eTwinning	TEAM:3	
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Smashing! Real-world clashes into physics classes	Italy	Sara Gentilini, Viviana Matei and Rebecca Capelli
EXPERIMENT: Collision of petanque balls		

1. ORIENTATION

1.1. Research question:

- How much force is necessary to bounce the other ball away?

Sub-questions:

- Does it matter on which surface the second ball is lying to roll away well or not?
- How much speed does the first ball need so that the second would roll away?
- How much energy is transfered to the second ball?
- Examine the Impulse-Momentum theorem for the second ball.

1.2. Hypothesis

The harder the ground, the faster the ball will roll away

The first ball must have only a small amount of speed before the second ball will roll away.

The smaller the angle the further the ball will bounce away.

The amount of energy that passes to the second ball will be equal to the amount of energy that the first ball possesses.

2. PREPARATION

2. Material:

2.1.1. Ramp

2.1.2. 2 petanque balls (<u>Italy</u>: mass 1: 215,8 g; mass 2: 219,8 g / <u>Belgium</u>: mass 1: 720g; mass 2: 720g)

2.1.3. Surface 2: wood thickness (put it under the ramp)

2.1.4. Surface 3: scarf

2.1.5. Concave plastic rod

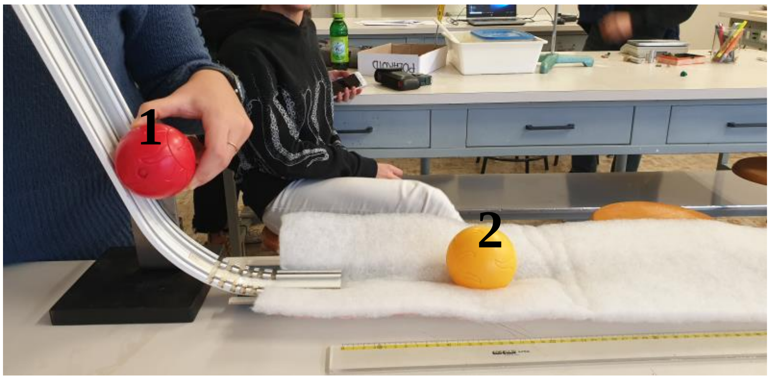
2.1.6. Balance

2.1.7. Long ruler

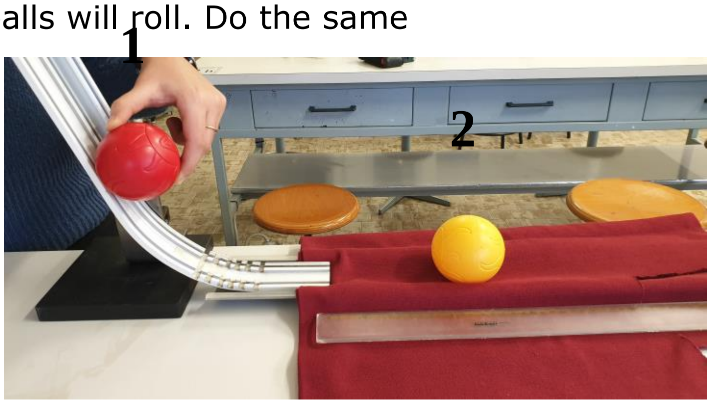
2.1.8. Motion sensor (CBR)

2. Method:

- With the first surface we use the concave plastic rod. Place the ball 1 at a certain high on the ramp. See the figure where you are doing the experiment, from the end of the ramp place the ball 2 a certain distance. With the motion sensor measure the speed of ball 2 and estimate the speed of ball 1 from its initial potential energy.
- With the second surface use a sponge (see the figure) and place it at the end of the ramp. Do the same procedure performed with the first surface and write down the data obtained.



- With the third surface use a cloth and place it a little bit under the ramp so it won't move when the balls will roll. Do the same procedure performed with the first surface and write down the data obtained.



- Calculate the transferred momentum and energy (from the velocities V_{1i} and V_{2f}).
- From the graph $a_2(t)$ (obtained by the motion sensor) estimate a limit for the interaction time Δt and use the Impulse-momentum theorem to estimate a limit to the mean force.

3. DATA ANALYSIS and DISCUSSION

3. **Observations and Measurements**:

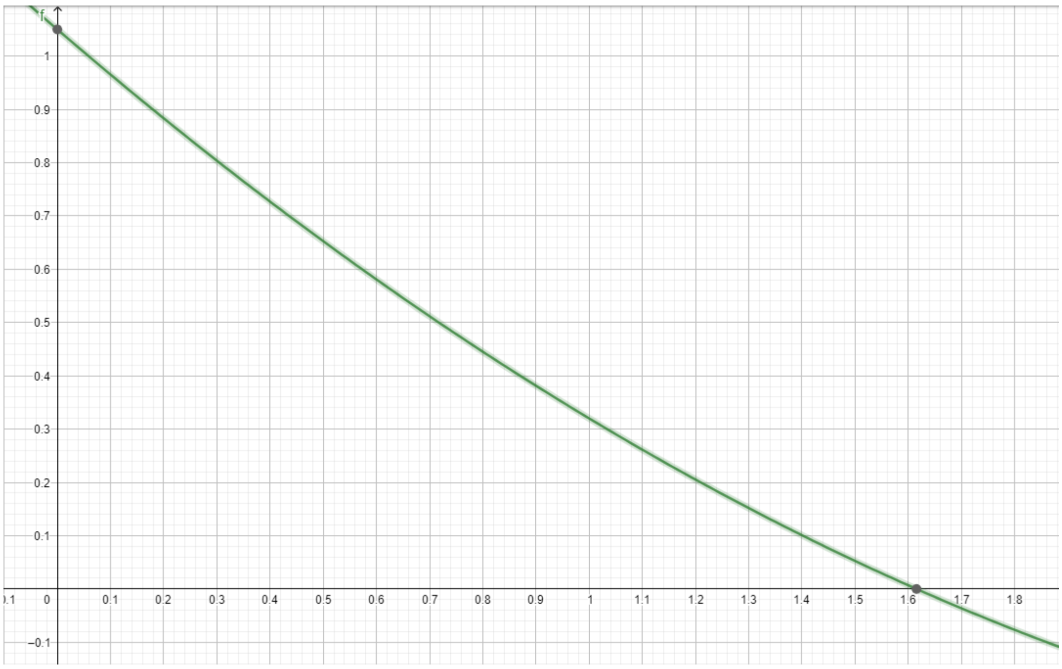
Belgium:

- First surface
  - $x(t) = 0{,}13t^2 - 0{,}86t + 1{,}05$
  - $(x(t) = 0{,}023t^2 - 0{,}70t + 0{,}84)$

    => $v(t) = 0{,}26t – 0{,}86$

    $a = 0{,}26\ m/s^2$
  - $F= m*a$ -> $F= 0{,}780\ (kg) * 0{,}26\ m/s^2$
    - The force on the second ball is 0,20 N.
  - The second ball will come to a standstill after approximately 3,2 seconds.

Graph



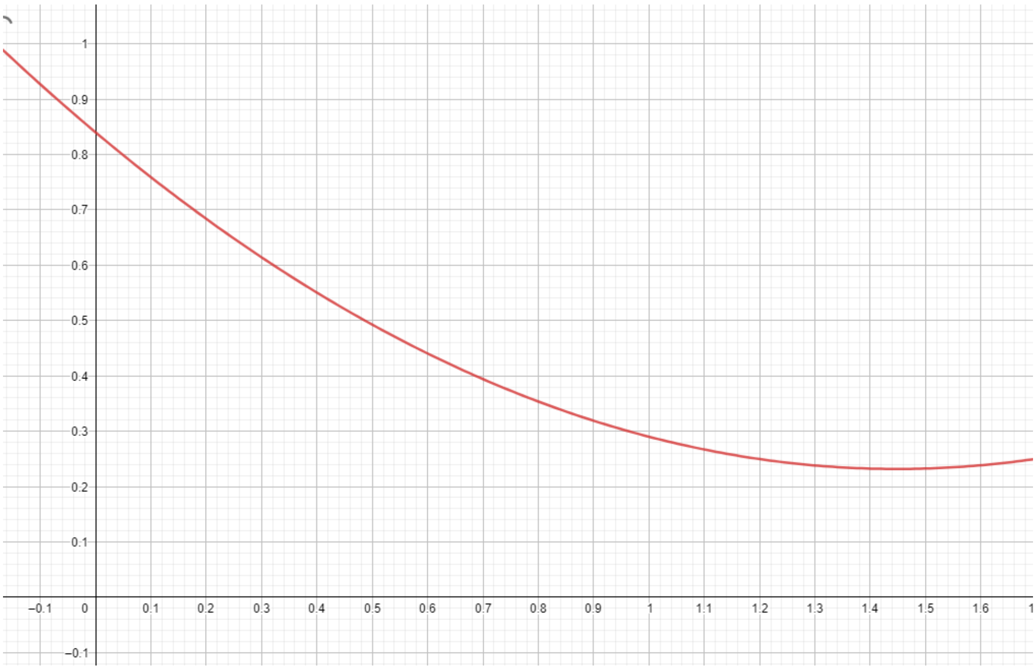
- Second surface
  - $x(t) = 0{,}35t^2 - 0{,}66t + 0{,}76$
  - $x(t) = 0{,}23t^2 - 1{,}02t + 0{,}92$

    => average: $x(t) = 0{,}29\ t^2 - 0{,}84t + 0{,}84$

    $v(t) = 0{,}58t – 0{,}84$

    $a = 0{,}58\ m/s^2$
  - $F = m*a$ -> $F = 0{,}780\ (kg) * 0{,}58\ m/s^2$
    - The force on the second ball is 0,45 N.
  - The second ball will come to a standstill after approximately 1,4 seconds.

Graph



- Third surface
  - $x(t) = 0{,}27t^2 - 0{,}76t + 0{,}74$
  - $x(t) = 0{,}29t^2 - 0{,}92t + 0{,}87$

    => average: $x(t) = 0{,}28t^2 - 0{,}84t + 0{,}81$

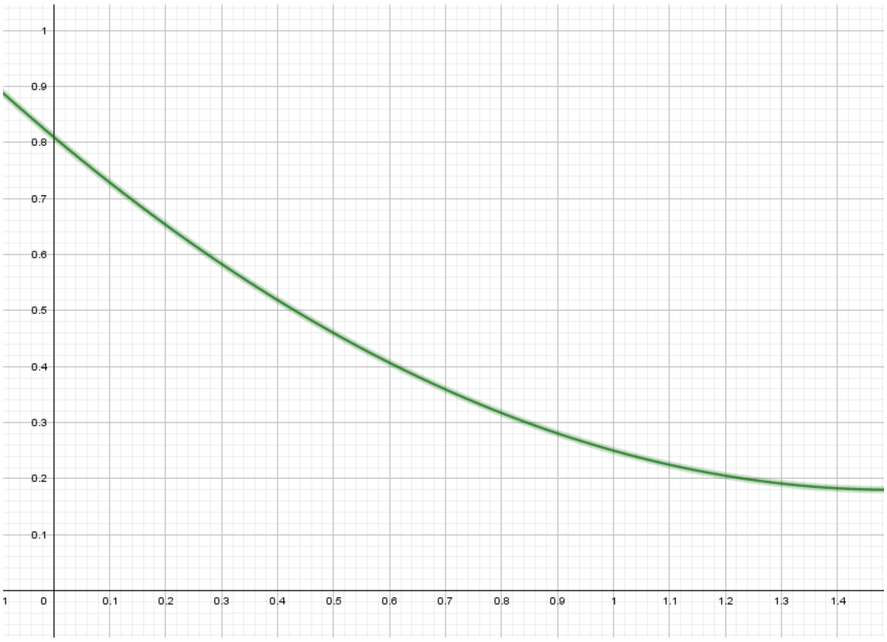
    $v(t) = 0{,}56t - 0{,}84$

    $a = 0{,}56\ m/s^2$

  - $F = m*a$ -> $F = 0{,}780\ (kg) * 0{,}56\ m/s^2$
    - The force on the second ball is 0,43 N

  - The second ball will come to a standstill after approximately 1,5 seconds.

Graph

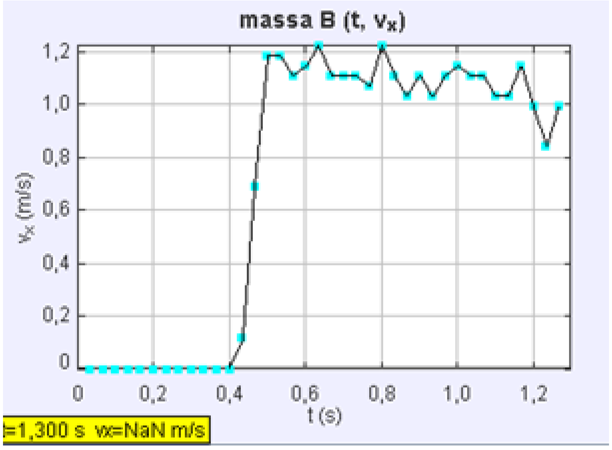


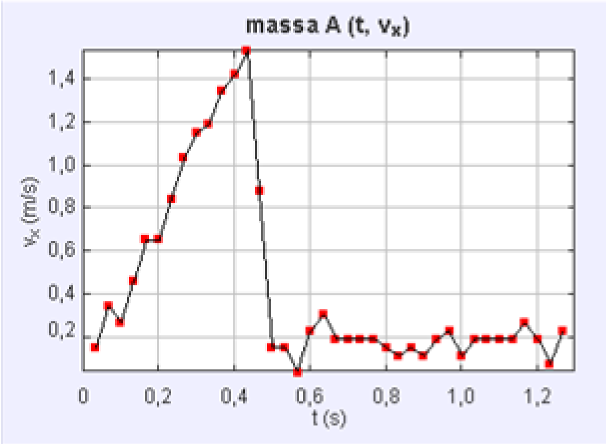
Italy:

Formulas used:

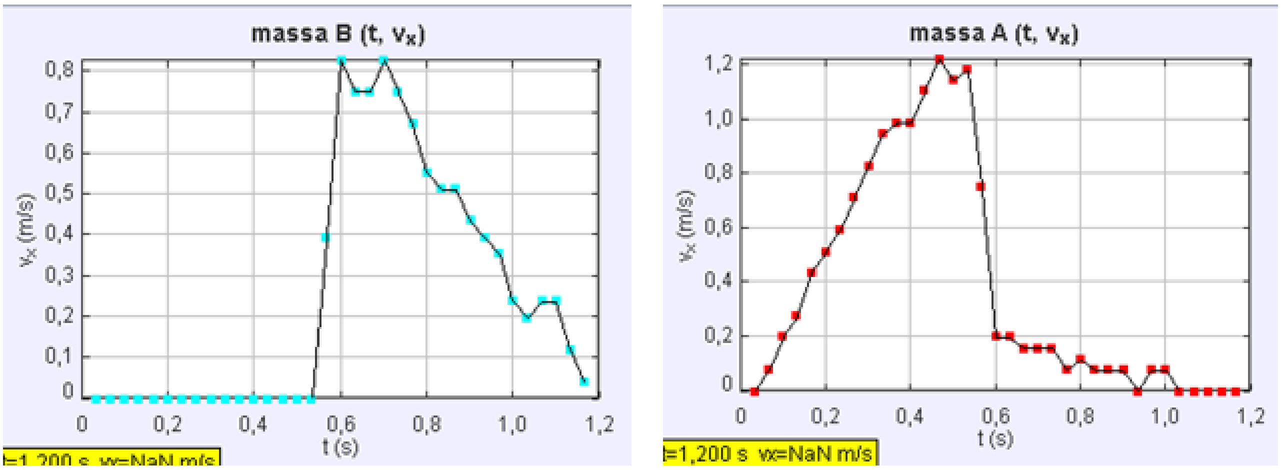
qi1= m1*vi1   qf1=m1*vf1   Fm1 = q1/Δt1   Ki1 = ½*m1*vi1²   Kf1=½*m1*vf1²   Mass1 : 0,216 kg

qi2= m2*vi2   qf2=m2*vf2   Fm2 = q2/Δt2   Ki2 = ½*m2*vi2²   Kf2=½*m*v2f²   Mass2 : 0,220 kg

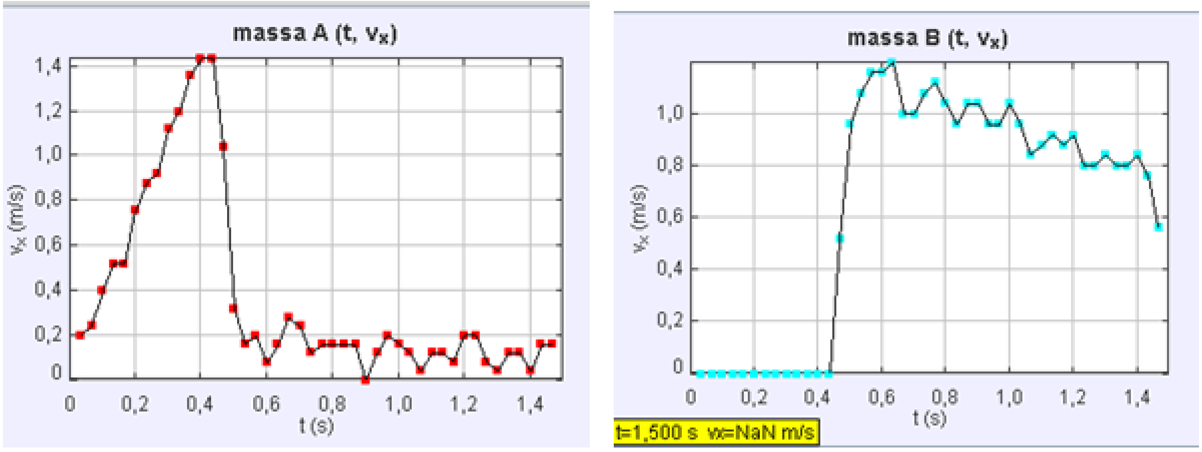




(time-speed graphs first surface)



(time-speed graphs second surface)



(time-speed graphs third surface)

This is the table with our results :

	First surface	***Second surface***	***Third surface***
qi1 (kg*m/s)	0,311	0,2592	0,3024
qf1 (kg*m/s)	0,053	0,0425	0,0432
qi2 (kg*m/s)	0,0	0,0	0,0
qf2 (kg*m/s)	0,271	0,182	0,264
Δq1 (kg*m/s)	-0,258	-0,2167	-0,2592
Δq2 (kg*m/s)	0,271	0,182	0,264
Δt1 (s)	0,0033	0,0033	0,0033
Δt2 (s)	0,0033	0,0033	0,0033

Fmi (N)	78,18	65,67	78,55
Fmf (N)	82,12	55,15	80
Vi1 (m/s)	1,422	1,2	1,4
Vf1 (m/s)	0,246	0,197	0,2
Vi2 (m/s)	0,0	0,0	0,0
Vf2 (m/s)	1,231	0,829	1,2
Ki1 (J)	0,225	0,156	0,212
Kf1 (J)	0,0023	0,0042	0,0043
Ki2 (J)	0,0	0,0	0,0
Kf2 (J)	0,167	0,0756	0,158
Ktot_i (J)	0,227	0,160	0,216
Ktot_f (J)	0,167	0,0756	0,158
Ktot (J)	0,394	0,236	0,374
E lost %	15,23	35,76	15,5

3. Discussion:

Belgium:

We can see that the deceleration on the first surface is lower than on the second and third surface. The second and third surface don't differ a lot from each other. On the graphs, we can also see that the balls stop rolling a lot faster on the second and third surface, because they are steeper than the first graph. We can see from the graph that the subsurface is important for the ball. Because a softer surface easily absorbs the energy of the ball. The softer the ground, the slower the ball will roll.

We can determine the amount of energy transmitted to the second ball through the law of conservation of energy. The first ball passes all its energy to the other ball, we know this by this law. We know the speed at the end of the orbit, the mass of the ball, the height of the cube so we can calculate the energy via the potential energy and kinetic energy. From this we then know how much energy is passed on to the second ball.

We can prove that this is true with the Impulse-Momentum theorem, because we can calculate the work using the acceleration and force. We also know that the ball has no energy in the starting position, because the speed is zero. From this we can conclude that the end energy equals the work.

For the first surface, we didn't use the result of the second attempt as it was very different from the other results. This could be the result of a mistake made whilst measuring, therefore it is not a representative value. Since we do not know the friction constant, it is difficult to determine the exact force the second ball experiences.

Italy:

Depending on the different surfaces on which the balls roll, the first ball hits the other one with different forces and at different speeds; although, as can be seen from the graphs and the table, surfaces 1 and 3 have similar values. We estimate that the errors in the extracted values from the graphs of Tracker to be about 10%. For the interaction time we have used 1/10th of tframe = 0,033 s, because the collision occurs between two slides and there isn't the precise moment of the collision.

4. REFLECTION

4. Conclusion: On a smooth, hard surface, we need less force to move the second ball than on a rough, soft surface. Just like we expected. We weren't able to discover how much force was necessary to bounce the other ball away as the ball rolled away at every attempt. We didn't reach a force small enough to see the minimal force necessary to bounce the second ball away.

We also discovered that, the smaller the angle, the shorter the ball will roll, this is logical because the ball has less potential energy so therefore also less kinetic energy.

The energy transmitted to the second ball by the first ball is equal if we look at a system without frictional force. Otherwise, the energy of the first ball will be greater than that of the second ball.

4. **Comparison** of the results of the different countries

4. **Reflection:**

Sometimes we had some trouble with the measurements but in the end everything went smoothly.

5. REFERENCES