	TEAM:4	
eTwinning	Belgium	Wout Debie, Kobe Declerck, Manu De Groote, Noah Duyck
Smashing! Real-world clashes into physics classes	Italy	Gabriele Bartolotti, Redi Dedej, Antonio Palmieri
EXPERIMENT: Collision of billiard balls		

- ORIENTATION
  - **Research question:**

What will happen with the billiard ball in rest, if another billiard ball hits it with speed?

Sub-questions:

- Does the angle matter?

- What is the speed of the ball?

- Which type of graph do you get?

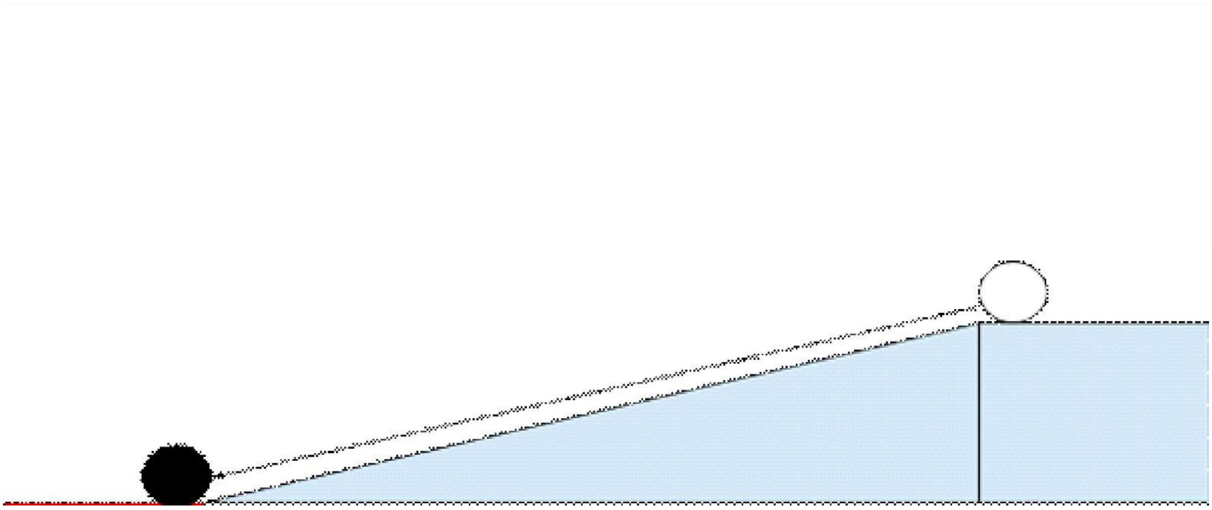
Hypothesis The ball at rest is going to be moved at a certain angle.

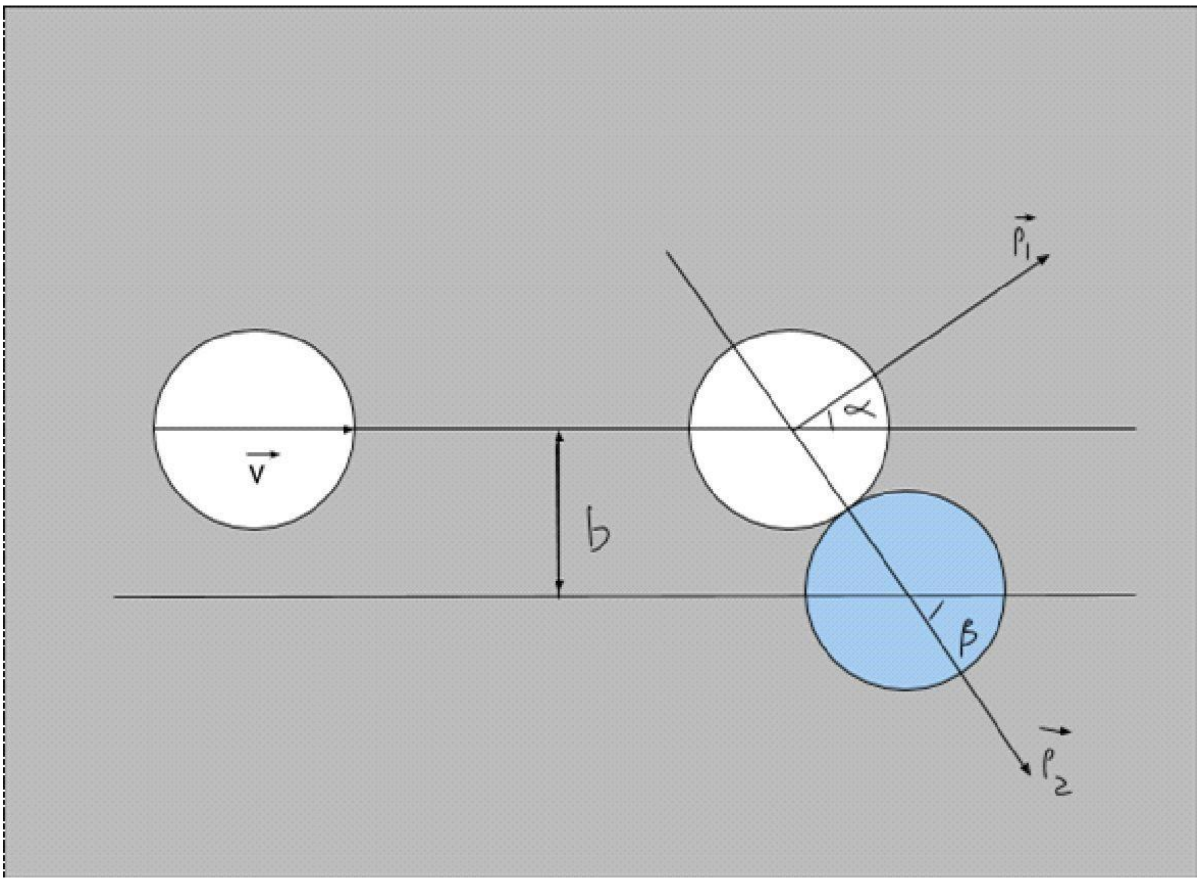
If the ball at rest is hit in the middle, it will move straight forward. If you hit the left side of the ball at rest, it will move to the right and vice versa.

- PREPARATION
  - **Material**:
    - Two billiard balls,
    - A fixed slope,
    - A platform that resembles the one in billiard tables.
  - **Method:**
    - Rolling a ball from a fixed slope that hits another ball with a determined impact parameter. The two balls after the impact will continue on a platform that resembles the billiard tables.
    - Make a series of collisions for different impact parameters. For example $b=0, b = R/2$, $b = R$ and $b = 3R/2$, where R is the radius of the balls. ● Film and plot the y(x)-graph with Tracker.
    - Study the scattering angle as a function of impact parameter and the final velocity of the second ball as a function of impact parameter.

With this we want to analyze:

1. From tracker estimate v_{1i}, v_{1f}, v_{2f}, and the scattering angles α and β (see figure).
2. For each impact parameter calculate the momenta an kinetic energies and verify the conservation of total momentum and of total kinetic energy.
3. For one impact parameter estimate the interaction time from the video. Use the Impulse-Momentum theorem to estimate the total force in the collision.





The collision of the two balls: The two balls are not in a line ,the white one is moved by the line with a distance b , called the impact parameter.

•DATA ANALYSIS and DISCUSSION

- **Observations and Measurements**:

We have analyzed the collisions with Tracker (see figure), and extracted the quantities in the

following table.

b (cm)	v_{1i} (m/s)	v_{1fx} (m/s)	v_{1fy} (m/s)	v_{1f} (m/s)	v_{2fx} (m/s)	v_{2fy} (m/s)	v_{2f} (m/s)
0,0 / 0,0	1,05 / 1,80	0,08 / 0,16	-0,01 /0,00	0,00 / 0,00	0,90 / 1,71	0,01 / 0,00	0,90 / 1,71
1,5 / 1,0	1,05 / 1,80	0,23 / 0,23	-0,16 / -0,13	0,30 / 0,30	0,86 / 1, 56	0,23 / 0,32	0,89 / 1,21
2,9 / 2,0	1,05 / 1,81	0,64 / 0,79	-0,19 / -0,18	0,70 / 0,85	0,30 / 1,02	0,54 / 0,39	0,62 / 0,99
4,4 / 3,0	1,05 / 1,83	0,84 / 0,88	-0,36 / -0,42	0,90 / 1,00	0,29 / 0,46	0,35 / 0,50	0,46 / 0,70

- b = impact parameter.
- v_{1i} = velocity of the first ball immediately before the collision.
- v_{1fx} = the x-component of the velocity of the first ball immediately after the collision.
- v_{1fy} = the y-component of the velocity of the first ball immediately after the collision.
- $v_{1f} = [(v_{1fx})^2 + (v_{1f})^2]^{1/2}$ = the module of the velocity of the first ball immediately after the collision.
- v_{2fx} = the x-component of the velocity of the second ball immediately after the collision.
- v_{2fy} = the y-component of the velocity of the second ball immediately after the collision.
- $v_{2f} = [(v_{2fx})^2 + (v_{2f})^2]^{1/2}$ = the module of the velocity of the second ball immediately after

the
collision.

Black ball

m_1=0,1825kg/ 0.270kg

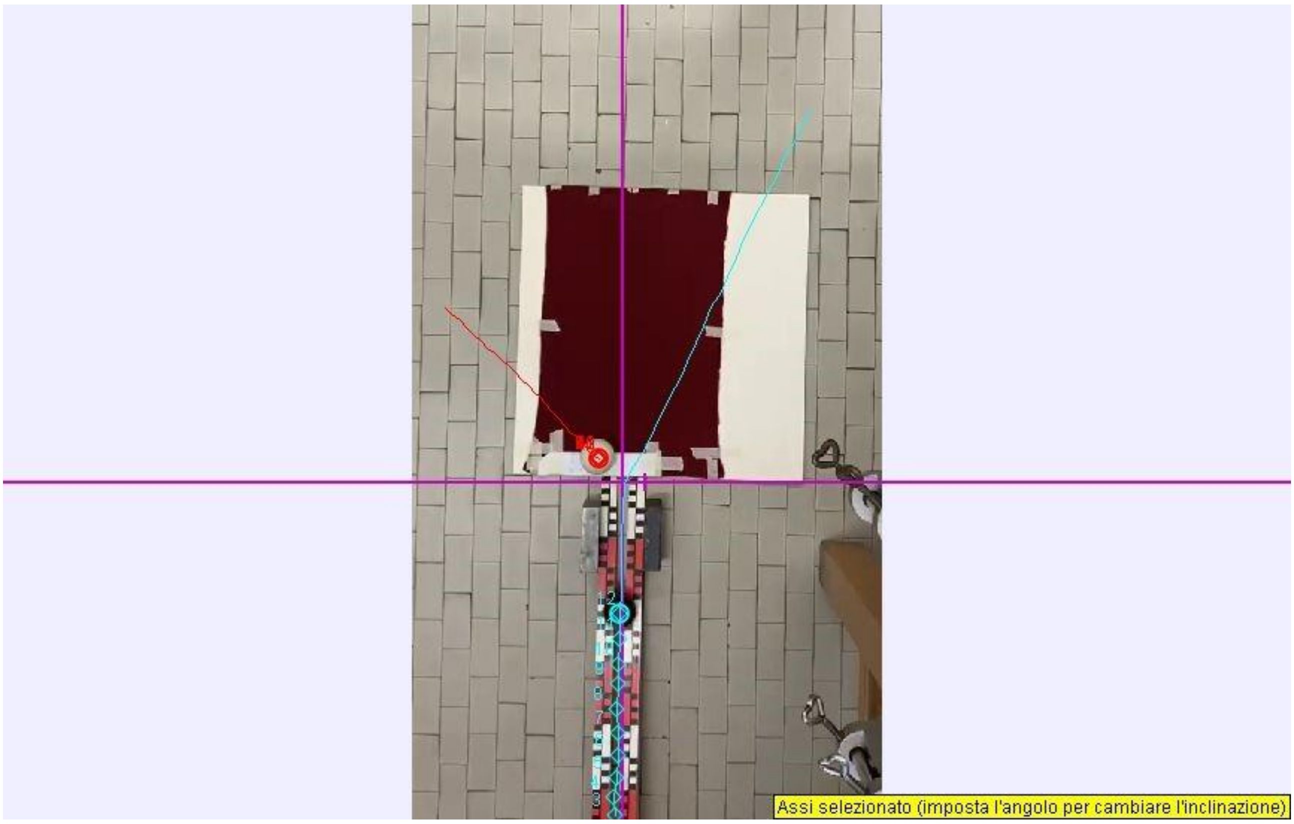
White ball

m_2=0,207kg/ 0.273kg

From the measured quantities we have calculated the scattering angles and the linear momenta. The results are summarized in the following table

b (cm)	p_{1i} (kgm/s)	p_{1fx} (kgm/s)	p_{1fy} (kgm/s)	p_{2fx} (kgm/s)	p_{2fy} (kgm/s)	p_{Tfx} (kgm/s)	p_{Tfy} (kgm/s)
0,0 0.0	0,19 0.49	0,02 0.04	-0,002 0.00	0,19 0.47	0,002 0.00	0,20 0.51	0,0002 0.00
1,5 1.0	0,19 0.49	0,04 0.06	-0,03 -0.04	0,18 0.43	0,05 0.09	0,22 0.49	0,02 0.05
2,9 2.0	0,19 0.49	0,12 0.21	-0,04 -0.05	0,06 0.28	0,11 0.11	0,18 0.49	0,08 0.06
4,4 3.0	0,19 0.49	0,15 0.24	-0,07 -1.11	0,06 0.13	0,07 0.14	0,21 0.37	0,01 -0.97

- $p_{1i} = m_1 \cdot v_{1i}$ $p_{1fx} = m_1 \cdot v_{1fx}$ $p_{1fy} = m_1 \cdot v_{1fy}$ $p_{2fx} = m_2 \cdot v_{2fx}$
- $p_{2fy} = m_2 \cdot v_{2fy}$ $p_{Tfx} = p_{1fx} + p_{2fx}$ $p_{Tfy} = p_{1fy} + p_{2fy}$



From the measured quantities we have calculated the scattering angles and the kinetic energies. The results are summarized in the following table

b (cm)	α (ball 1)	β (ball 2)	K_{1i} (J)	K_{1f} (J)	K_{2f} (J)	K_{Tf} (J)
0,0 / 0,0	0° / 0°	0°/ 0°	0,10 /6.00	0,00/ 0.00	0,08 / 5.36	0,08 / 5.36
1,5/ 1.0	28° / 55°	15° /35°	0,10 /6.00	0,01/ 0.17	0,08 / 2.68	0,09 / 2.85
2,9/ 2.0	27° / 45°	30° /37°	0,10/ 6.07	0,04/ 1.34	0,03 / 1.80	0,07 / 3.14
4,4/ 3.0	30° / 35°	45° / 40°	0,10/ 6.20	0,07 / 1.85	0,02 / 0.90	0,09 / 2.75

- $K_{1i} = (v_{1i})^2 / (2m_1)$ $K_{1f} = (v_{1f})^2 / (2m_1)$ $K_{2f} = (v_{2f})^2 / (2m_2)$ $K_{Tf} = K_{1f} + K_{2f}$

Black results = Italian results – red results = Belgian results

- **Discussion:**

- REFLECTION

- **Conclusion**: The billiard ball at rest will roll away due to the impact of the rolling ball. The more he is hit on the side, the sharper the angle in which he rolls away will be. The angle of impact between the two balls also has an effect on the speed of the second ball. The sharper the angle of impact, the slower the second ball will roll away and the faster the first ball will keep rolling.

- **Comparison:** The results of both groups match fairly well, which was of course the intention.
- **Reflection:** The communication and cooperation went well.

• REFERENCES