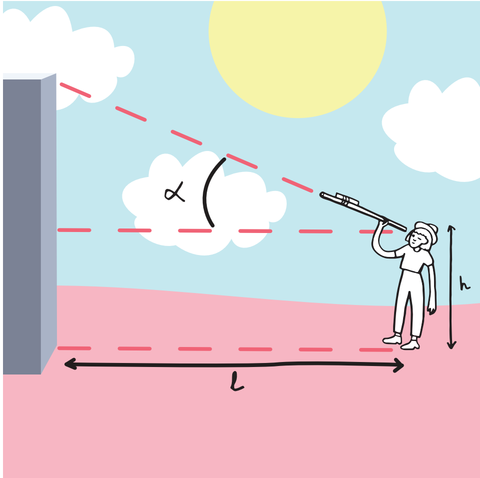
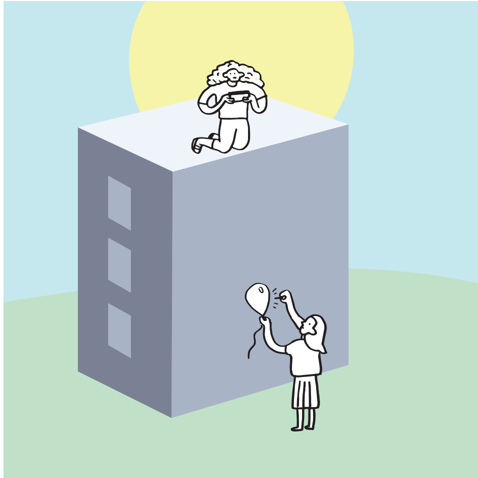
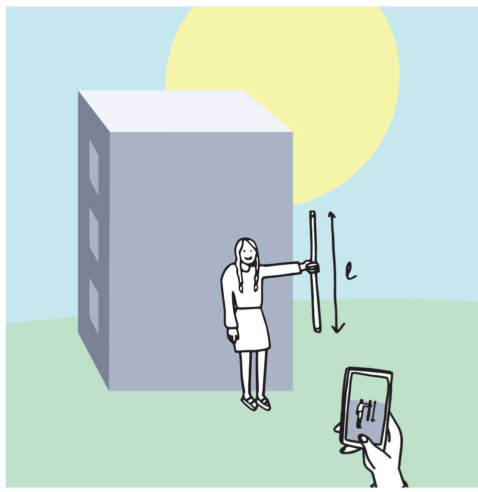
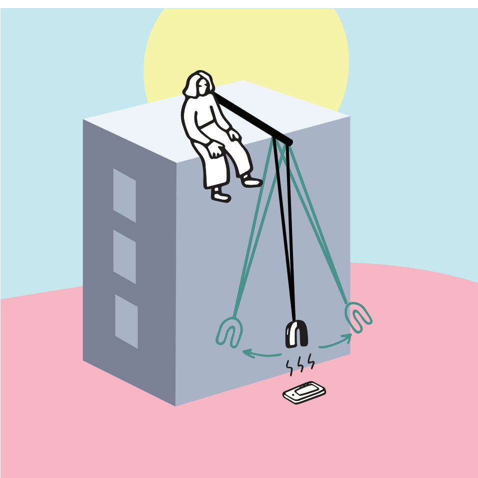


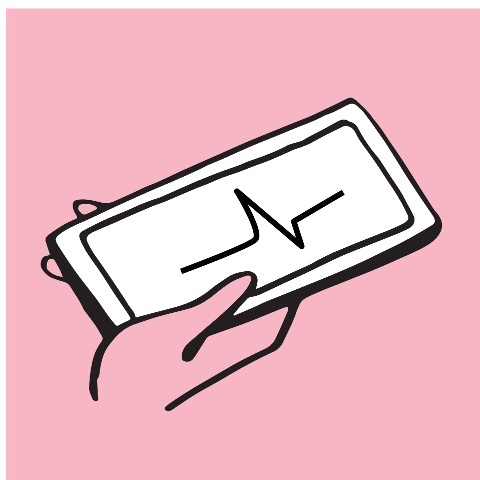


Theme:
WAVES

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







Discover The Smartphone Physics Challenge at VULGARISATION.FR

«Physics Reimagined» team (Paris-Saclay University)

Precision: intermediate

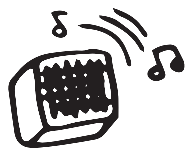
Difficulty: intermediate

№6. End of the Fall & Doppler

Formula

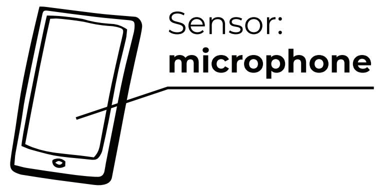
$$H = \frac{v^2}{2g}$$

Material

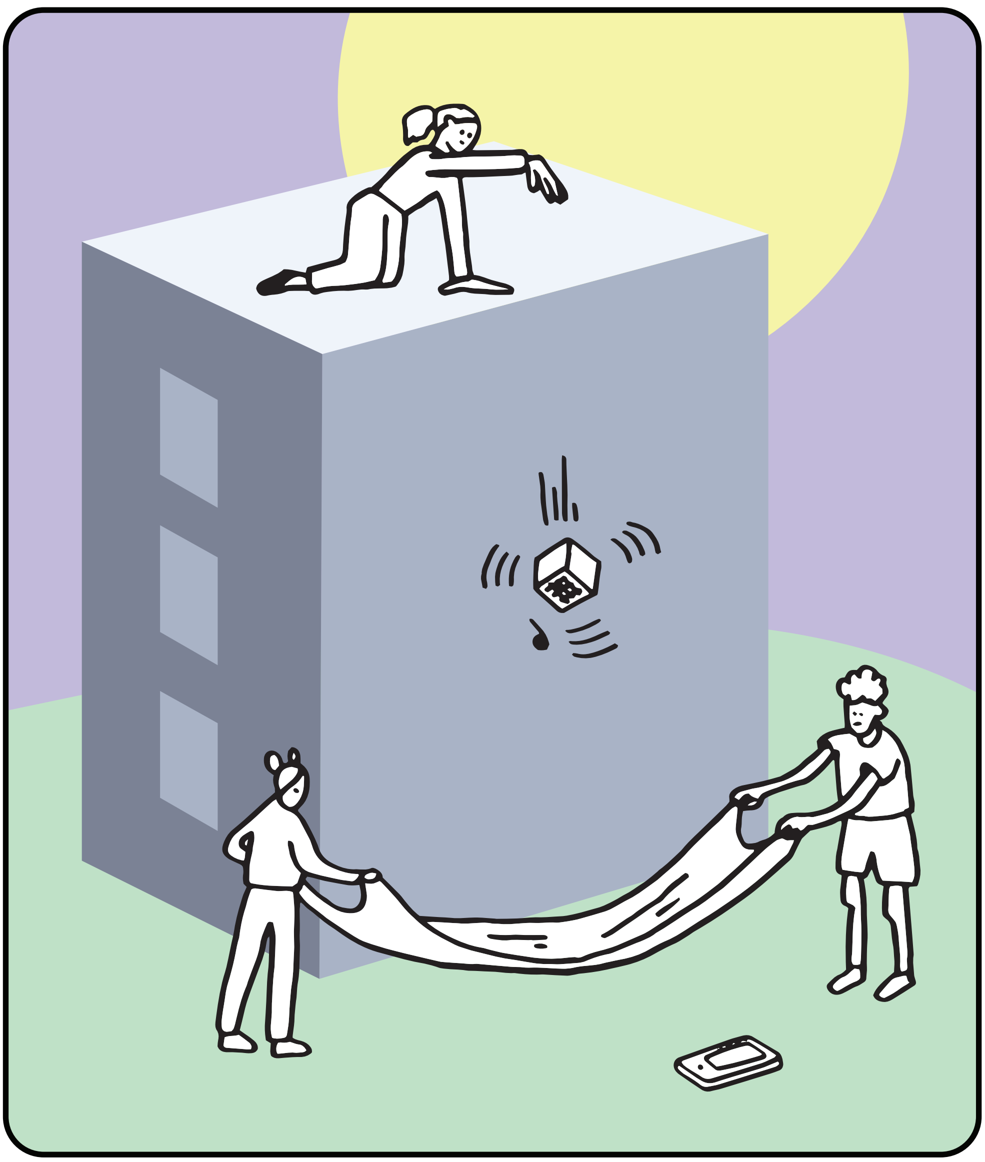


1 bluetooth speaker

1 sheet

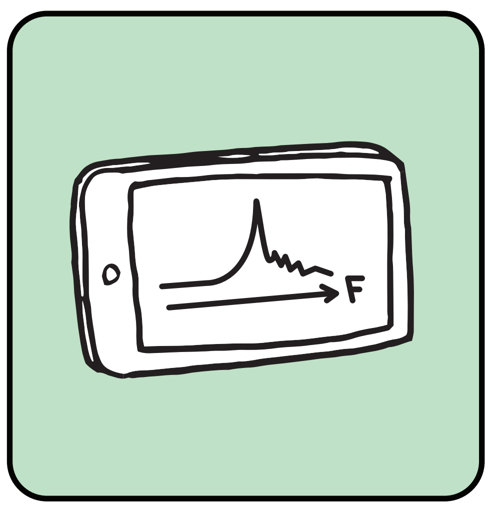


1 smartphone



Let the loudspeaker fall from the top of the building, making it sound a continuous note. At the bottom, the smartphone records the sound to determine the speed of fall by Doppler effect. (Catch the speaker in a sheet stretched between two people.)

v = speaker's final velocity,
g = 9.8 ms^{-2}



The formula does not consider air drag.

Precision: high

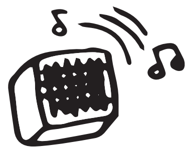
Difficulty: high

№44. Phase Shift of a Note

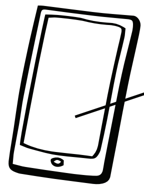
Formula

$$H = \Phi \frac{v}{2\pi f}$$

Material

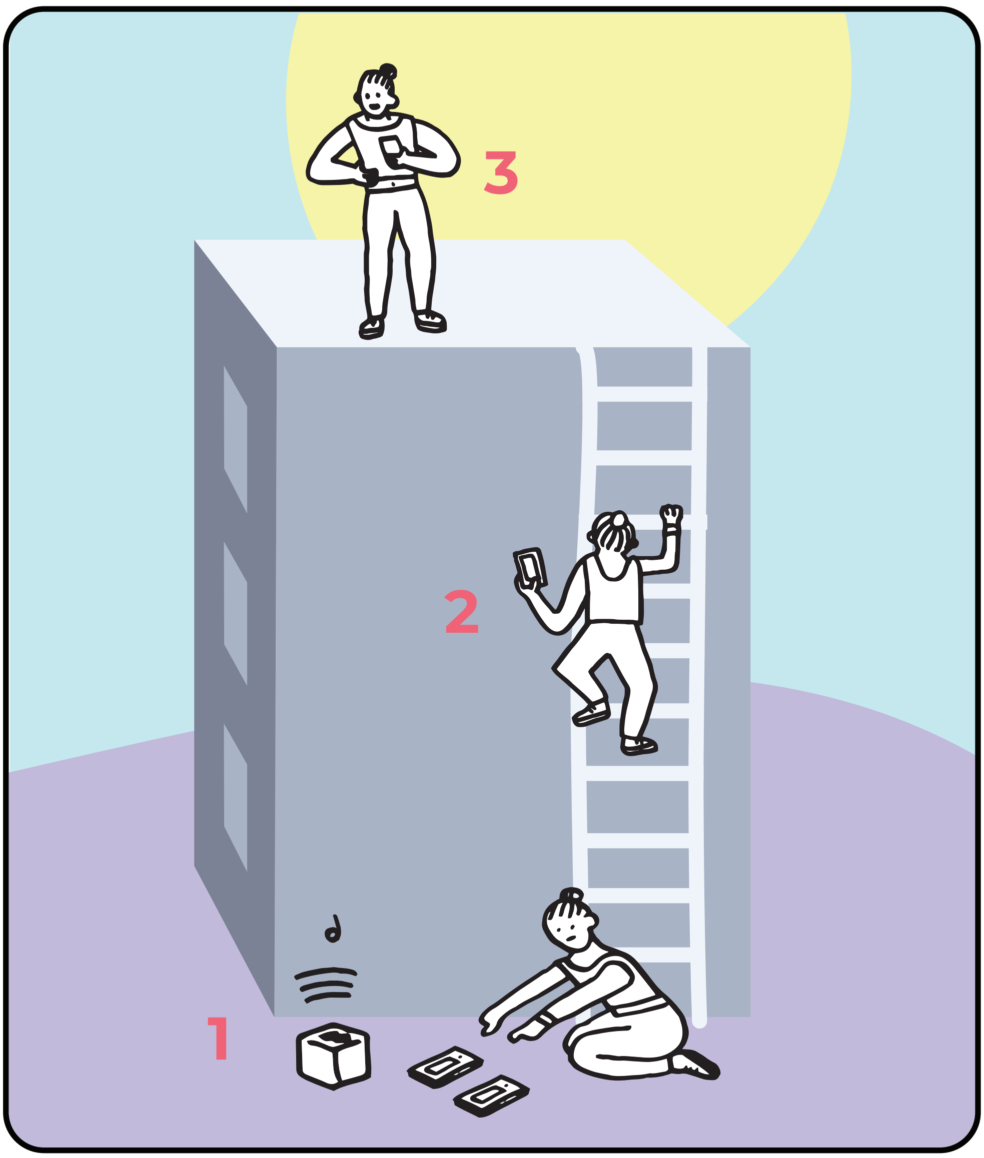


1 bluetooth speaker



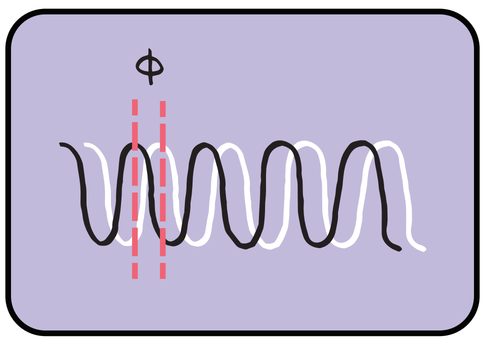
Sensor: **microphone**

2 smartphones



Place the loudspeaker at the bottom of the building, and let it sound a continuous note. Launch audio recordings on both smartphones. One stays at the bottom. Climb to the top by the fire escape with the second smartphone, still recording. Compare the records to determine the phase shift between the top and bottom of the building.

v = speed of sound, f = frequency, Φ = phase difference in radian



Avoid high frequencies that have too short wavelengths.

Precision: high

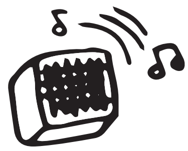
Difficulty: high

№45. Phase Shift

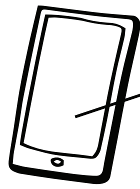
Formula

$$H = \frac{d\Phi}{df}\,\frac{v}{2\pi}$$

Material

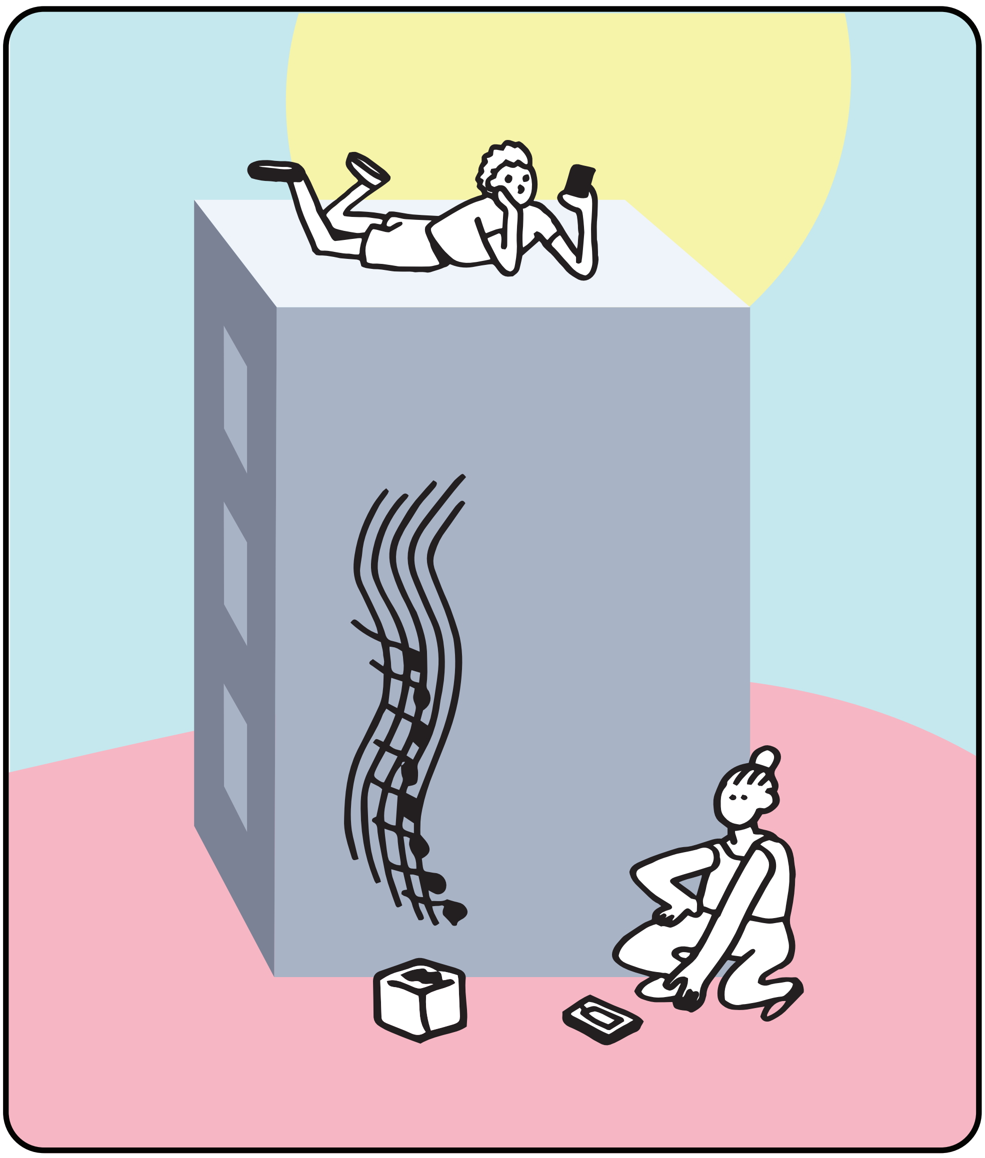


1 bluetooth speaker

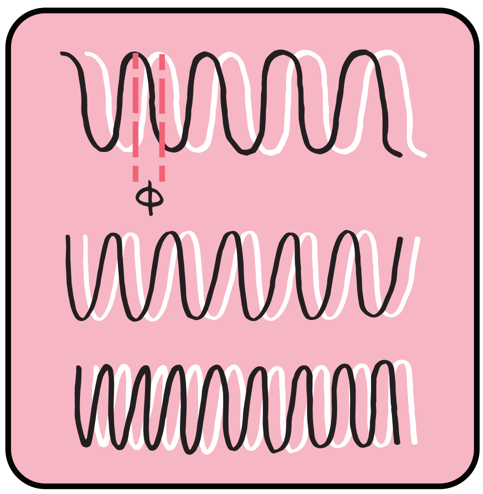


Sensor: **microphone**

2 smartphones



Place the loudspeaker at the bottom of the building, and let it sound a continuous note. Launch audio recordings on both smartphones, one at the top, the other at the bottom. Compare the records to determine how phase shift changes when the frequency of the note varies.



v = speed of sound, f = frequency, Φ = phase difference in radian

The analysis of the data is not immediate and requires a certain technicality.

Precision: high

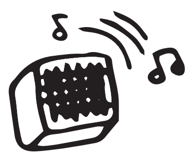
Difficulty: high

№46. Lateral Phase Shift

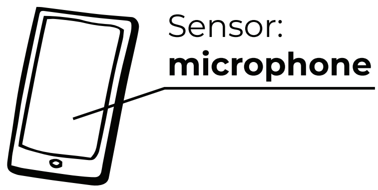
Formula

$$H = \frac{\pi f}{v} \quad \frac{1}{\frac{d\Phi}{dd^2}}$$

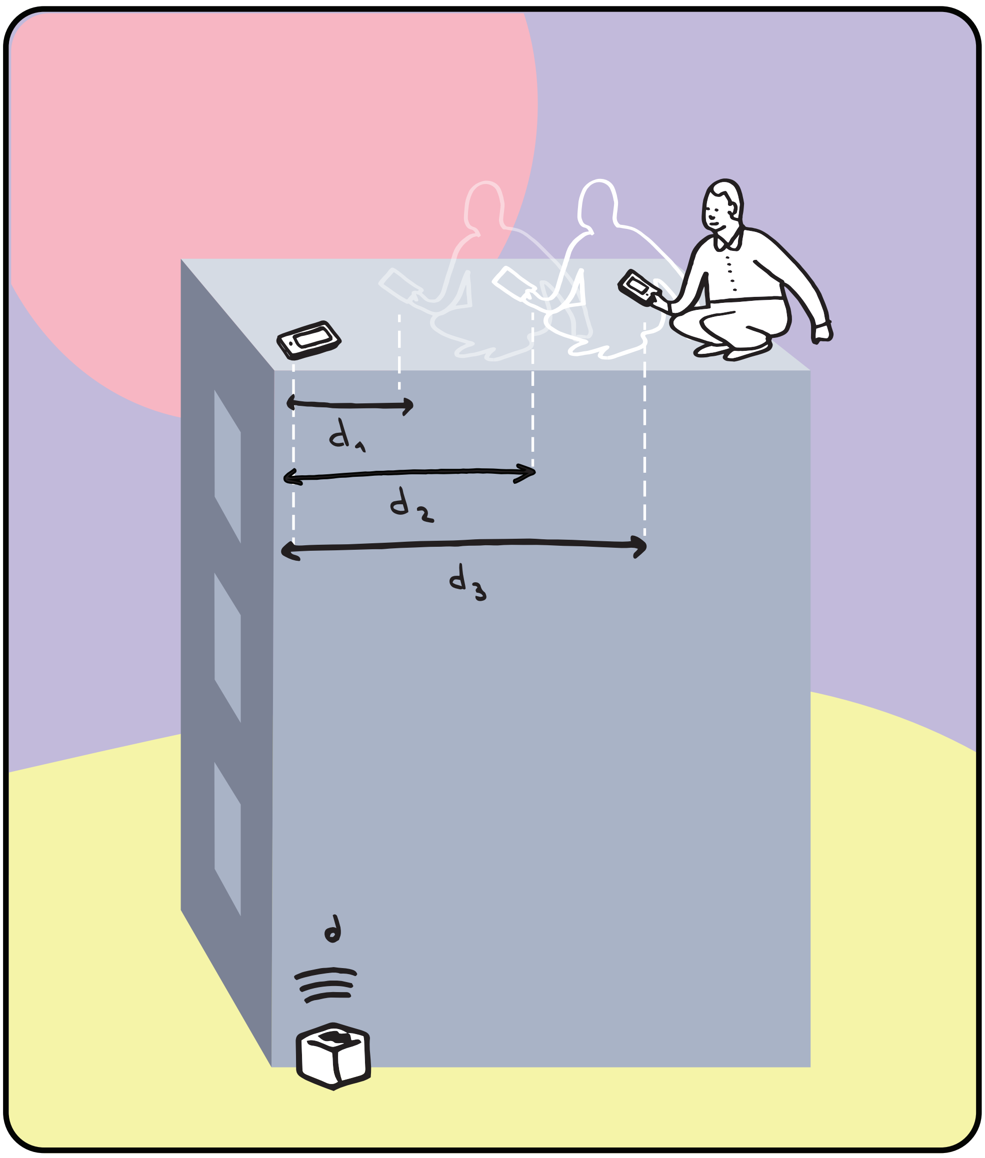
Material

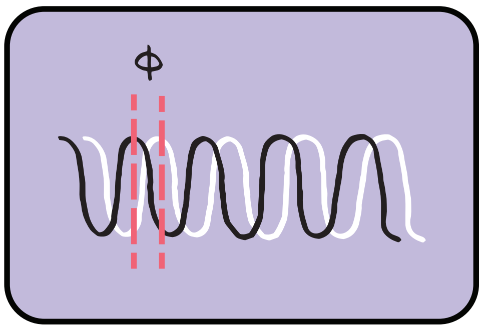


1 bluetooth speaker



2 smartphones





Place the speaker at the bottom of the building, and let it sound a continuous note. Launch recordings on both smartphones, at the top of the building and at the vertical of the loudspeaker. Move one of the smartphones sideways. Compare the recordings to determine the phase shift between both smartphones.

v = speed of sound, f = frequency,
Φ =phase difference in radian,
d = distance between smartpones

The formula assumes that d << H.

Precision: intermediate

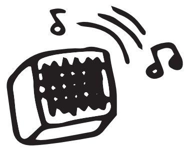
Difficulty: intermediate

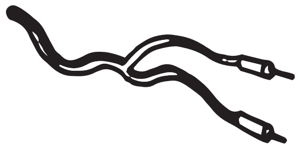
№47. Acoustic Interference

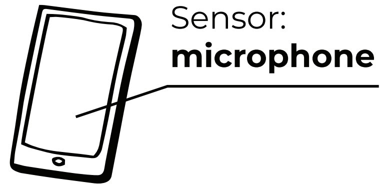
Formula

$$H = \frac{ldf}{v}$$

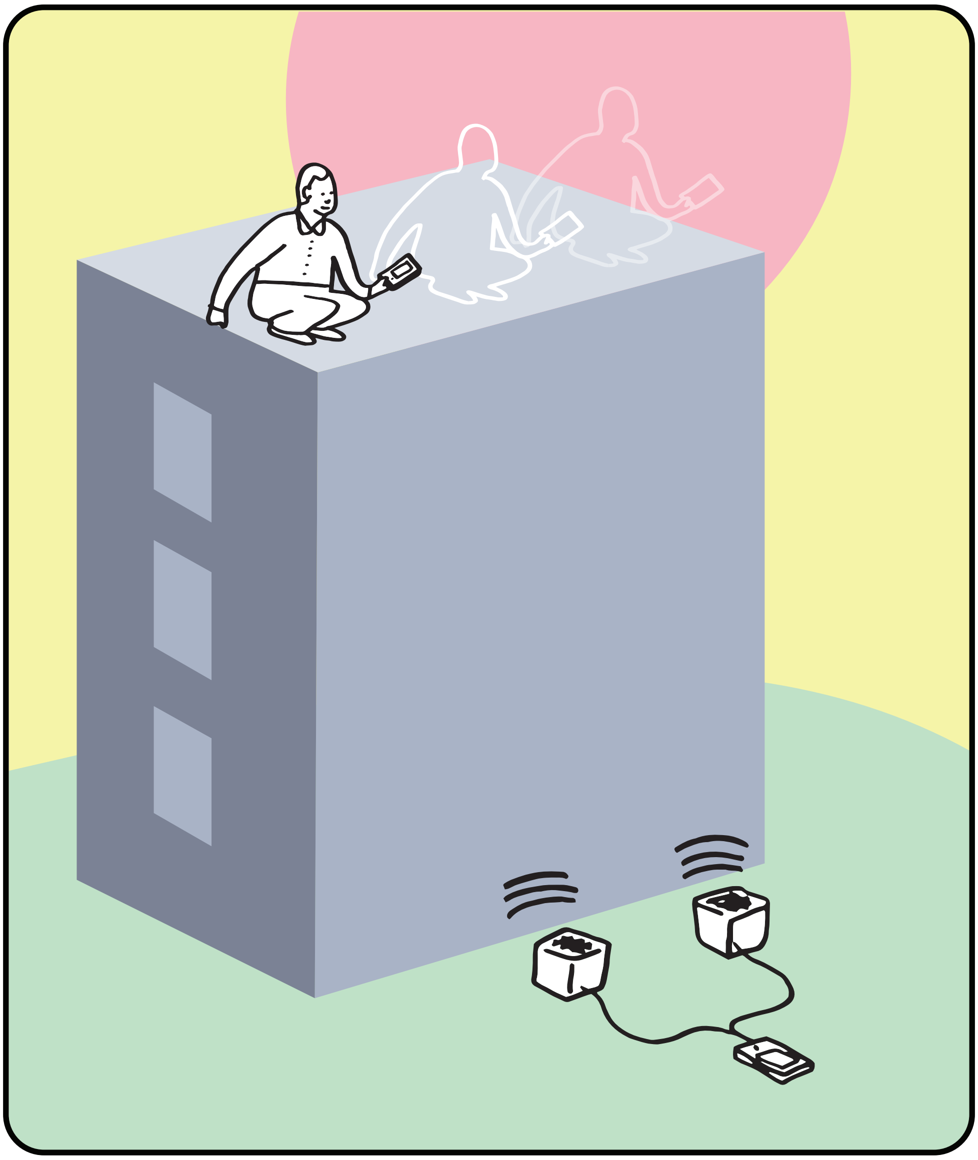
Material


2 bluetooth speakers

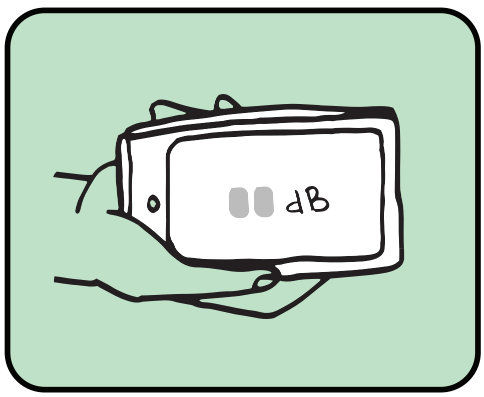

1 jack splitter



2 smartphones



Place the two speakers on the ground separated by some distance. By connecting both of them to a smartphone with the jacksplitter, issue the same continuous note on both devices. On the top of the building, use a smartphone to determine the positions of minimum sound level.



v = speed of sound, f = frequency, l = distance between loudspeakers, d = distance between the two audio minimums

The formula assumes that d << H and l << H.

Precision: high

Difficulty: low

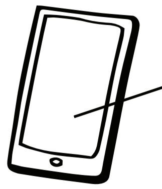
№48. Resonance of a Tube

Formula

$$H = \frac{v}{2f}$$

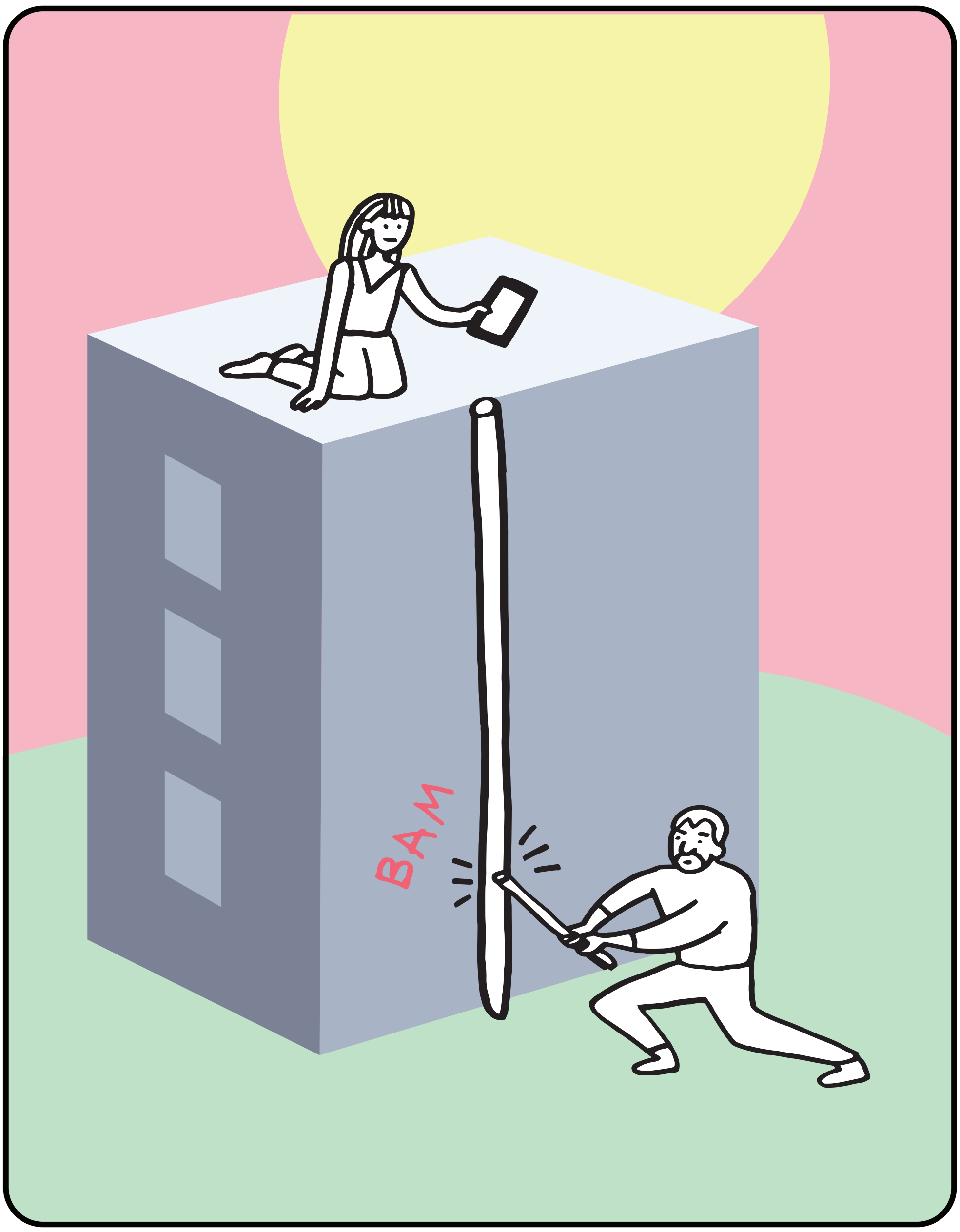
Material

1 long tube of the same length as the building height

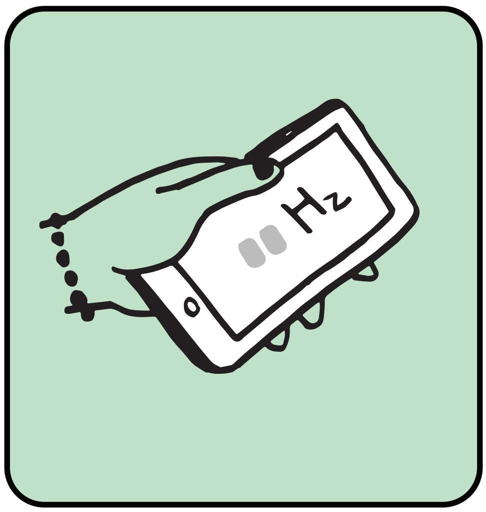


Sensor: **microphone**

1 smartphone



Find a rigid tube the same length as the height of the building. Determine the note that can propagate in the tube.



v = speed of sound, f = frequency

Precision: high

Difficulty: high

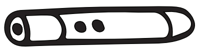
№55. Hair Diffraction

Formula

$$H = \frac{ld}{2\lambda}$$

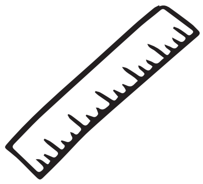
Material

1 hair

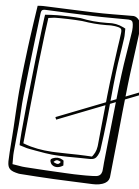


1 laser

1 drop of water

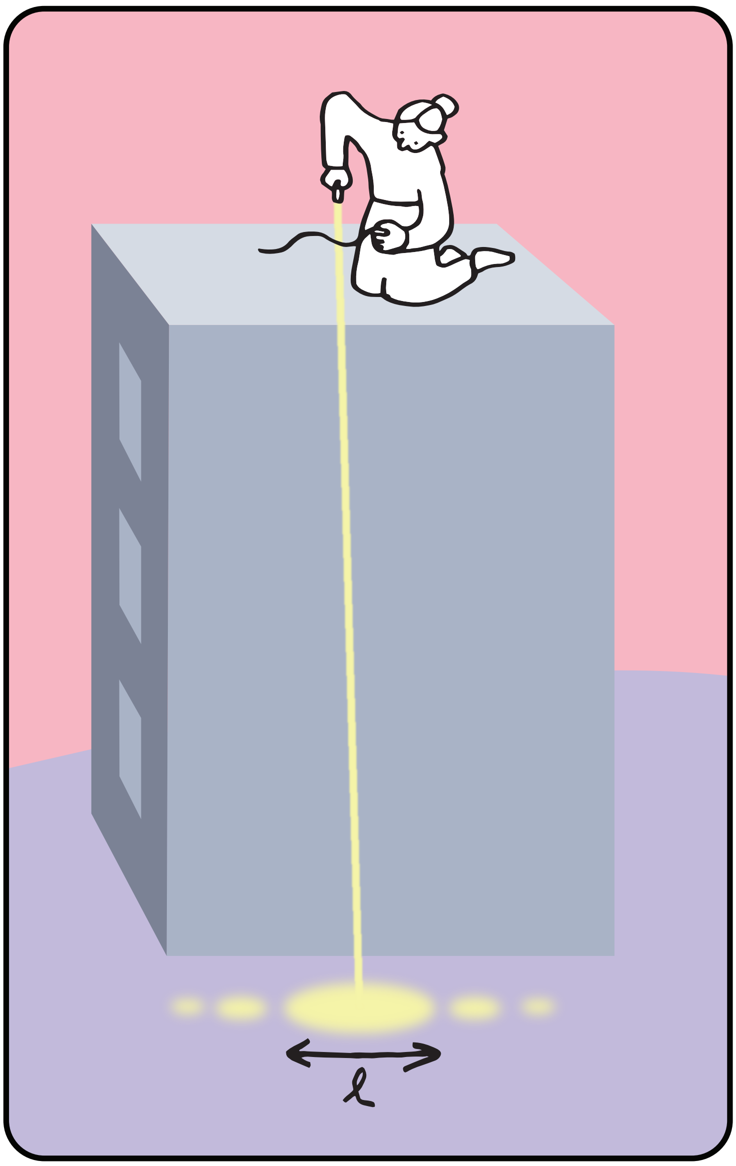


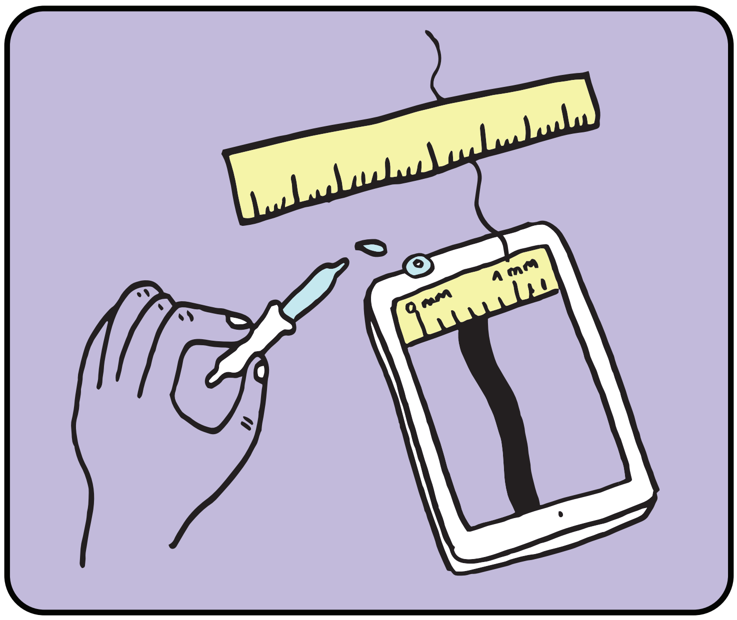
1 ruler



Sensor: **camera**

1 smartphone





From the top of the building, illuminate the hair with a laser down. Measure the diffraction spot at the bottom of the building. Then, using a drop of water placed on the camera lense, turn your smartphone into a microscope, and measure the diameter of the hair.

l = size of the diffraction spot, d = hair diameter, λ = wavelenght of the laser

Warning: handling a laser is dangerous.

Precision: high

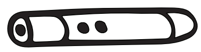
Difficulty: high

№56. LCD Screen Diffraction

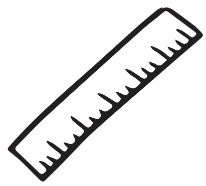
Formula

$$H = \frac{lp}{\lambda}$$

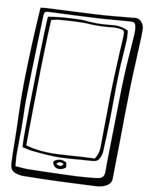
Material



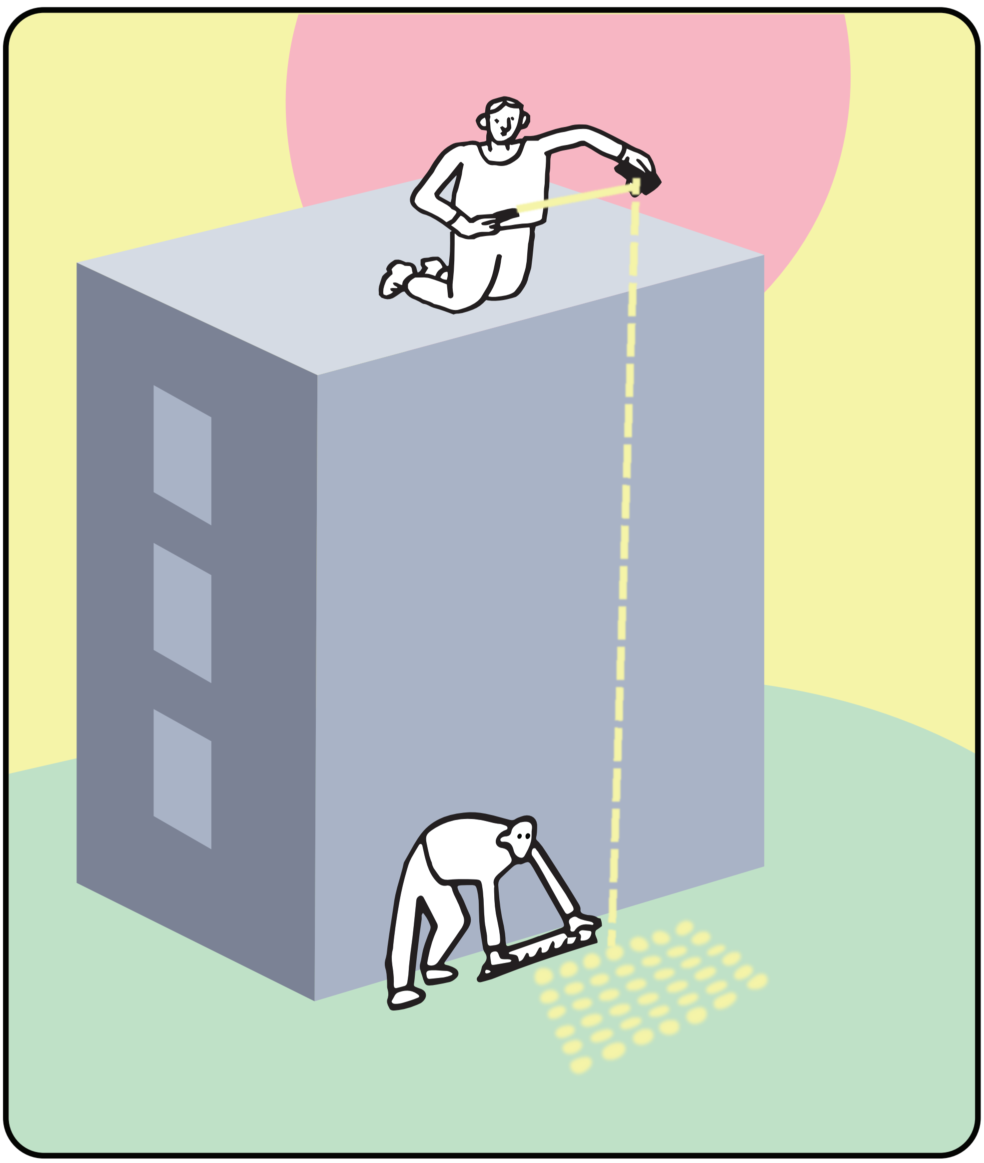
1 laser



1 ruler



1 smartphone



From the top of the building, illuminate the smartphone screen with the laser and project the diffraction pattern on the ground. Measure the characteristic distance of the pattern. Determine the size of the pixels by comparing their number and the size of the screen. (Some screens diffract better than others.)

l = distance between the diffraction spots, p = size of a pixel, λ = wavelenght of the laser

Warning: handling a laser is dangerous.

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

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