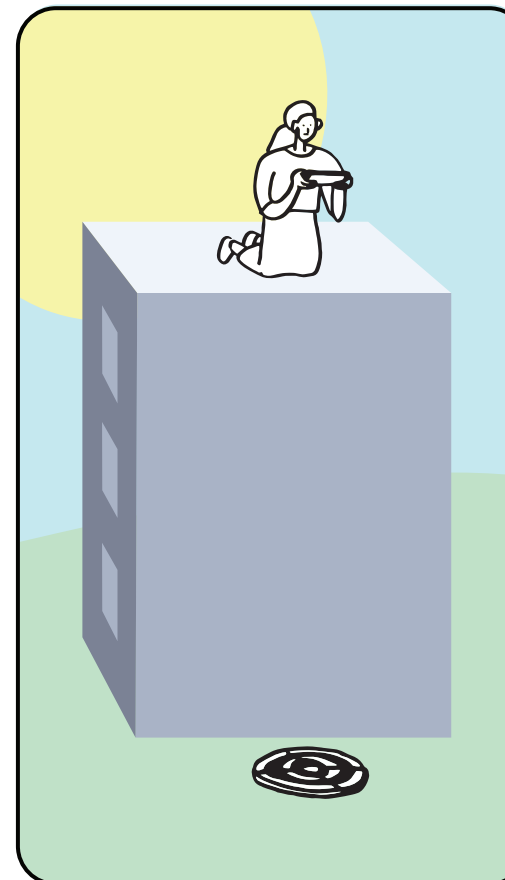


1 target



Sensor: camera

1 smartphone



Install the target at the bottom of the building, and take a picture from the top of the building. The number of pixels representing the target in the picture varies in  $1/R^2$ , and must be calibrated before.

$N$  = number of pixels



Precision: maximum



Difficulty: minimum

# Nº28. Picture with Scale

## Formula

$$H = \frac{d_2}{d_1} l$$

## Material

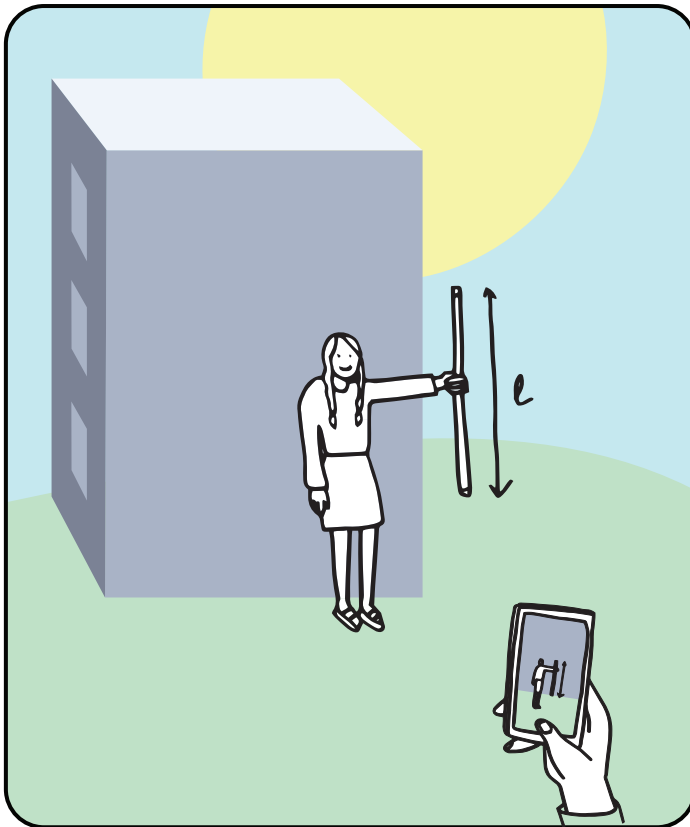


1 bar of known size

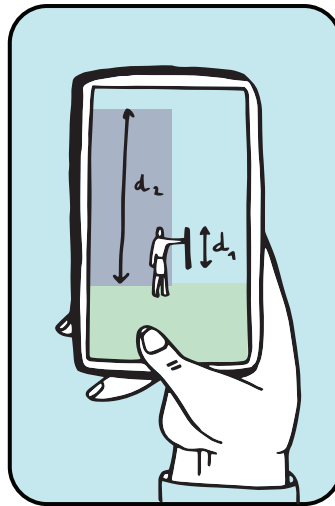


1 smartphone

Sensor:  
**camera**



Minimize perspective distortion while taking the picture!



Take a picture of the facade of the building, with the bar serving as a scale. Measure the sizes of the building and the bar on the picture.

$d_2$  = size of the building on the photo,  $d_1$  = size of the bar on the photo,  $l$  = actual size of the bar



Precision: high



Difficulty: minimum

# Nº21. Thales and the Shadows

## Formula

$$H = h \frac{l_2}{l_1}$$

## Material

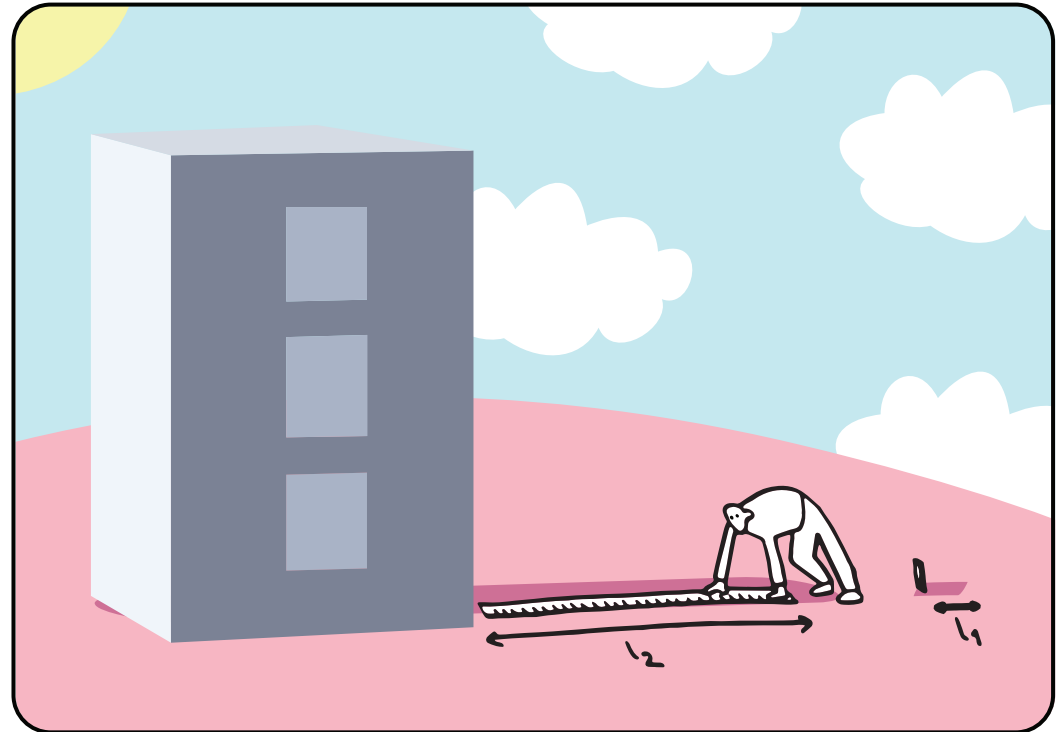


1 tape measure



1 smartphone

Measure the shadow of a smartphone and the shadow of the building. Use Thales' method to determine the height of the building from the height of the smartphone.



$h$  = height of the smartphone  $l_2$  = shadow of the building,  $l_1$  = shadow of the smartphone



Precision: maximum



Difficulty: low

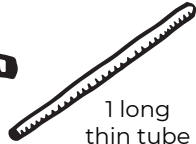
# Nº24. Trigonometry Version 1

## Formula

$$H = h + l \tan \alpha$$



1 tape measure



1 long thin tube

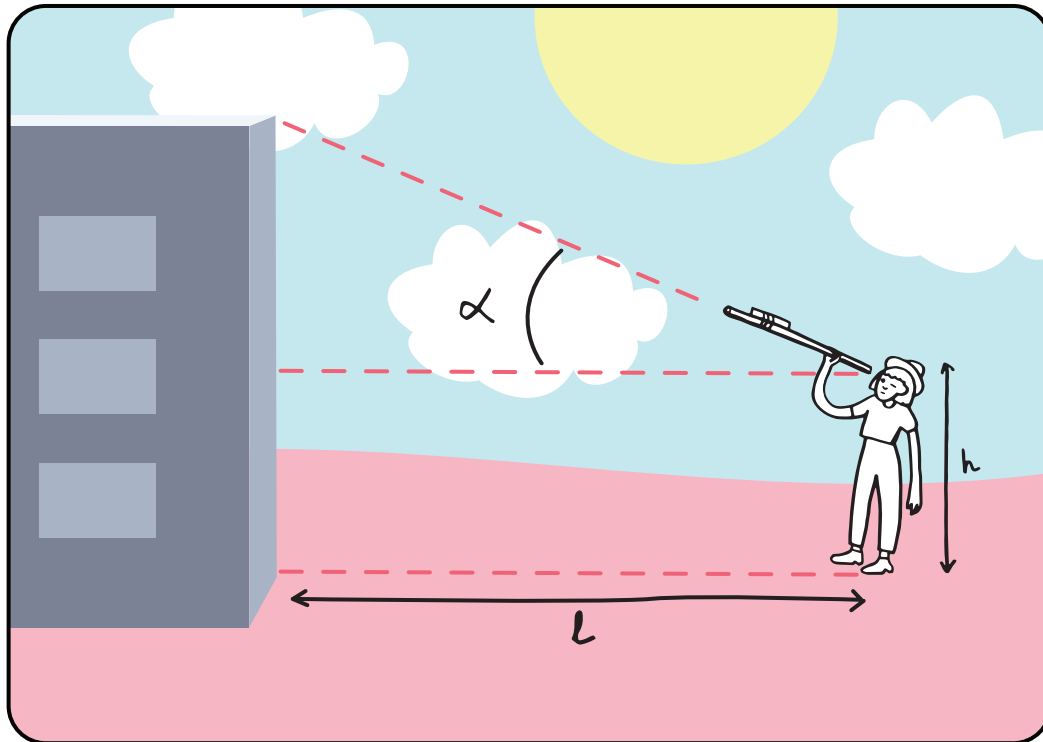


1 smartphone

Sensor: accelerometer

Attach the smartphone to the tube, and go at a known distance from the building. With the accelerometer, measure the inclination from the horizontal when you aim at the top of the building.

$h$  = height of eye of the investigator,  $l$  = distance to the building,  $\alpha$  = angle of the top of the building



Precision: high



Difficulty: minimum

# Nº27. Angle of View of a Picture

## Formula

$$H = \frac{l}{2 \tan(\alpha/2)}$$



1 bar of known size



1 protractor

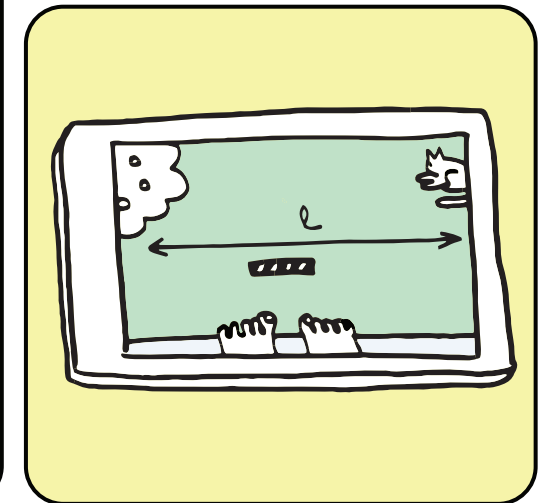
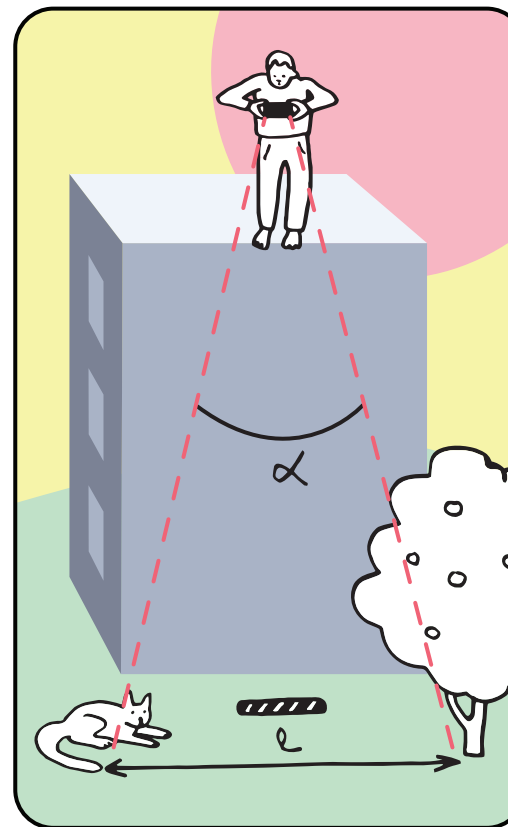


1 smartphone

Sensor: camera

From the top of the building, take a picture of the ground, and determine the length of the ground photographed, the bar serving as a scale. Using the protractor, determine the angle of view of your smartphone.

$l$  = length of ground visible in the picture,  $\alpha$  = smartphone angle of view



The angle of view can also be determined by taking a picture of the bar at a known distance.