	TEAM 8	
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Smashing! Real-world clashes into physics classes	Italy	Camilla Barilari Alice Berti Alessandro Righi
Etwinning experiment		

1. ORIENTATION

1.1. **Research question:**

Does the underground have an impact during a collision?

Sub-questions:

- What is the height when the ball bounces back?
- What is the velocity of the ball when it bounces back?
- What is the acceleration of the ball when it bounces back?

1.2. **Hypothesis**

Yes, the underground has. If the soil is flat we think the ball will bounce back higher than with a raw underground. We believe that the density from the underground has something to do with it, the denser the higher. The elasticity of the soil is something to take in count too, the more elastic the harder.

2. PREPARATION

2.1. Material:

-A bouncy ball of 41.6g mass.

-Two different surfaces like a table and a towel or something soft.

-Two structures (see the photo and drawings). One with a tape measure and the other able to support the position sensor.

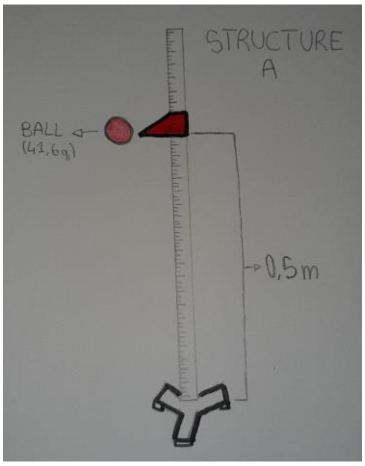
-A speed and position sensor.

-A computer where you can use Tracker.

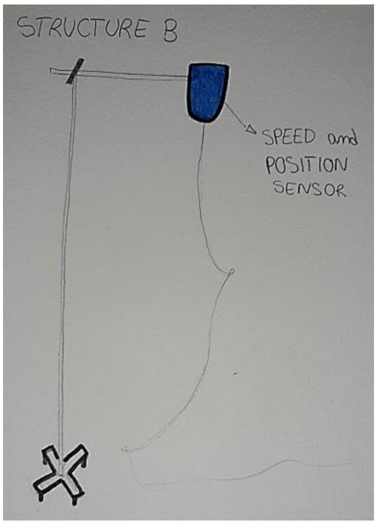
-Objects such as a meter, a telephone, a calculator and a stopwatch.

2.2. Method:

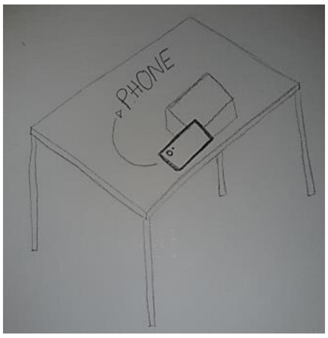
-Make a structure like A in the photo to drop the ball (41,6g) from the same high at each fall.



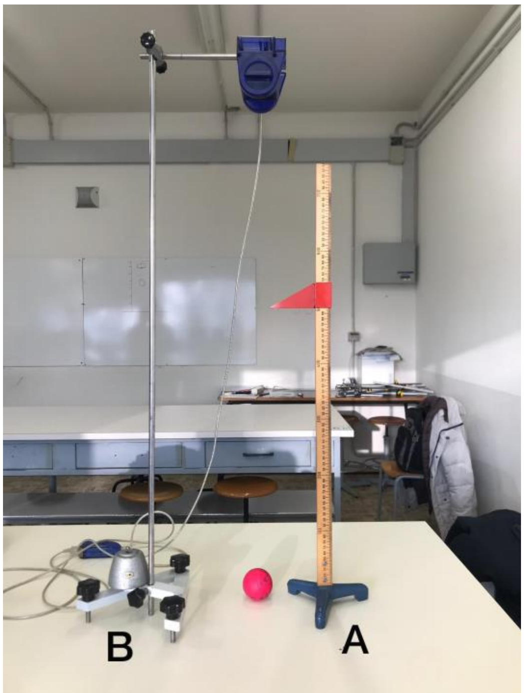
-Make another structure like B with speed and position sensor. It must be placed higher than structure A.



-Place a phone on a table to record a video of the falls.



-Do 3 test for every one of the 2 surfaces.
-Drop the ball from a height of 0,5m.
-Make a video for each fall.
-Analyse all the videos with Tracker and identify the bounce height, speed, and position as time changes and acceleration.



3. DATA ANALYSIS and DISCUSSION

Belgian experiments

3.1. Observations and Measurements:

stone		
	test 1	test 2
height (cm)	30	30
average height (cm)	30	

Experiment

position function (m)	X(t)= 4,46 t² -2,27 t – 1,52	X(t)=4,25t²-2,21t-1,57
velocity function (m/s)	V(t)= 8,43t-2,33	V(t)=8,50t-2,21
acceleration (m/s²)	8,43	8,50
average acceleration (m/s²)	8,47	

gravel		
	test 1	test 2
height (cm)	9	6,5
average height (cm)	7,8	
position function (m)	X(t)= 4,95t²-1,20t-1,76	X(t)=1,71t²-5,56t-9,60
velocity function (m/s)	V(t)=7,09t-1,04	V(t)=3,83t-5,98
acceleration (m/s²)	7,09	3,83
average acceleration (m/s²)	5,46	

wood shavings		
	test 1	test 2
height (cm)	22,5	22,2
average height (cm)	22,4	
position function (m)	X(t)=3,21t²-1,70t-1,23	X(t)=2,99t²-1,65t-7,24
velocity function (m/s)	V(t)=5,54t-1,72	V(t)=5,30t-1,68
acceleration (m/s²)	5,54	5,30
average acceleration (m/s²)	5,42	

grass		
	test 1	test 2
height (cm)	18,1	18,6
average height (cm)	18,4	
position function (m)	X(t)=4,15t²-1,51t-2,95	X(t)=1,26t²-1,01t-4,96
velocity function (m/s)	V(t)=8,53t-1,63	V(t)=3,53t-1,21
acceleration (m/s²)	8,53	3,53
average acceleration (m/s²)	6,03	

Experiment

mat		
	test 1	test 2
height (cm)	11	20,5
average height (cm)	15,8	
position function (m)	X(t)=1,01t²-7,02t-1,14	X(t)=4,14t²-1,74t-3,09
velocity function (m/s)	V(t)=2,25t-7,34	V(t)=8,00t-1,73
acceleration (m/s²)	2,25	8,00
average acceleration (m/s²)	5,13	

fine gravel		
	test 1	test 2
height (cm)	26	26,5
average height (cm)	26,3	
position function (m)	X(t)=3,96t²-2,00t-1,59	X(t)=1,49t²-1,49t-3,05
velocity function (m/s)	V(t)=7,84t-1,98	V(t)=3,82t-1,54
acceleration (m/s²)	7,84	3,82
average acceleration (m/s²)	5,83	

sand
The ball didn't bounced back so there's no height, no velocity and no acceleration.

3.2. Discussion:

Some measurements aren't quite right. That's because it is really hard to be very specific with tracker. So sometimes the 2 tests are very different. The measurements of grass and mat are a bit similar. That is because neither of the two has a total flat surface but they are both hard end flat enough for the ball to bounce back.

The measurements of stone and gravel are also quite similar because they both have a hard surface.

The ball bounces back higher if the surface is flat instead of raw (stone <-> gravel).

Italian experiments.

Experiment

3.3. Observations and Measurements:

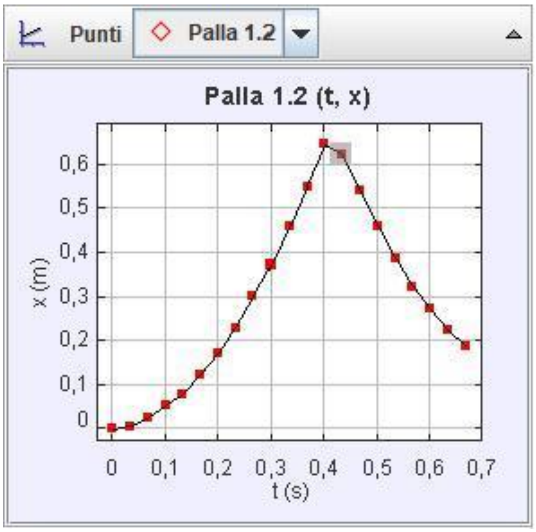
We used tracker to analyse the falling balls and get the speeds

m= 0,0416g

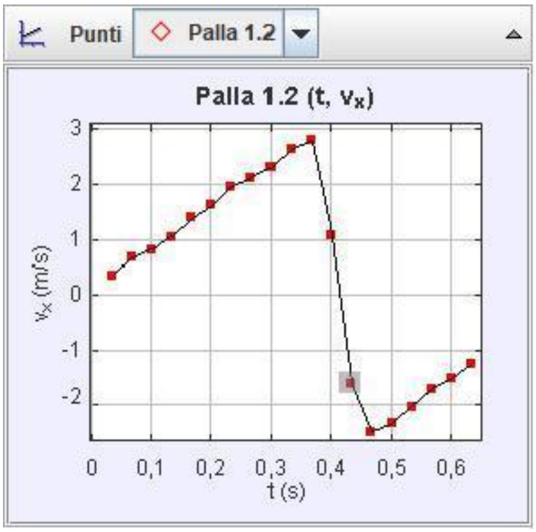
h= 0,85cm

DESK

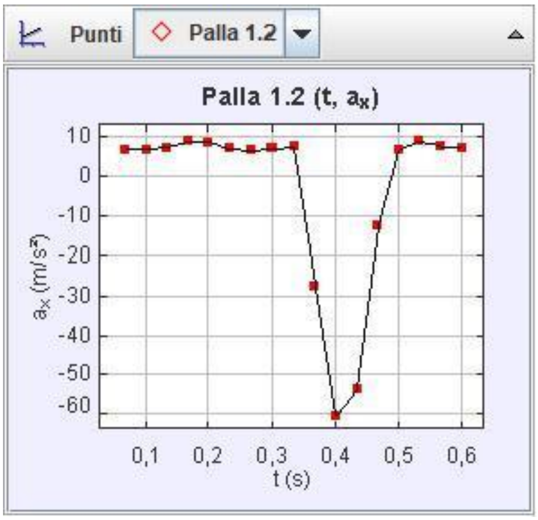
BALL POSITION GRAPH



BALL SPEED GRAPH



BALL ACCELERAPTION GRAPH



SPEED BEFORE	2,821 m/s
SPEED AFTER	-2,465 m/s

FORMULAS:

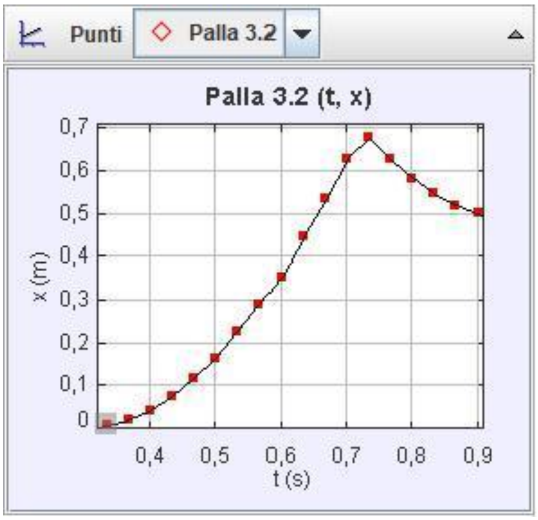
- Kinetic energy: 1/2*m*v^2
- K% lost: ((KA-KB)/KB)*100
- Momentum: m*v
- Delta momentum: MA-MB
- Average force:
  Delta momentum/ (frame's duration 0,033/10)

KINETIC E. BEFORE	0,166 J
KINETIC E. AFTER	0,126 J
K% LOST	-23,647
MOMENTUM BEFORE	0,117 Kg*m/s
MOMENTUM AFTER	-0,103 Kg*m/s
DELTA MOMENTUM	-0,220 Kg*m/s
AVERAGE FORCE	-66,636 N

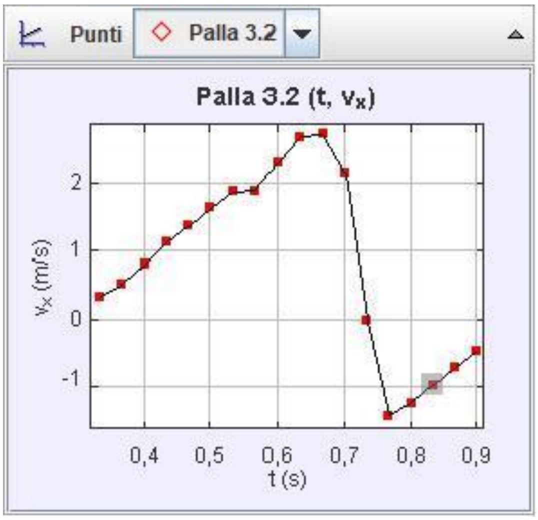
Experiment

SPONGE

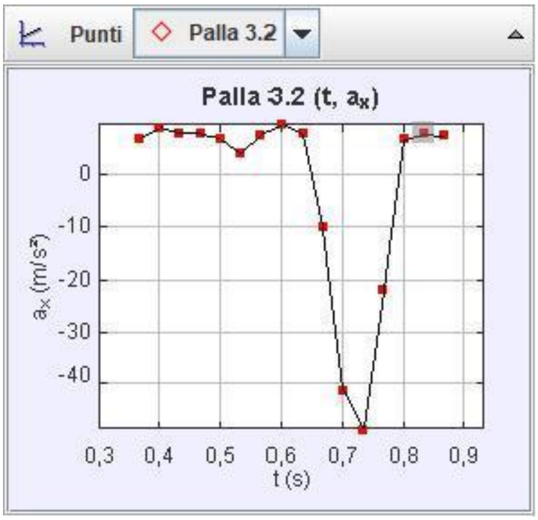
BALL POSITION GRAPH



BALL SPEED GRAPH



BALL ACCELERAPTION GRAPH



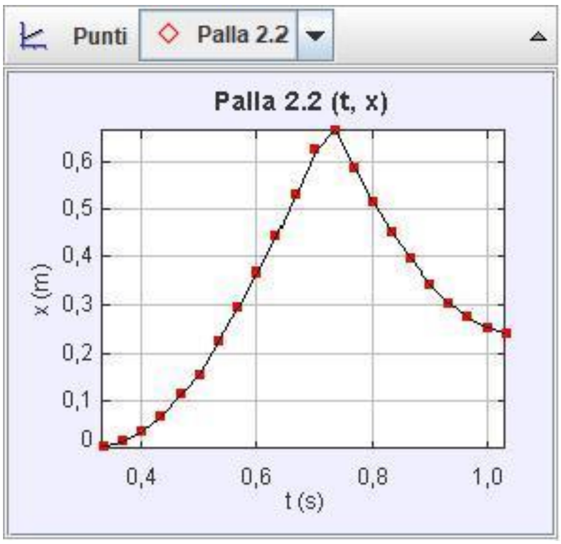
Experiment

SPEED BEFORE	2,168 m/s
SPEED AFTER	-1,421 m/s

KINETIC E. BEFORE	0,098 J
KINETIC E. AFTER	0,042 J
K% LOST	-57,039
MOMENTUM BEFORE	0,090 Kg*m/s
MOMENTUM AFTER	-0,060 Kg*m/s
DELTA MOMENTUM	-0,150 Kg*m/s
AVERAGE FORCE	-45,243 N

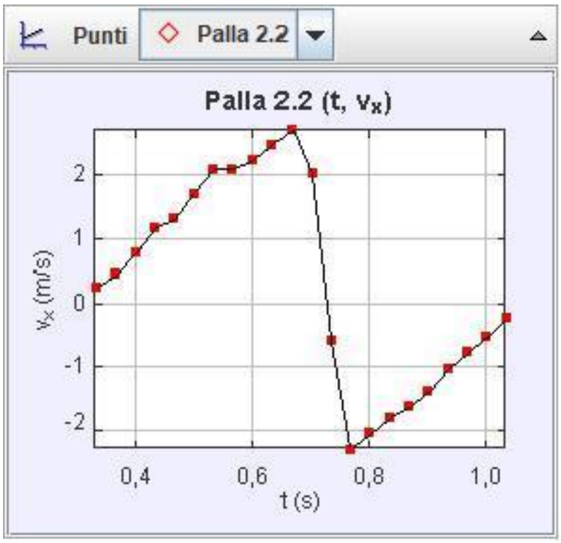
MOUSE PAD

BALL POSITION GRAPH

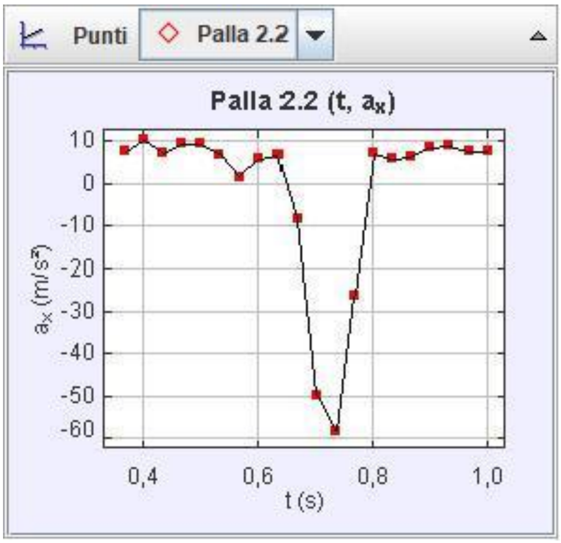


BALL SPEED GRAPH

Experiment



BALL ACCELERAPTION GRAPH



SPEED BEFORE	2,724 m/s
SPEED AFTER	-2,272 m/s

KINETIC E. BEFORE	0,154 J
KINETIC E. AFTER	0,107 J
K% LOST	-30,433
MOMENTUM BEFORE	0,113 Kg*m/s

Experiment

MOMENTUM AFTER	-0,095 Kg*m/s
DELTA MOMENTUM	-0,208 Kg*m/s
AVERAGE FORCE	-62,980 N

3.4. Discussion:

All the measurements taken aren't precise because of the experimental error during execution and the error in tracking positions during the analysis by Tracker, which leads to errors in the calculation of speed and acceleration.

Moreover, in the calculation of the average force the error caused by the estimate of the impact time is added.

To calculate it we used the duration of a frame and divided it by 10 since the interaction time was very small.

We used the impulse-momentum theorem to calculate the medium force during the collision: Fm=I/delta t.

The rebound depends on the elasticity of the material, if the material is elastic there is less rebound. In fact in the table experiment, which is the less elastic surface, the rebound is higher than the other one. Instead with the sponge the rebound is very low, because of the elasticity of the surface.

The data shows that the collision is more elastic with the higher Fm and the lower delta K, instead is more inelastic with the lower Fm and the higher delta K.

4. REFLECTION

Conclusion: The underground has an impact during a collision. The maximum height after the collision depends on the surface. A harder surface (stone, fine gravel…) doesn't absorb (a lot of) energy from the ball. So it bounces back high. A softer surface (mat, grass…) absorbs a bit energy from the ball, but not all of it because the ball bounces back. A weak surface (sand) absorbs all the energy from the ball, in order that the ball doesn't bounce back. In that case the shape of the surface changes. . If a surface is flat the ball will also bounce back higher than if a surface is non flat (grass) because then there is more friction on the ball.

4.1. Comparison of the results of the different countries

4.2. Reflection: Our hypothesis is quite good. We thought the roughness of the surface would influence the height, and the experiment shows this. We didn't really think about the hardness of the surface. The result sometimes are a bit odd because with 'tracker', it is hard to work precisely. We only got two measurements on the same surface, because the clips sometimes blocked so we couldn't use tracker.