THE EUROPEAN NETWORK FOR SCIENCE TEACHERS

SCIENCE ON STAGE DEUTSCHLAND

ISTAGE 3
TEACHING UNIT „UNDER PRESSURE“

ACTIVITIES AND EXPERIMENTS WITH THE AIR PRESSURE INSIDE THE BALL

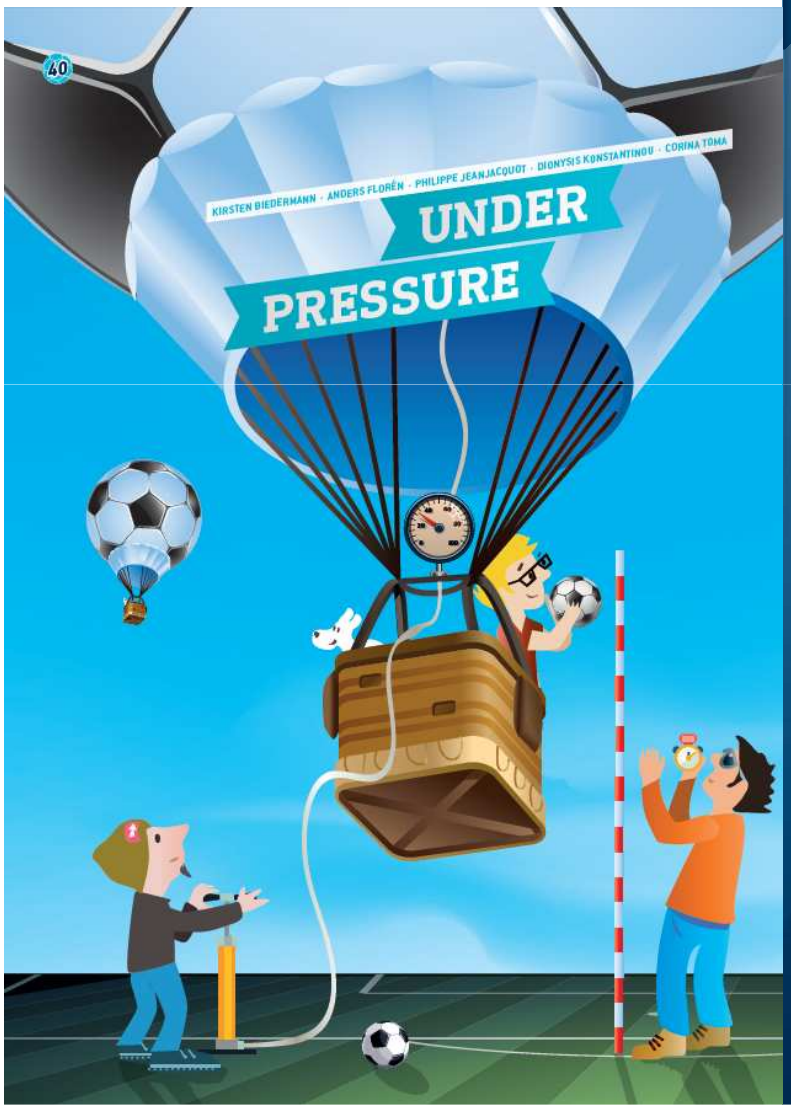
Corina TOMA

Philippe JEANJACQUOT

PARTS OF THIS TEACHING UNIT

SCIENCE ON STAGE DEUTSCHLAND

- PRESSURE
- BOUNCE

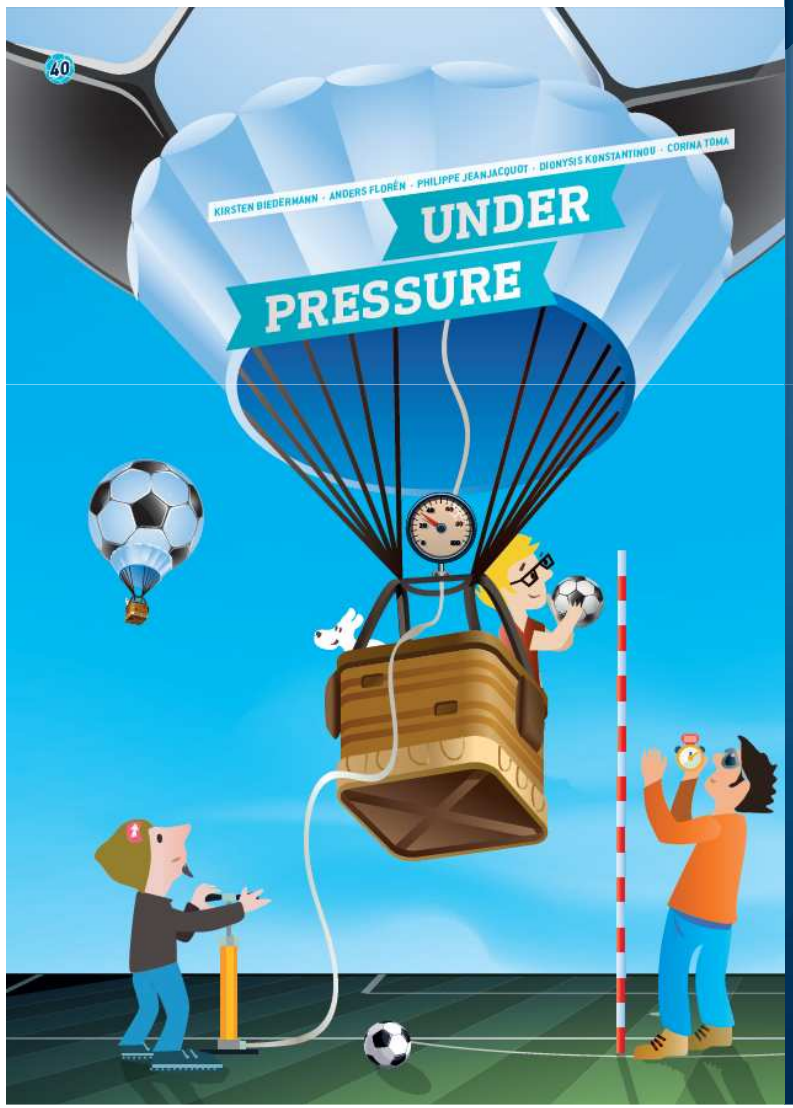


PARTS OF THIS TEACHING UNIT

SCIENCE ON STAGE DEUTSCHLAND

★PRESSURE

An inventive way to study the properties of the aur across the football



PRESSURE:
WHAT WE ARE GOING TO DO

SCIENCE ON STAGE DEUTSCHLAND

WE ARE GOING TO MEASURE:

- The pressure inside the ball
- The mass of the ball
- The volume of the ball

WE ARE GOING TO FIGURE OUT:

- That air has a mass.
- The link between the pressure and the mass of the air.
- The density of the air.
- The ideal gas law and the mass of one mole of air.

PRESSURE: FIT TO EVERY LEVEL

SCIENCE ON STAGE DEUTSCHLAND

PRIMARY SCHOOL:

- The air has a mass.

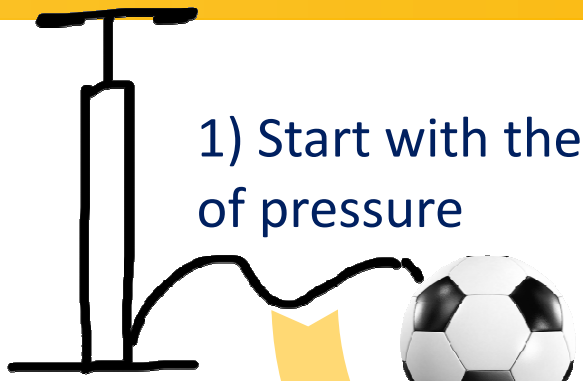
MIDDLE SCHOOL:

- The link between the pressure and the mass of the air.
- Density of the air.

HIGH SCHOOL:

- The ideal gas law and the mass of one mole of air.
- Show the effect of the buoyancy of the air.

PRESSURE: PROCEDURE



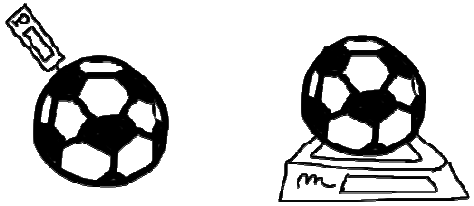
1) Start with the maximum of pressure

2) Measure the mass

3) Measure the pressure

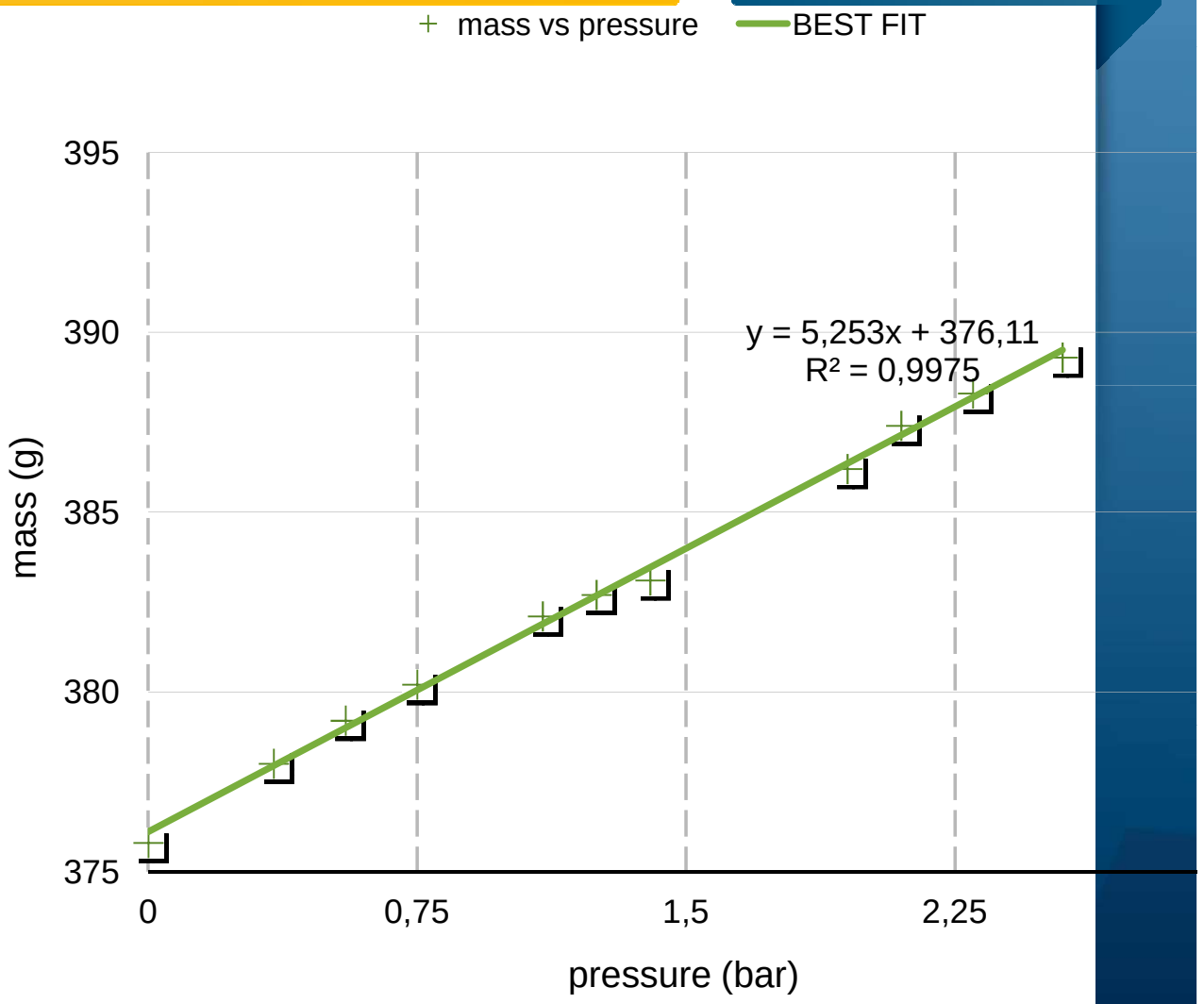
4) Let a part of the air out

PRESSURE: MEASURES



MASS vs. PRESSURE

PRESSURE (bar)	MASS (g)
2.55	389.3
2.3	388.3
2.1	387.4
1.95	386.2
1.40	384.1
1.25	382.7
1.10	382.1
0.75	380.2
0.55	379.2
0.35	378
0	375.8



PRESSURE: MASS OF AIR

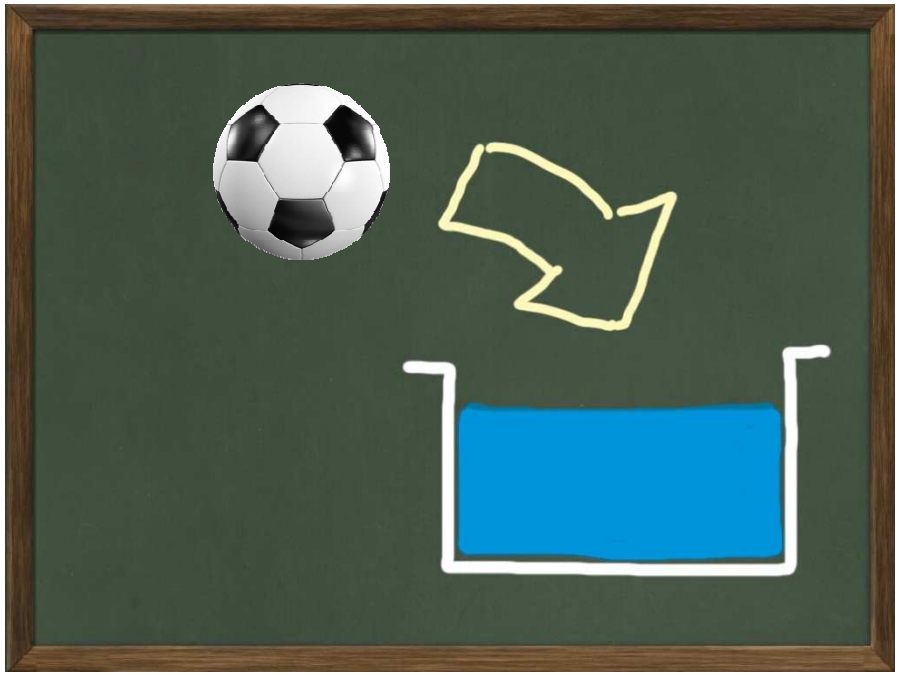
MASS OF AIR INSIDE THE BALL

Mass of air inside the ball

m = 5.2 g for p = 1 bar

VOLUME OF THE BALL

VOLUME OF THE BALL

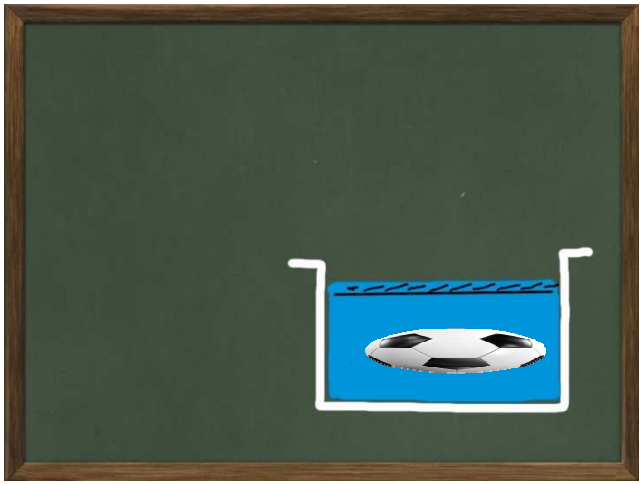


VOLUME OF THE BALL

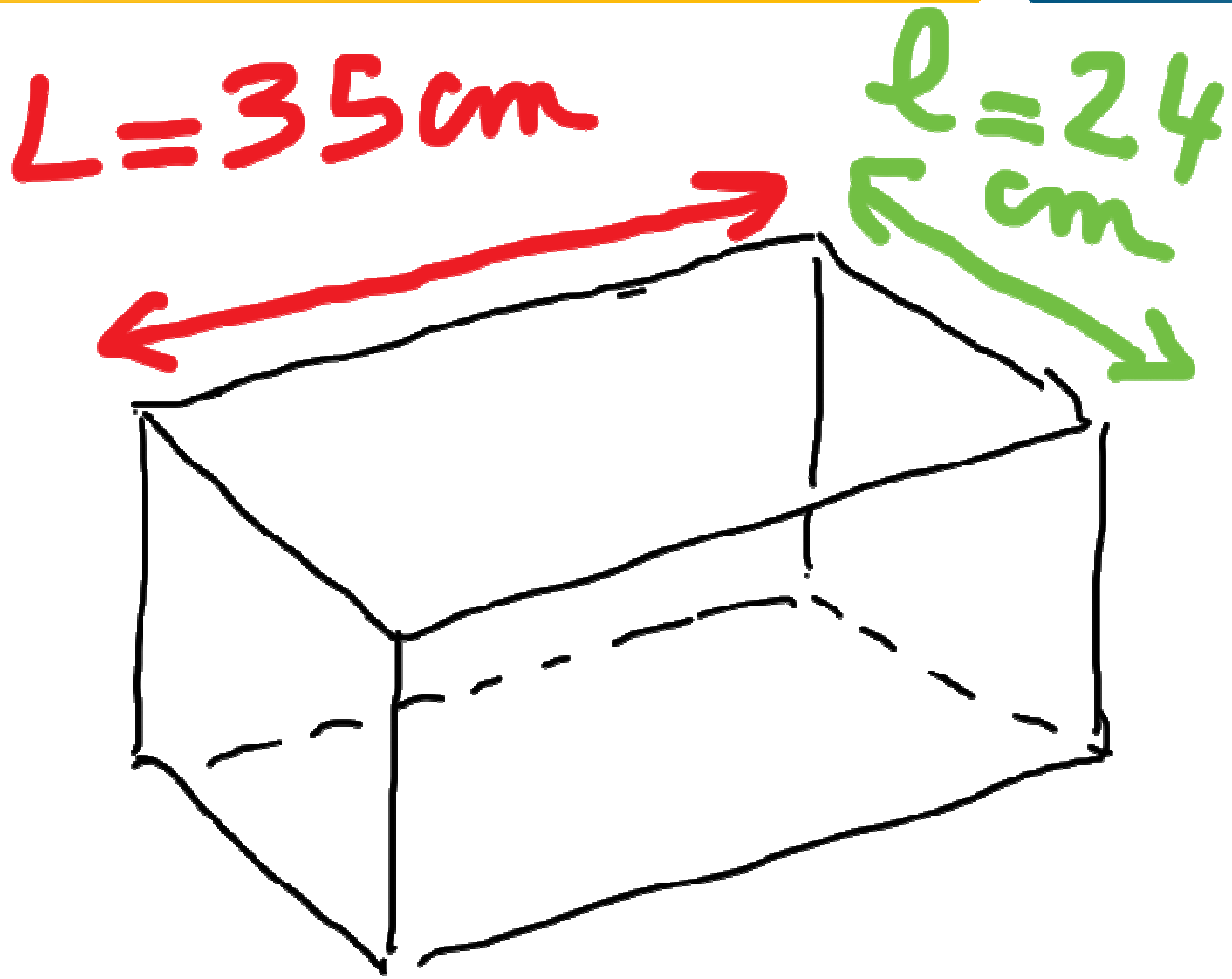
h(full)= 5.6 cm

VOLUME OF THE BALL

h(empty)= 0.9 cm



VOLUME OF THE BALL



VOLUME OF THE BALL

$V(full) = 35x24x5.6 = 4704\ cm^3$ $V(full) = 4.70\ L$

$V(empty) = 35x24x0.9 = 756\ cm^3$ $V(empty) = 0.76\ L$

$V(air) = 4.70\text{-}0.76 = 3.94\ L$ $V(air) = 3.94\ L$

DENSITY OF THE AIR

$$d = m/v(air)$$

$$d = 5.2/3.94$$

$$d = 1.32\ g/L$$

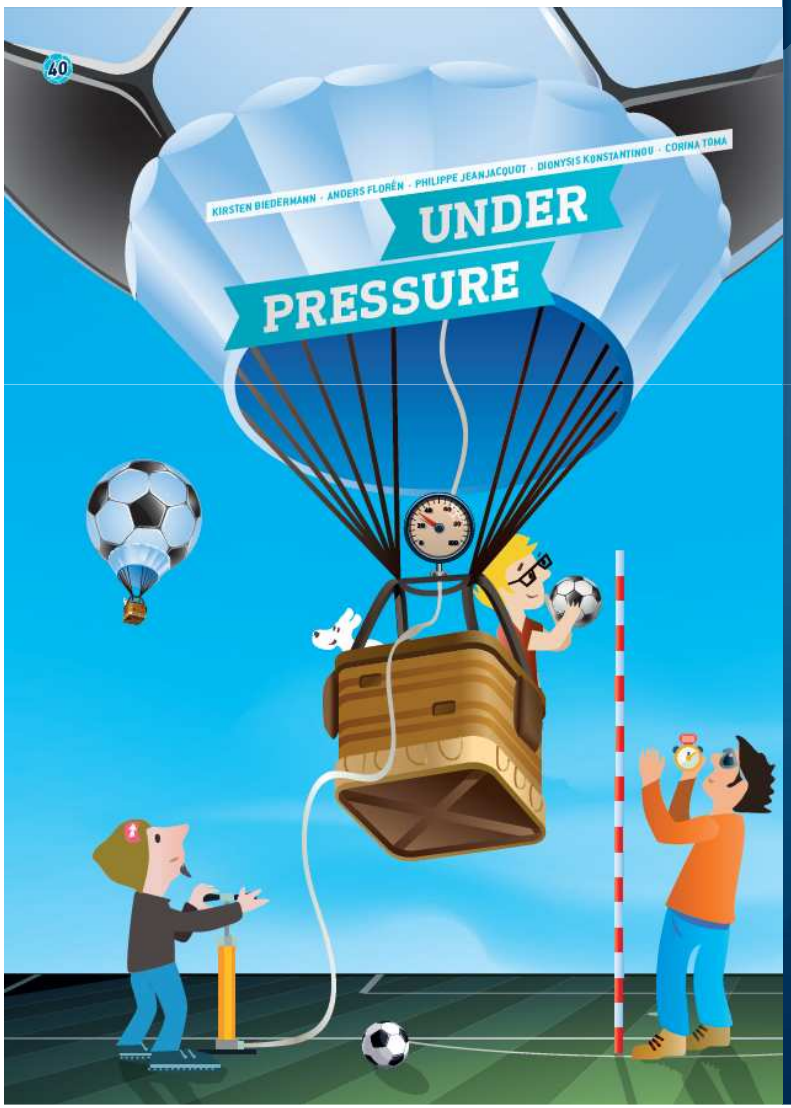
The real value is 1.2 g/L at the temperature of the measure (25°C)

The errors can occur principally from the measure of the volume (to get a good empty ball) and also from the measure of the pressure

PARTS OF THIS TEACHING UNITS

SCIENCE ON STAGE DEUTSCHLAND

BOUNCE



Dependence of the bouncing height with the pressure

SCIENCE ON STAGE DEUTSCHLAND

For an elastic collision with the ground the coefficient of restitution is:

$$e = \frac{v_{separation}}{v_{approach}}$$

$$mgh_1 = \frac{mv^2_{approach}}{2}$$

the ball is falling down from the height h_1

$$mgh_2 = \frac{mv^2_{separation}}{2}$$

after the collision the ball can reach the height h_2

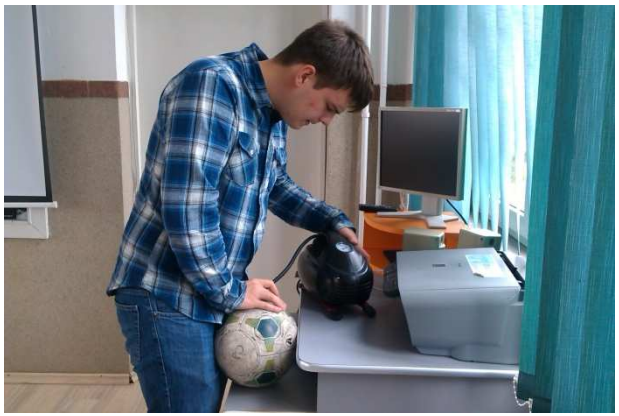
$$e = \sqrt{\frac{h_2}{h_1}}$$

What you need?

SCIENCE ON STAGE DEUTSCHLAND

- Football
- Pump with manometer
- Measuring tape or a marked paper tape that can be stuck on the wall
- Smartphone
- VidAnalysis application

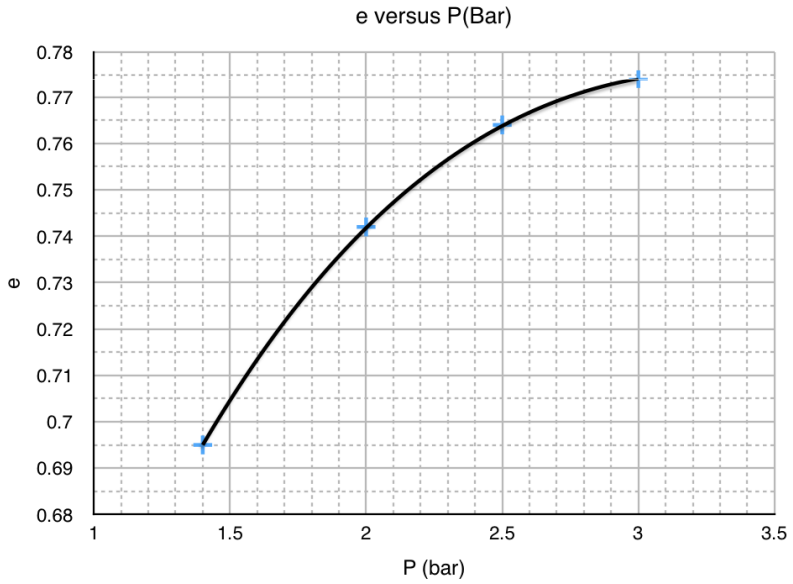
What to do?

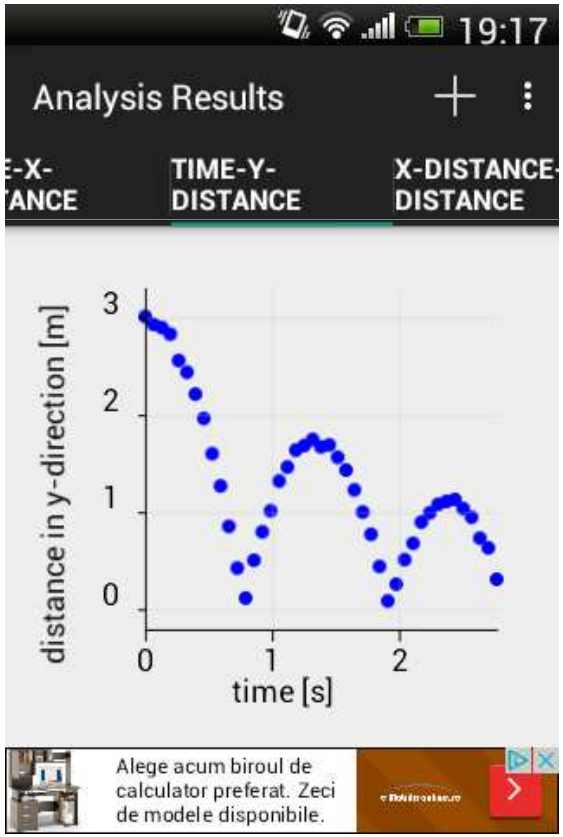


Results

SCIENCE ON STAGE DEUTSCHLAND

Reading the heights from the video using VidAnalysis





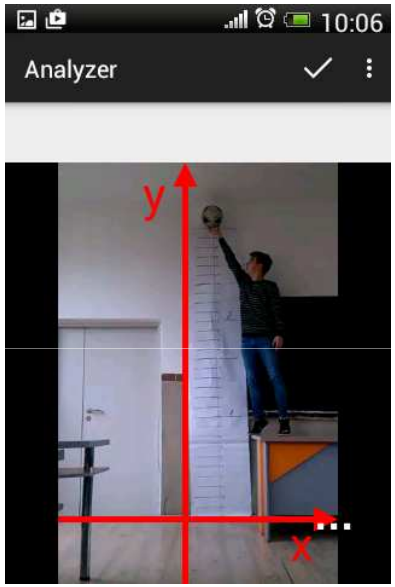
VidAnalysis

https://play.google.com/store/apps/details?id=com.vidanalysis.free

Record a video and import into the app.

Calibrate the video: mark the length of the known distance in the frame and insert the real length

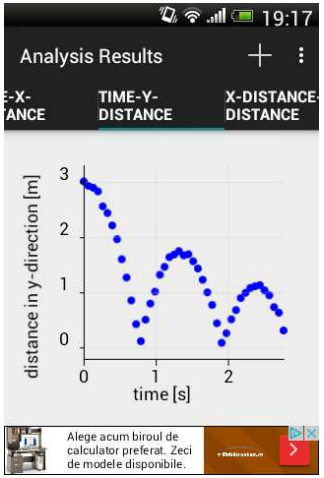
VidAnalysis



Pick the origin of the coordinate system.

Mark the ball by tapping on it in every frame.

Diagrams are generated automatically:
$x = f(t)$, $y = f(t)$ and $y = f(x)$
$v_x = f(t)$ and $v_y = f(t)$



Data table