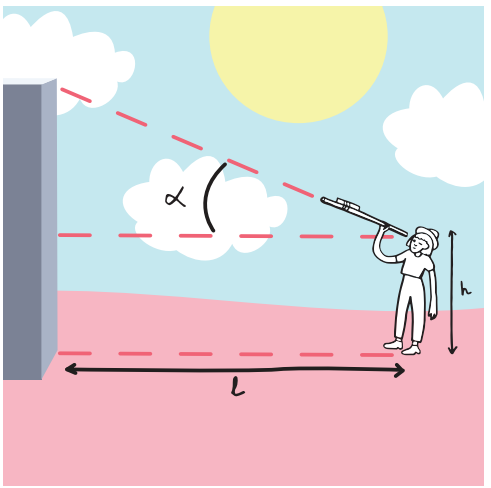
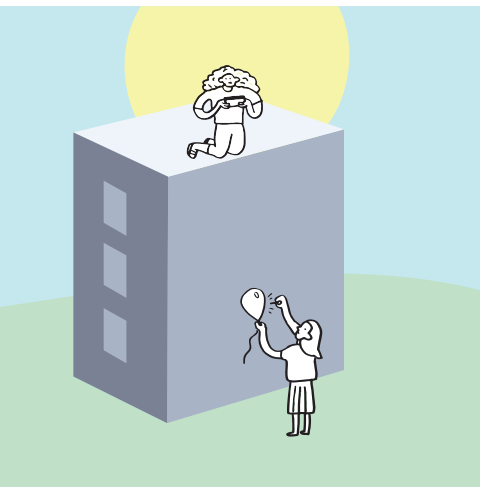
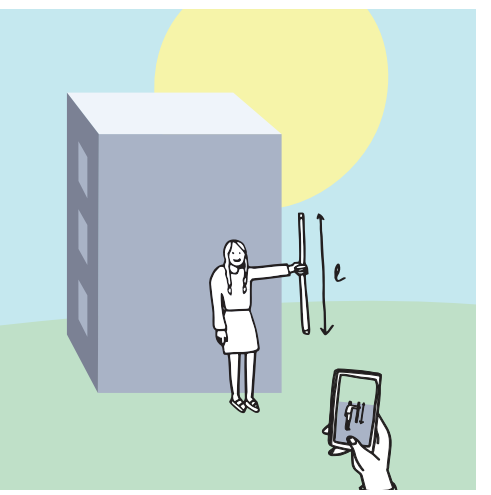


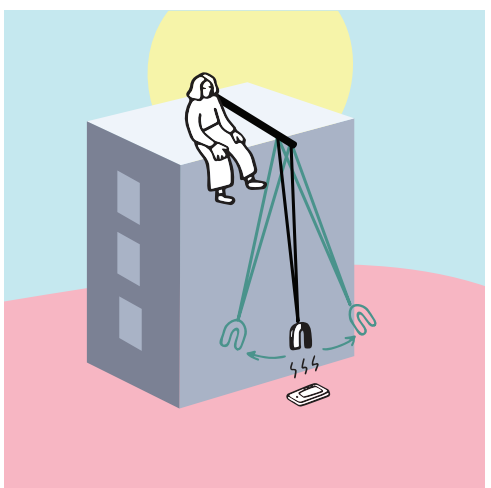



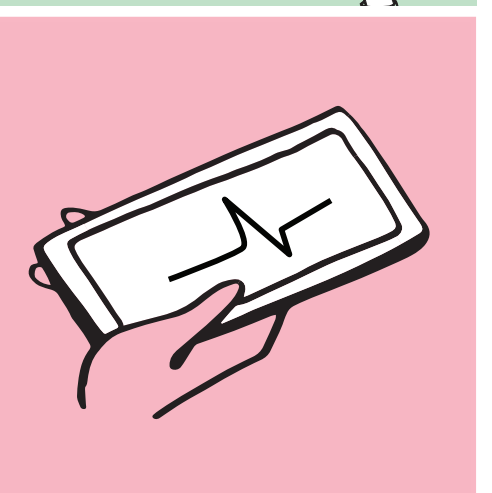
Theme:

# MATHEMATICS

All the methods using mathematics principles and smartphones to determine the height of a building.





**Discover The Smartphone Physics Challenge at VULGARISATION.FR**

«Physics Reimagined» team (Paris-Saclay University)

Precision: high

Difficulty: minimum

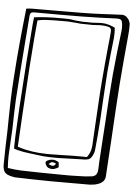
# №21. Thales and the Shadows

## Formula

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

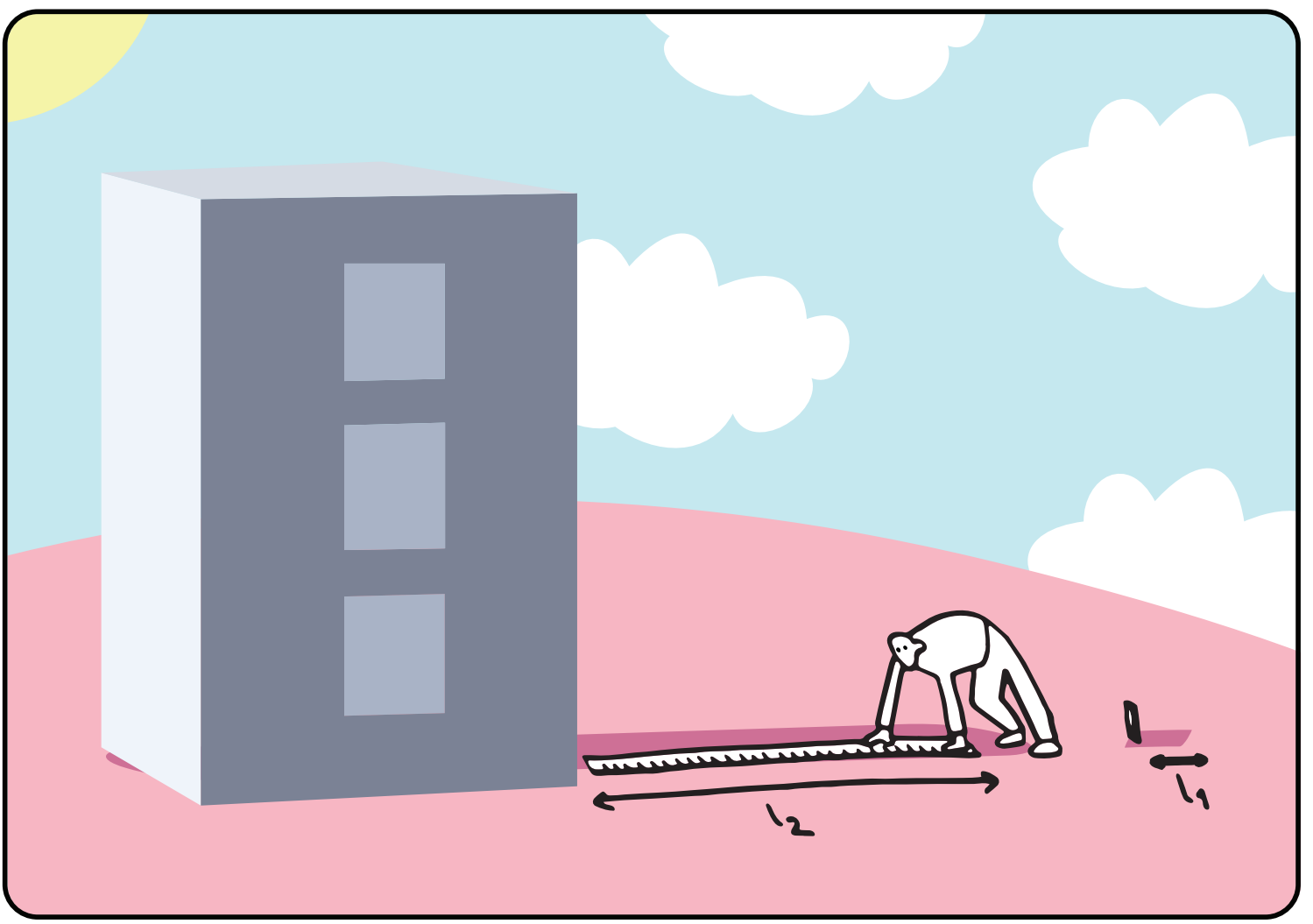
## Material

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: minimum

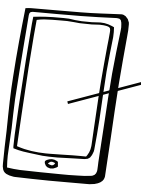
# №22. Shadow and Position of the Sun

## Formula

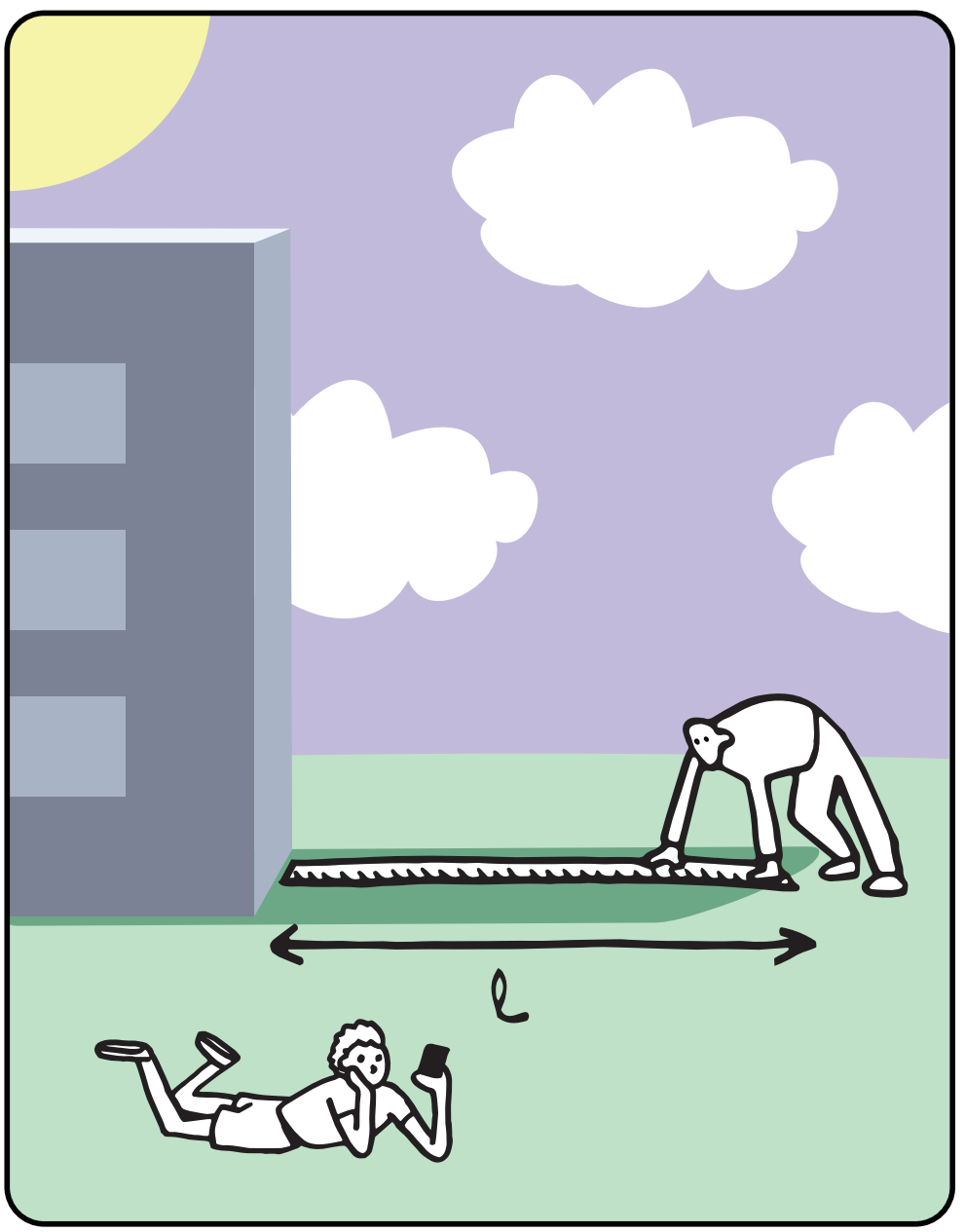
$$H = l \tan(\alpha)$$

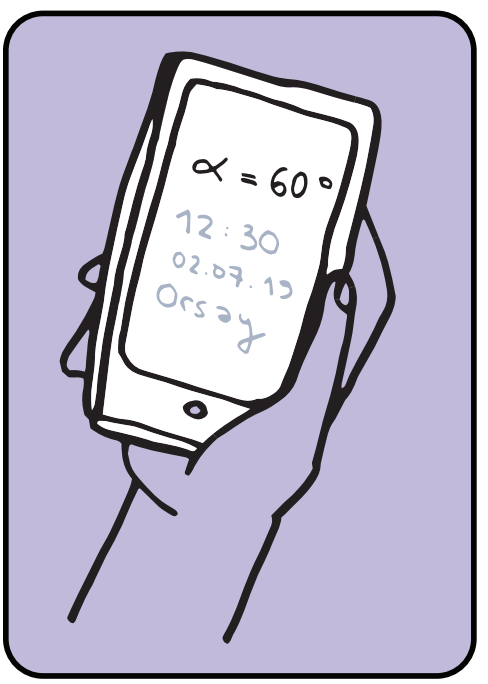
## Material

1 tape measure




1 smartphone




Measure the shadow of the building. Measure your latitude, longitude, and time with your smartphone. Find on the internet the elevation of the sun at that moment and place.

l = building shadow,
α = sun elevation

Precision: high

Difficulty: intermediate

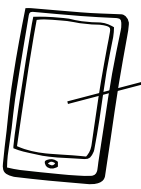
# №23. Shadow at the Equinox

## Formula

$$H = l \tan(\alpha)$$

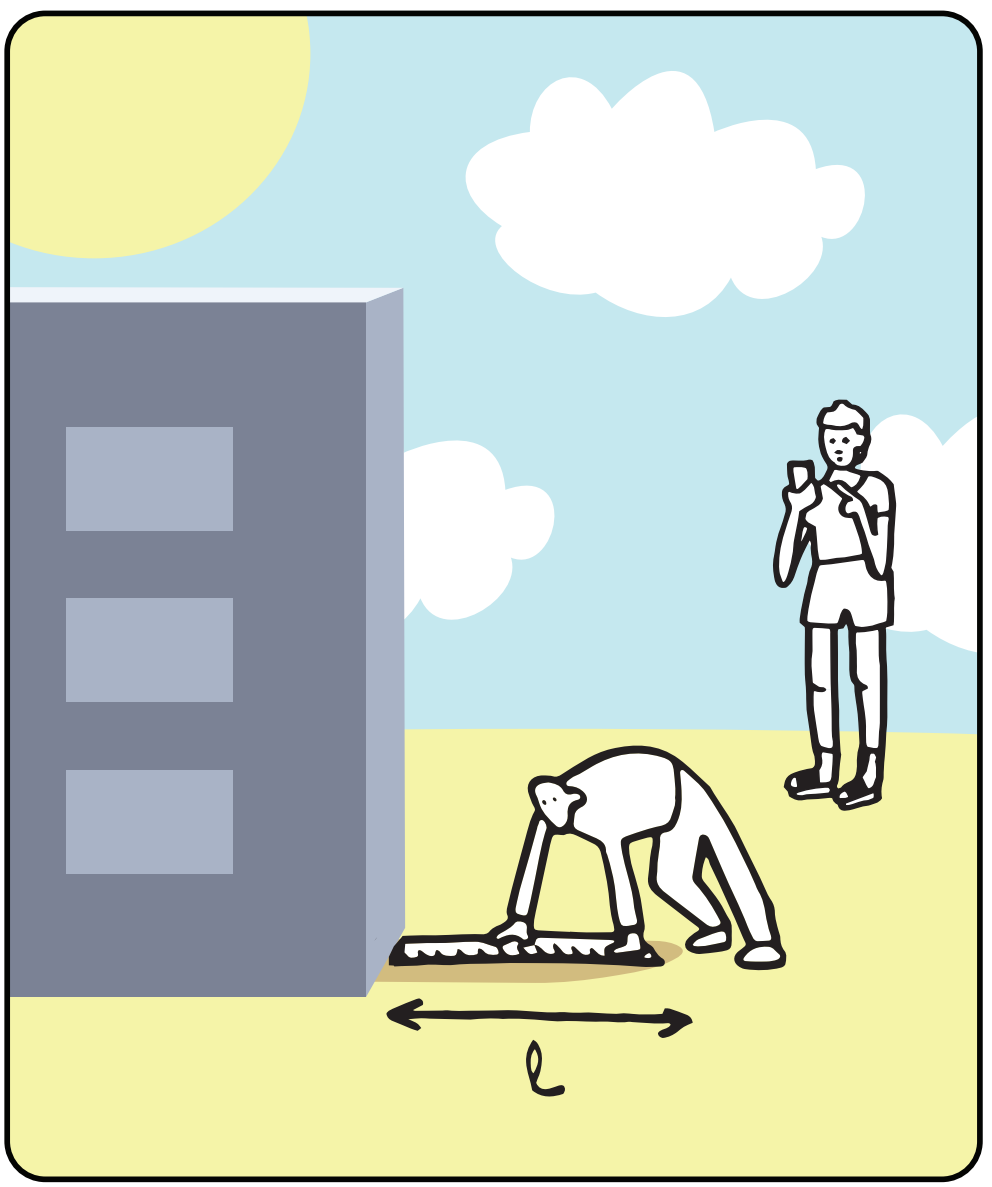
## Material

1 tape measure



Sensors:
**GPS, camera**

1 smartphone





Make a timelapse of the building shadow to determine the position of the shortest shade at noon. Measure the length of this shadow, as well as the latitude. At the equinox, the elevation of the sun corresponds to 90 ° - latitude.

l = building shadow,
α = sun elevation

*This method can be used at soltices by adding or subtracting the latitude of the tropics.*

Precision: maximum

Difficulty: low

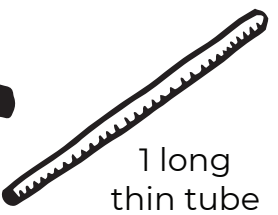
# №24. Trigonometry Version 1

## Formula

$H = h + l \tan \alpha$

## Material

1 tape measure



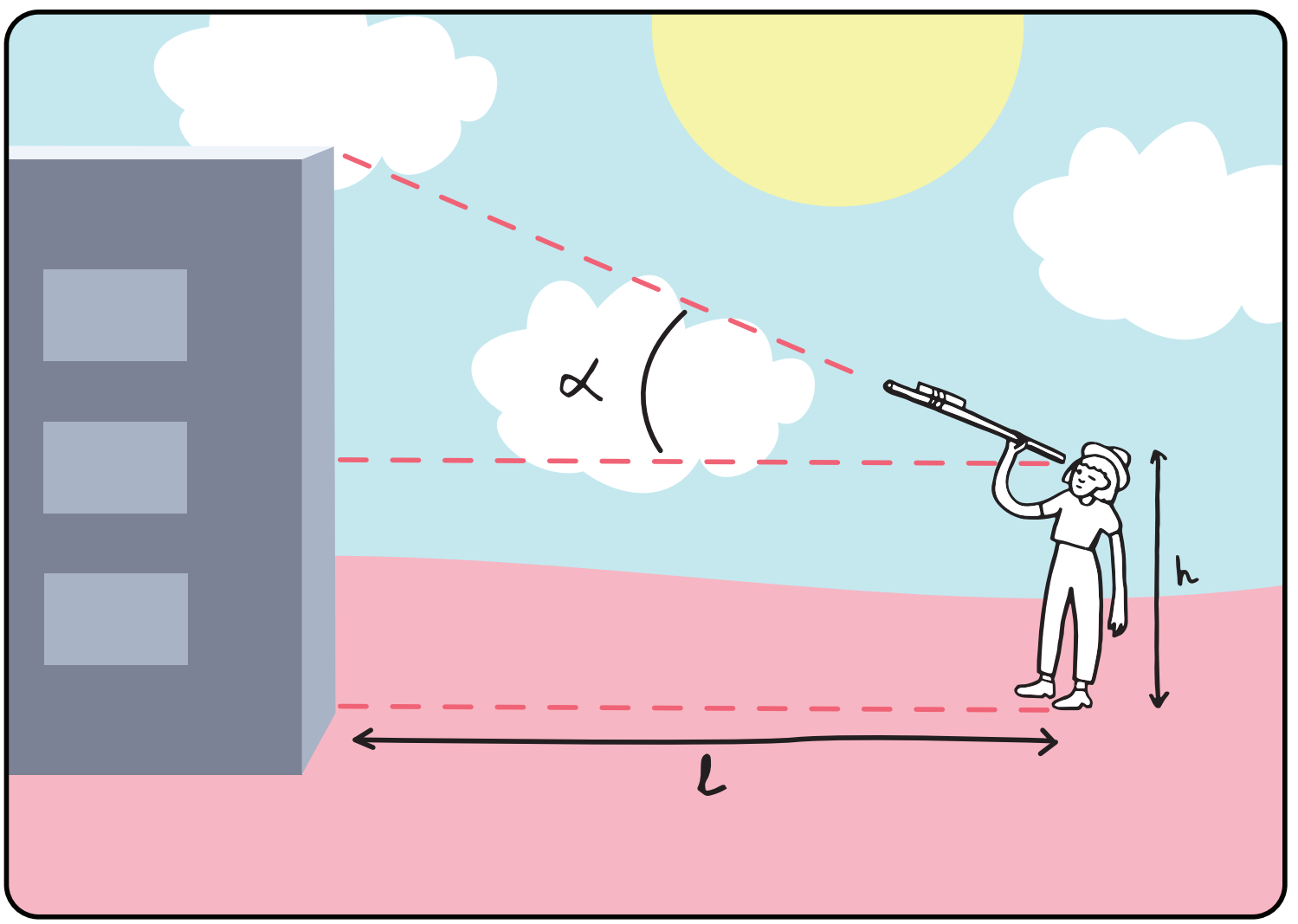
1 long thin tube

Sensor: **accelerometer**

1 smartphone

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: low

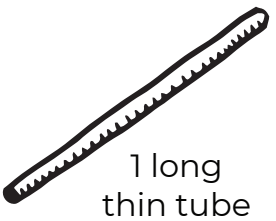
Difficulty: low

# №25. Trigonometry Version 2

## Formula

$$H = h + \frac{h}{\tan\alpha_2}\tan\alpha_1$$

## Material



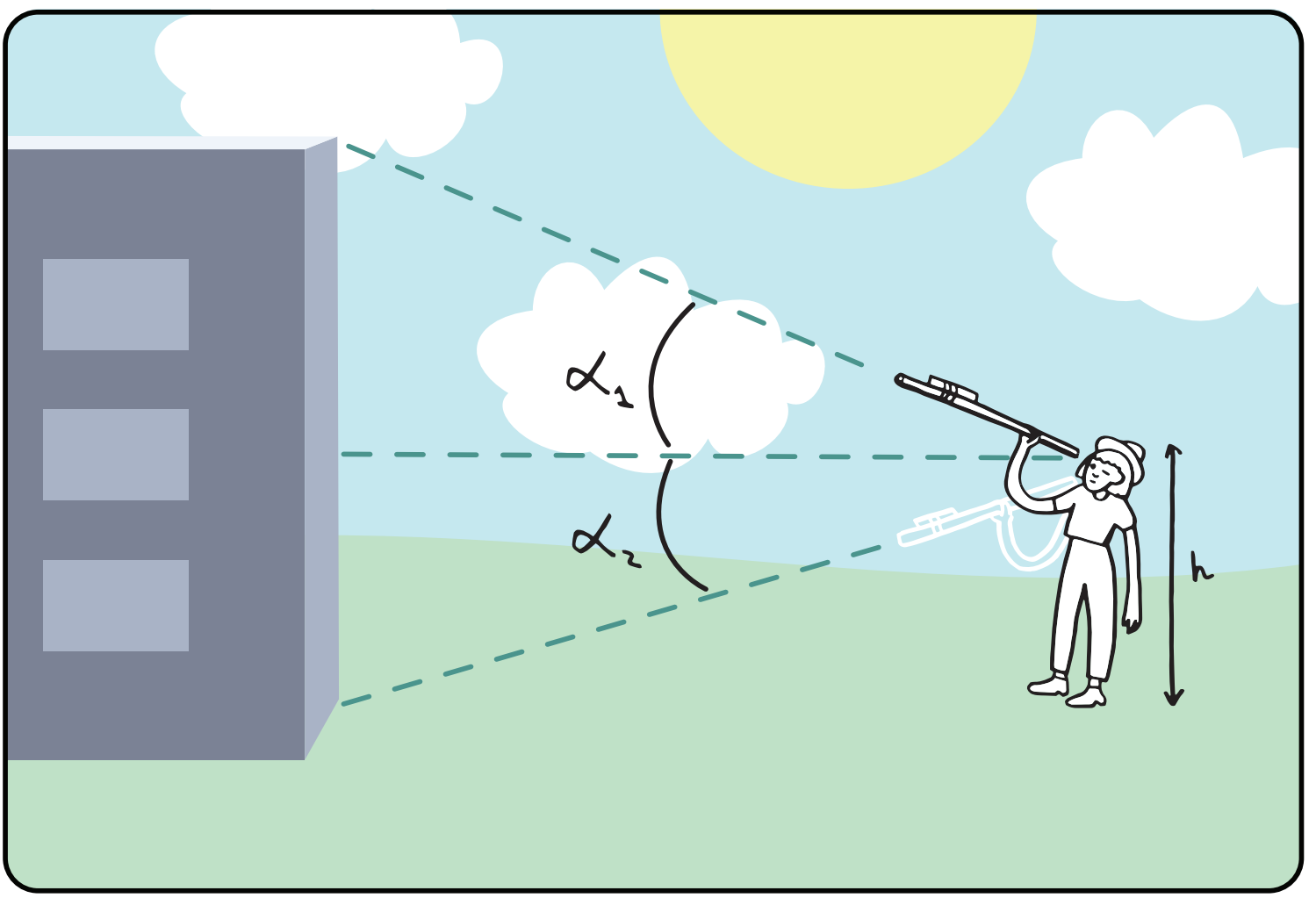
1 long thin tube

Sensor: **accelerometer**

1 smartphone

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

h = height of the eye of the investigator, $\alpha_1$= angle of the top of building, $\alpha_2$= angle of the bottom



Precision: intermediate

Difficulty: low

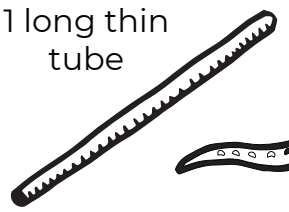
# №26. Trigonometry Version 3

## Formula

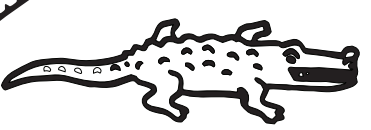
$$H = \frac{l}{2\tan(\alpha/2)}$$

## Material

1 long thin tube

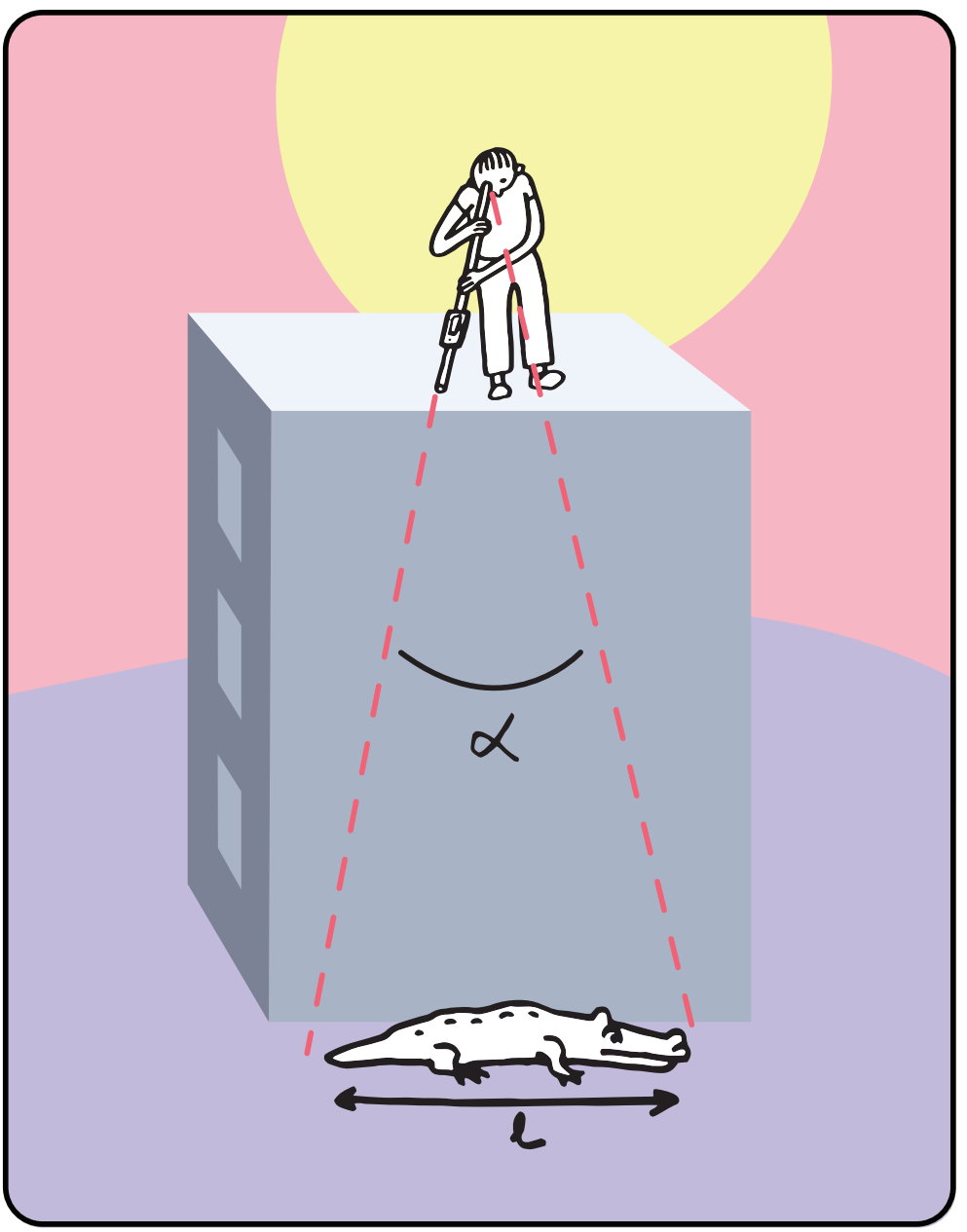


1 object of known size



Sensor: **accelerometer**

1 smartphone




Attach the smartphone to the tube, place the object of known size at the foot of the building, and go at the top, to the vertical of the object. Use the accelerometer to determine the angular size of the object.

l = size of the object, $\alpha$ = angular size of the object

Precision: high

Difficulty: minimum

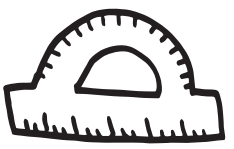
# №27. Angle of View of a Picture

## Formula

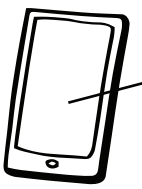
$$H = \frac{l}{2\tan(\alpha/2)}$$

## Material

1 bar of known size

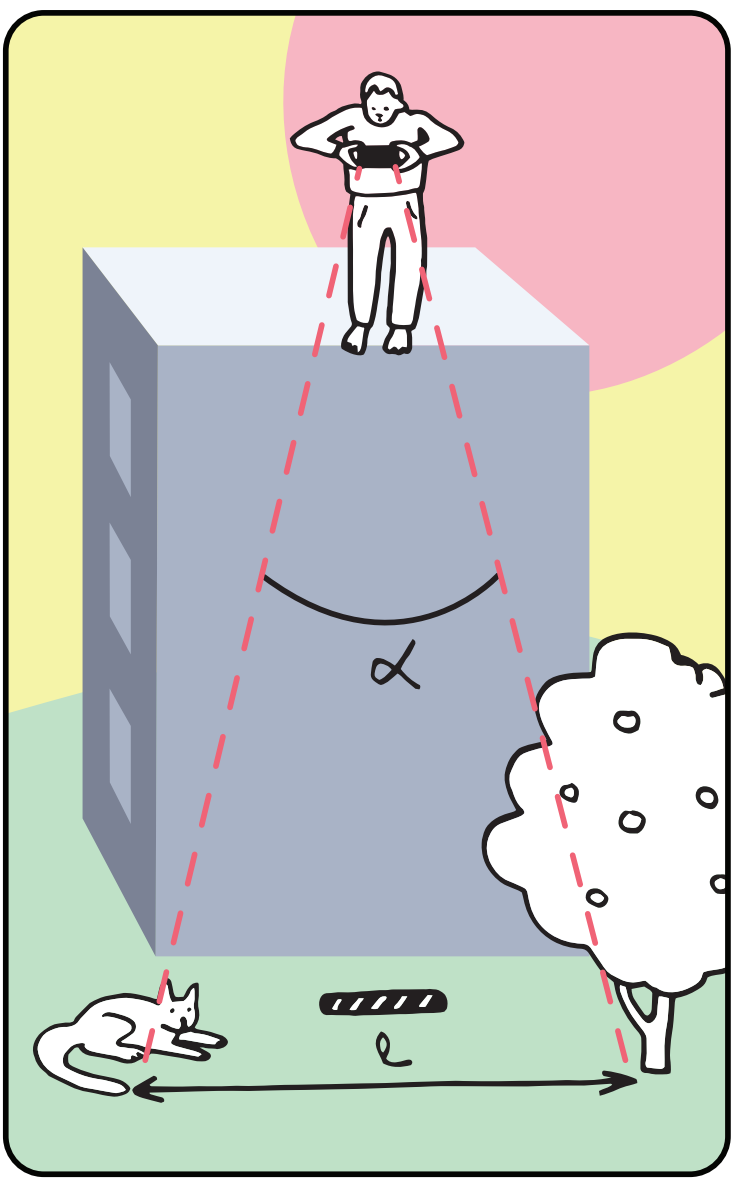


1 protractor



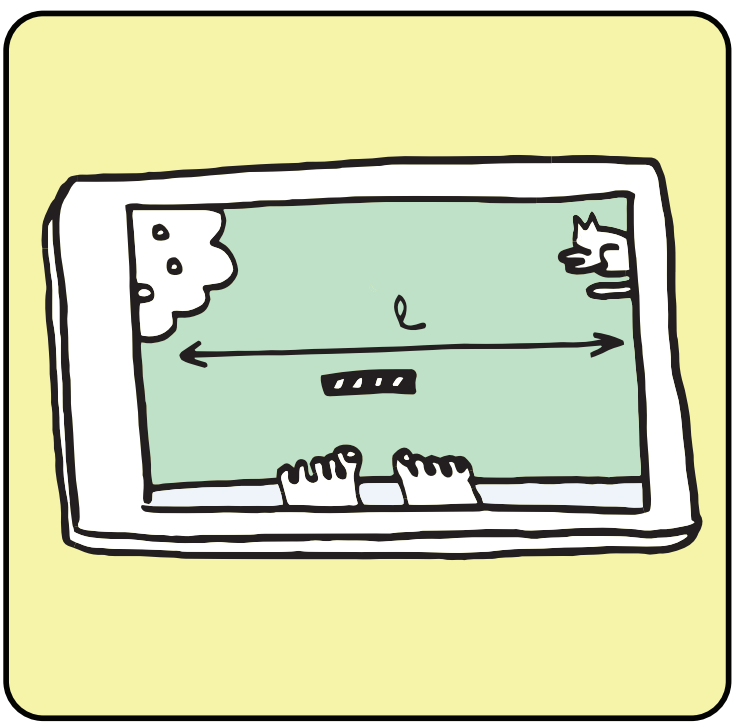
Sensor: **camera**

1 smartphone




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,
α = smartphone angle of view




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

Precision: maximum

Difficulty: minimum

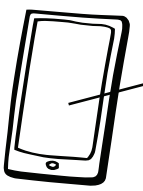
# №28. Picture with Scale

## Formula

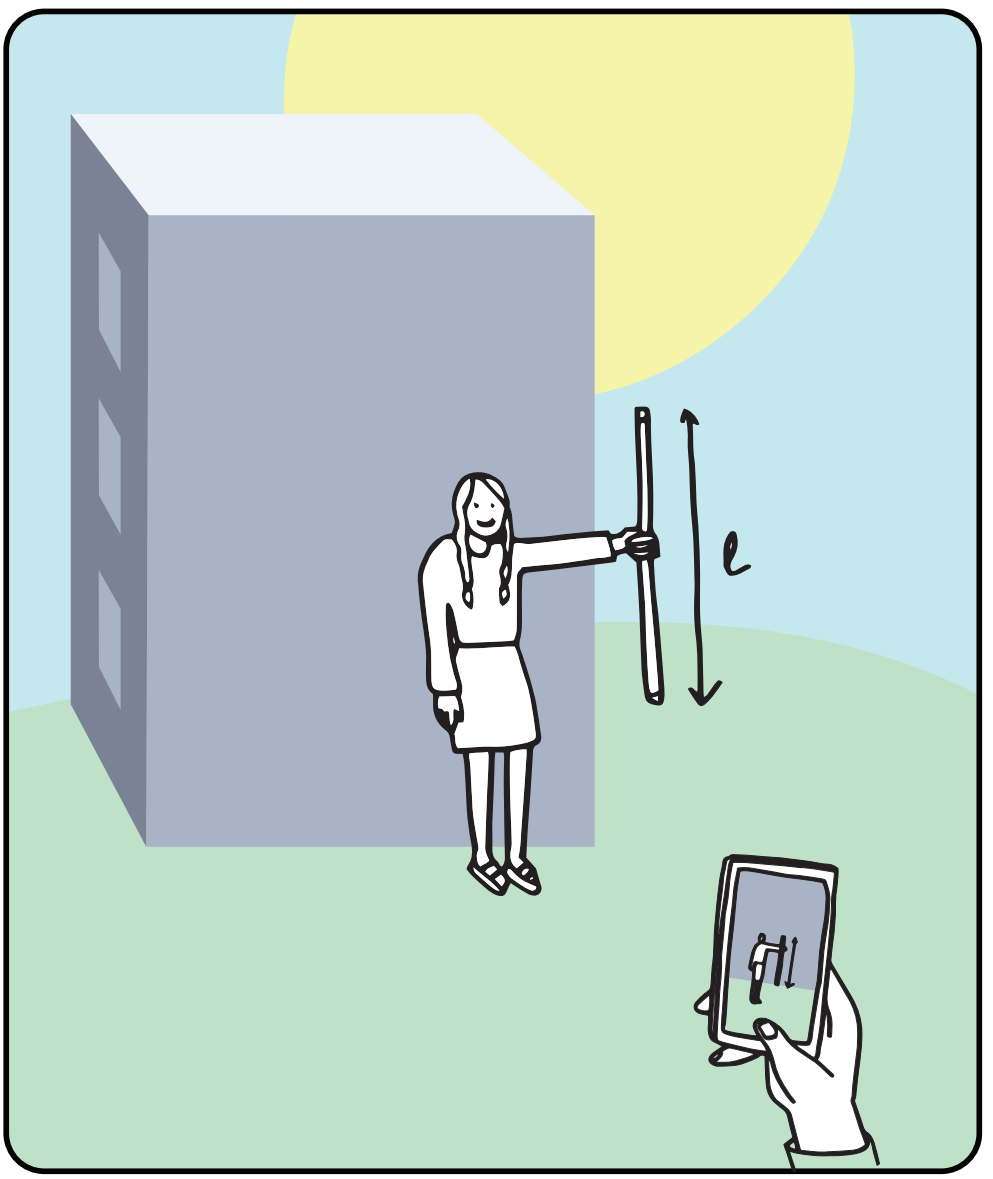
$$H = \frac{d_2}{d_1} l$$

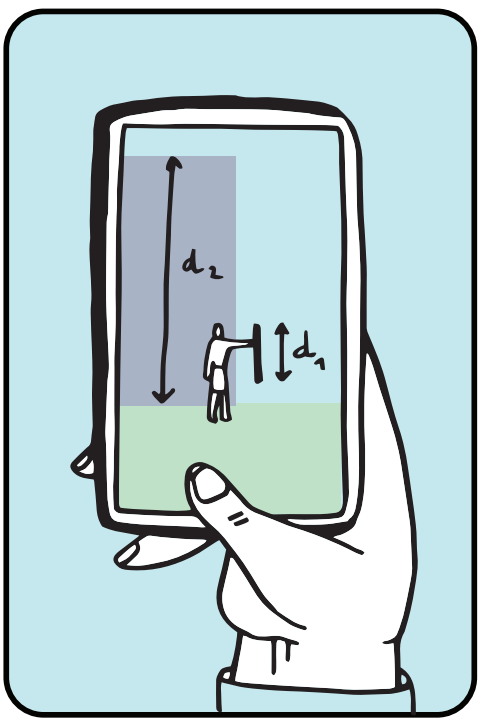
## Material

1 bar of known size




1 smartphone




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

*Minimize perspective distortion while taking the picture!*

Precision: high

Difficulty: low

# №54. Number of Pixels

## Formula

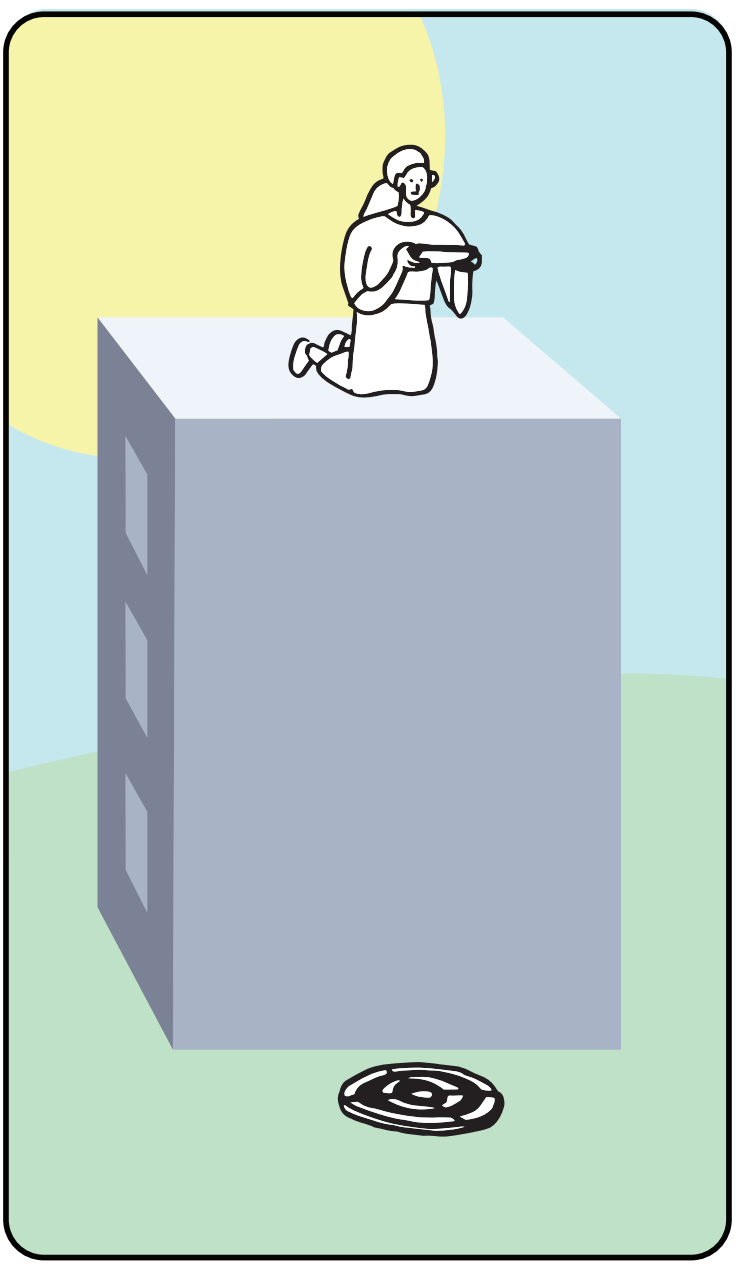
$$H \propto \frac{1}{\sqrt{N}}$$

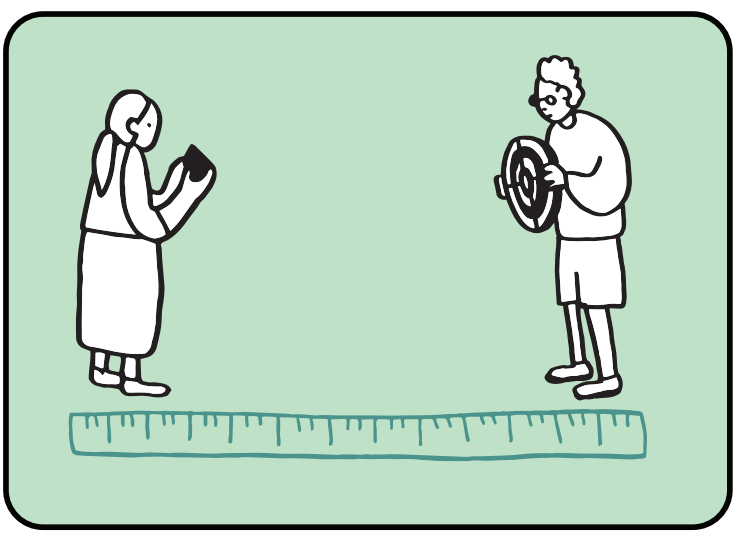
## Material

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

This project was imagined by Frédéric Bouquet (Paris-Saclay University) and Giovanni Organtini (Sapienza Università di Roma, Italy).

Physics: Frédéric Bouquet, Giovanni Organtini, Julien Bobroff

Videos, photos, gifs: Amel Kolli

Graphic design and illustrations: Anna Khazina

This project is a production of «Physics Reimagined» from Paris-Saclay University and CNRS. It benefited from the support of the IDEX Paris-Saclay and of the «Physique Autrement» Chair, held by the Paris-Sud Foundation and supported by the Air Liquide Group.