eTwinning	TEAM: 7	
	Belgium	Sien Gryspeert, Leonita Zeqiri, Victor Van Win and Arne Vercruysse
Smashing! Real-world clashes into physics classes	Italy	Giulia Albanese, Pietro Carnevali and Caterina Zaccari
EXPERIMENT: The impact of incoming meteors		

1. ORIENTATION (BELGIUM)

1.1. Research question:

If you drop balls with different mass, but of the same material, from the same height, will their mass affect the impact of the collision?

Sub-questions:

1) What force will be exerted on the sand by the different balls?

2) What work will the sand do on the different balls?

1.2. Hypothesis

The greater the mass of the ball, the greater the force exerted during the collision, so the greater the impact of the collision.

1. PREPARATION (ITALY)

1.1. **Material**:

•Plasticine
•Flour
•Meterstick
•Metallic support

- Weights with different masses
- Plastic container

- Polystyrene ball with a hole

  => (weight 11,5 g)

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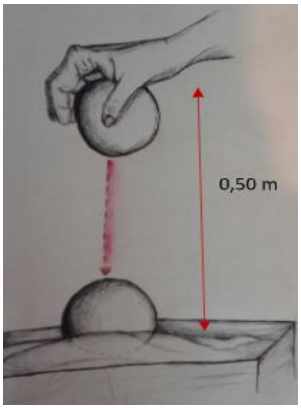
2.2. Method:

•The experiment consists on dropping a polystyrene ball from an assigned height. The ball has got a hole (1), where it's possible to insert different weights and plasticine, thus varying the mass (2). The ball is dropped in a plastic container ¾ filled with flour (repeat the procedure two times for each mass).



•Observe the impact and measure its depth with a meterstick.

•Repeat the same procedure increasing the mass of the ball.

•Regarding the analysis part, use inverse equations of the laws of dynamics to calculate the acceleration and the interaction time between the balls and the flour during the fall, having the depth of the impact and the height of the fall.

•Use the acceleration for each mass to calculate the total force on the ball with the second Newton's law and the force on the flour by the ball with the third Newton's law.

2)

m = 30 g

m = 60 g

m = 120 g

2. DATA ANALYSIS and DISCUSSION (ITALY)

	BALL 1	BALL 2	BALL 3
MASS (Kg)	0,03	0,06	0,120
HEIGHT (m)	0,500±0,001	0,500±0,001	0,500±0,001
DEEPNESS OF THE HOLE (m)	0,022±0,001	0,027±0,001	0,038±0,001

DATA COMMENTS:

Ball mass = 11,5g (polystyrene ball) + weights with different masses

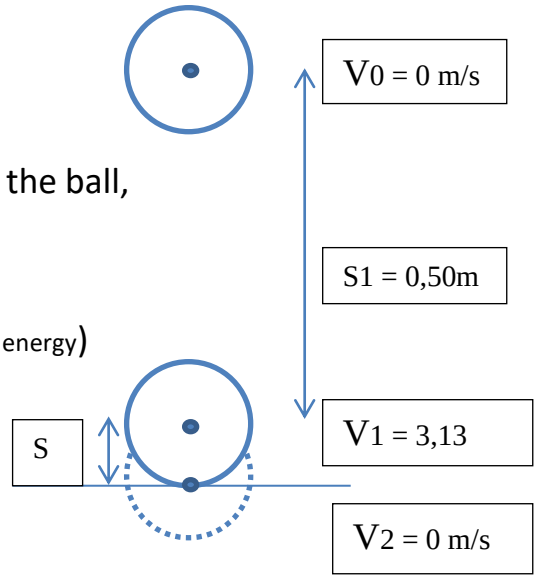
- To measure the height we took 50 cm from the surface of the flour plus the diameter of the polystyrene ball (d= 8,9 ± 0,05 cm) measured with calibre.

- To measure the deepness of the hole : difference between the distance from the centre of the hole to the edge of the container and the distance from the surface of the flour to the edge.

- We estimate the errors in the measurements of the heights end the deepness's to be 1 mm. In the calculated quantities below we have summed the relative errors and then calculated the absolute error by multiplying the relative error with the mean value.

	Mass 1	Mass 2	Mass 3
Force on the ball (N)	-6,7±0,4	-11,0±0,5	-15,5±0,5
Force on the surface (flour) (N)	6,7±0,4	11,0±0,5	15,5±0,5

CALCULATIONS:



-To calculate the total force which has an effect on the ball,

we used this method:

$U0 + K0 = U1 + K1$ (for the conservation of mechanical energy)

$m \cdot g \cdot S_1 = \frac{1}{2}\, m \cdot (V_1)^2$

$\Rightarrow (V_1)^2 = 2(g \cdot s_1)$

-So, we can use two different methods to calculate the force exerted on the ball:

1) $(V_2)^2 = (V_1)^2 + 2a(s_2)$

=> $a = -(g \cdot s_1)/s_2$

=> $F = m \cdot a$

2) $F \cdot S2 = K2 - K1$

=> $F \cdot S2 = -(m \cdot g \cdot S1)$

=> $F = -(m \cdot g \cdot S1)/ S2$

- MASS 1 = 0,030 Kg

F (on the ball) = -(m1·g·s1)/s2 = -(0,03Kg · 9,81N/Kg · 0,5m)/0,022m =
= **-6,7N**
F (on the ground) = -**F** (on the ball) = **6,7**= -(-6,7) N

- MASS 2 = 0,060Kg

F (on the ball) = -(m2·g·s1)/s2 = -(0,06Kg · 9,81N/Kg · 0,05m)/0,027m = **-11N**

F (on the surface) = **11N**

- MASS 3 = 0,120Kg

F (on the ball) = -(m3·g·s1)/s2 = -(0,120Kg · 9,81N/Kg · 0,05m)/0,038m=

-16N (-15,5N)

F (on the surface) = **16N**

- **Volume of the hole:**

$V = 1/3 \prod (s_2)^2 \cdot \{(3r_{ball}) - s_2\}$

-Hole 1:
- $s_2 =$ (22 ± 1) mm
- r_{ball}: (44,35 ± 0,05) mm

-Hole 2:
- $s_2 =$ (27 ± 1) mm
- r_{ball}: (44,35 ± 0,05) mm

-Hole 3:
- $s_2 =$ (38 ± 1) mm
- r_{ball}: (44,35 ± 0,05) mm

	Mass 1	Mass 2	Mass 3
Volume of the hole (mm^3)	56	81	144
Relative error	0,0987	0,0849	0,0647
Absolute error (mm^3)	6	7	10

-if we look at the results obtained by calculating the volume of each hole, we can observe that the volumes of the holes increases with increasing mass, just as the exerted forces do. To study the relation between these quantities we have divided the force by the volume. The results are summarized in the following table:

	Mass 1	Mass 2	Mass 3
F/V (N/mm^3)	0,12	0,14	0,11
Relative error	0,158	0,130	0,097
Absolute error (N/mm^3)	0,02	0,02	0,02

- Within errors the ratio is compatible with a constant value, suggesting the volume of the created hole is directly proportional to the exerted force. To make a more certain statement further data points are needed.

CALCULATION COMMENTS:

We could observe that the force exerted on the ball increased with the growth of the mass because:

-We obtained the equation: $F= -(mgs_1)/s_2$;

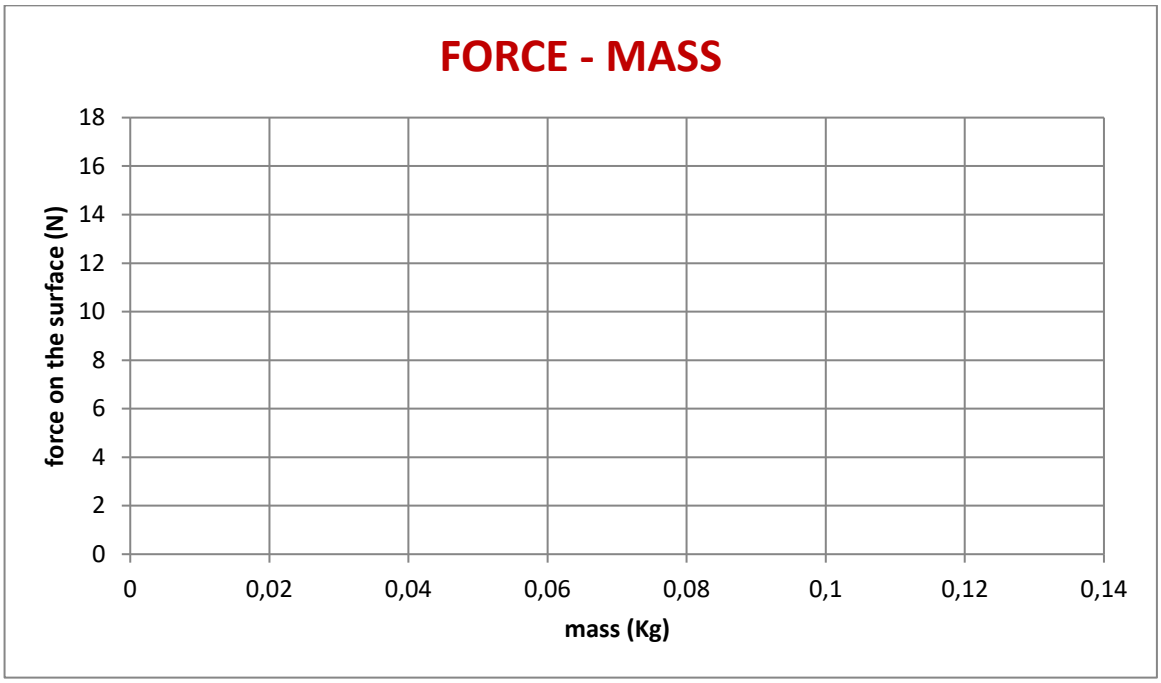
As we could see, the deepness of the hole increased with the increase of the ball's mass and also the measure of the resulting force grew;

So, because of the third Newton's law, the force exerted on the surface of flour had got the same intensity of the force applied to the ball, but the opposite way;

-We could also observe that the acceleration decreased because of the growth of the hole's deepness (in fact: a= -9,8/2S2);

But, because of the increase of the mass, using the second Newton's law, we could prove that the intensity of the force exerted on the ball grew;

So also the force applied to the surface of flour increased because of the third Newton's law;



If we look at the graphic we immediately notice that it isn't a direct proportionality; in fact it isn't possible to write a linear graphic. Only in small sections we can have a linear graphic but we have to consider also that the graphic isn't so accurate because there are few points and the experiment was made just one time.

Our data suggest that there is a direct proportionality between the exerted force and the volume of the created hole.

3. DATA ANALYSIS and DISCUSSION (BELGIUM)

3.1. **Observations and Measurements**:

- $E_{kin\ bottom} = E_{pot\ top}$

  $(M * v^2) / 2 = m * g * h$

  ⇩

  $v = \sqrt{2 * g * h}$

- $W = (m * v_t^2) / 2 - (m * v_b^2) / 2$ (work from the sand on the balls)

  $= 0$

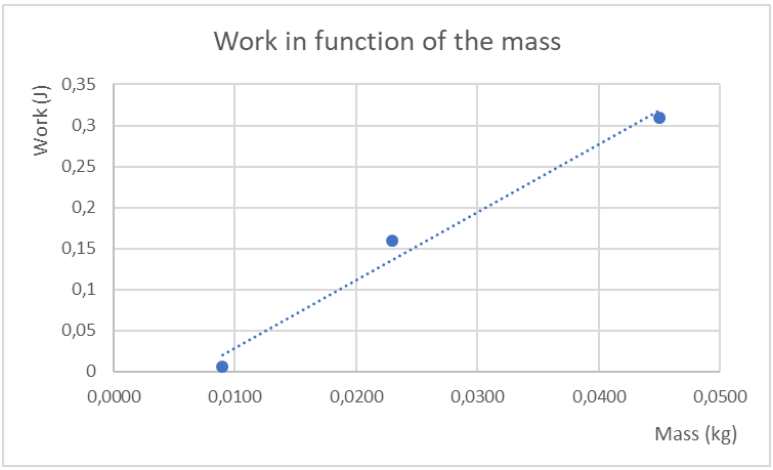
  $W = (m * v_b^2) / 2$

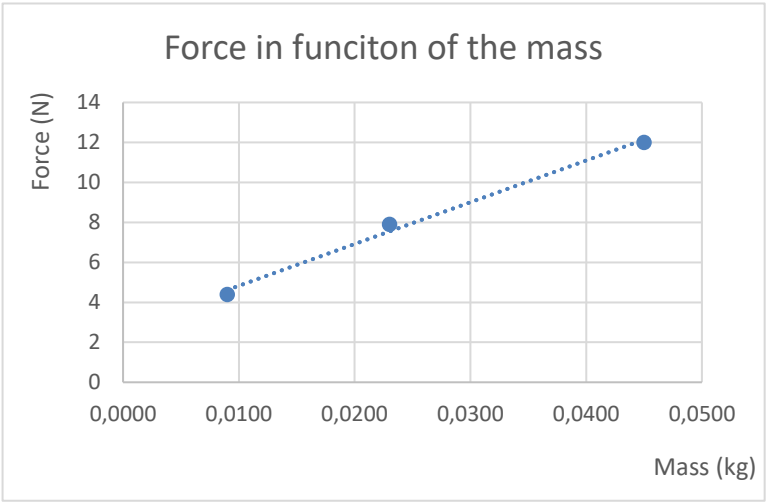
- $W = F * x$

  ⇩

  $F = W / x$

	m (kg)	X (m)	W (J)	F (N)
Small ball	0,0090	0,014	0,061	4,4
Middle ball	0,023	0,020	0,16	7,9
Big ball	0,045	0,025	0,31	12





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3.3. **Discussion:**

In the table you can see if the mass of the balls gains that the impact, the depth of the hole (x) gains too.

The first graph shows a linear relationship between the force and the mass. The heavier the object, the greater the force will be on the sand.

The second graph shows the relation between work and mass. Here you can see the same thing again. The greater the mass of the object, the greater the work of the sand on the balls. You can also derive it from the formula $W = (m * v_b^2) / 2$. If the mass increases the work increases too.

4. REFLECTION

4.1. **Conclusion** (BELGIUM):

Yes, their mass will effect the impact of the collision.
The greater the mass, the greater the force of the balls on the sand.
The greater the mass, the greater the work of the sand on the balls..

4.2. **Comparison** of the results of the different countries (ITALY)

The results of the two countries, Italy and Belgium, after the experiment, are different.
This happend because of three main reasons:

1) We chose different masses (Italy: 30g, 60g and 120 g; Belgium: 23g, 45g and 90 g);

2) We chose different materials for balls and the "ground" (Italy: polystyrene ball and flour; Belgium: wooden balls and sand)

Moreover, italian teammates used the same polystyrene ball for the experiment, inserting weights with different masses in it, but maintaining the same dimensions and volume. Belgian teammates used three different balls, with different masses and dimensions too.

4.3. **Reflection** (BELGIUM):

Our hypothesis were right. It's a pity everyone didn't put in the same effort. We were not accurate enough and did not take enough measurements.

5. REFERENCES

We didn’t have references.