eTwinning	TEAM: 2	
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Smashing! Real-world clashes into physics classes	Italy	Francesco Colombo, Alessia Guerra, Nazifa Noor Ahmad
EXPERIMENT: Boxing: a punch		

1. ORIENTATION

1.1. **Research question:**

What impact does the material used to punch the boxing ball have on the boxing ball itself?

Sub-questions:

What differences in -speed
-acceleration
-time before the ball stops moving
are there if you punch with or without boxing gloves?

1.2. **Hypothesis :**

If you hit with your fist the energy concentrates on a few points, with a boxing glove you spread it over a larger area, with a springy effect.

Sub-question hypothesis:

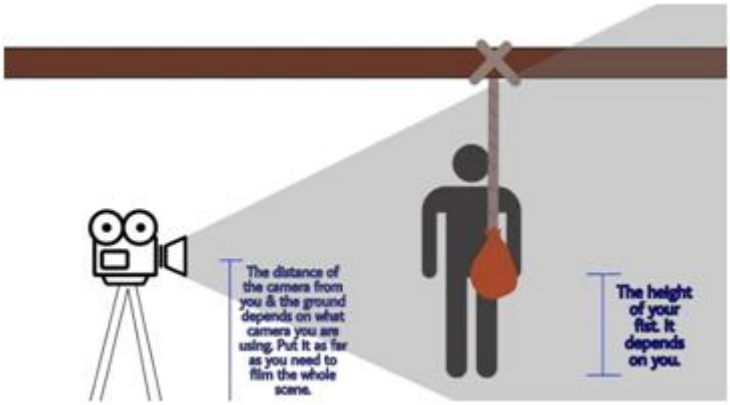
- The speed at which the punching bag is thrown away will be greater if you hit with the punching glove than with your bare hand.
- The acceleration of the punching ball will be greater when hitting with the boxing glove than when hitting with the bare hand because the force is much greater when hitting with a boxing glove.
- Because the force is much greater when hitting with a boxing glove, the punching ball will take much longer to come to a standstill.

2. PREPARATION

2.1. **Material**:

- a bag (cushion cover)
- a ball (or clothes)
- a rope
- a boxing glove (scarf)
- something with a good framerate to film the experiment with (phone camera)
- Tracker

2.2. **Method:**



1) Measure the weight of the sack (ours is 2.8 kg).
2) The stuffed bag is the boxing ball, attach the rope around the top of the bag and a beam or ceiling.
3) Punch the bag multiple times with and without the gloves. Record this. Attention: the bag must not rotate, your punch must fall a straight path.
4) Analyze the punches with Trackers. Determine the speed of the fist before the collision, the velocity of the boxing ball immediately after the collision and the height reached by the boxing ball.

3. DATA ANALYSIS and DISCUSSION

3.1. **Observations and Measurements**: Belgian students

With scarf:

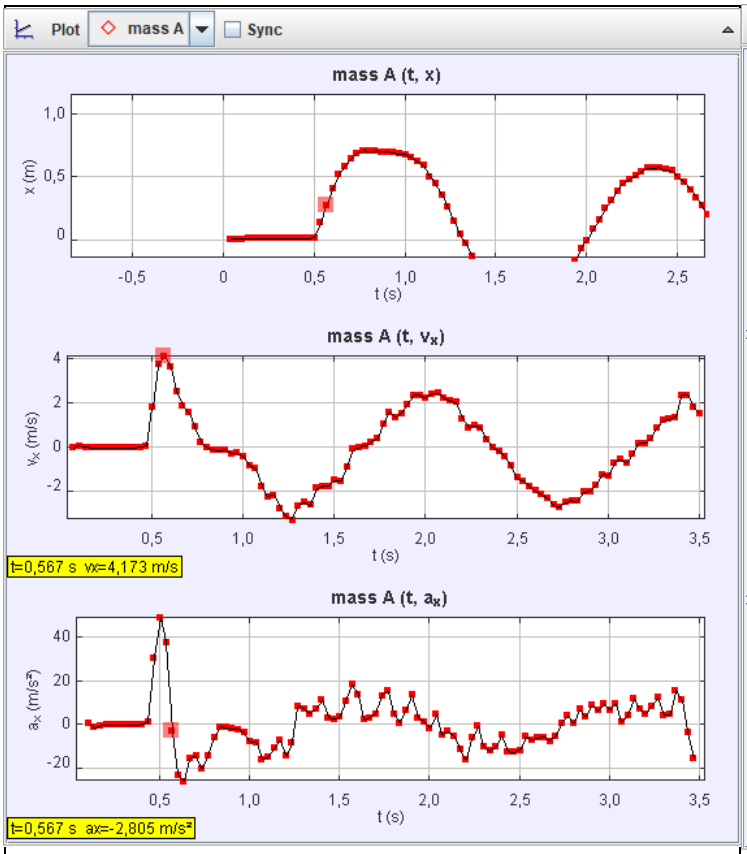
- x(t)= 2.7 *10-1 sin(1.1t +5.3*10-1)
- v(t)= 4.1*10-1 sin(1.3t-1.8*102)
- a(t)= 1.6 sin(1.5t-1.8*102)

Without scarf:

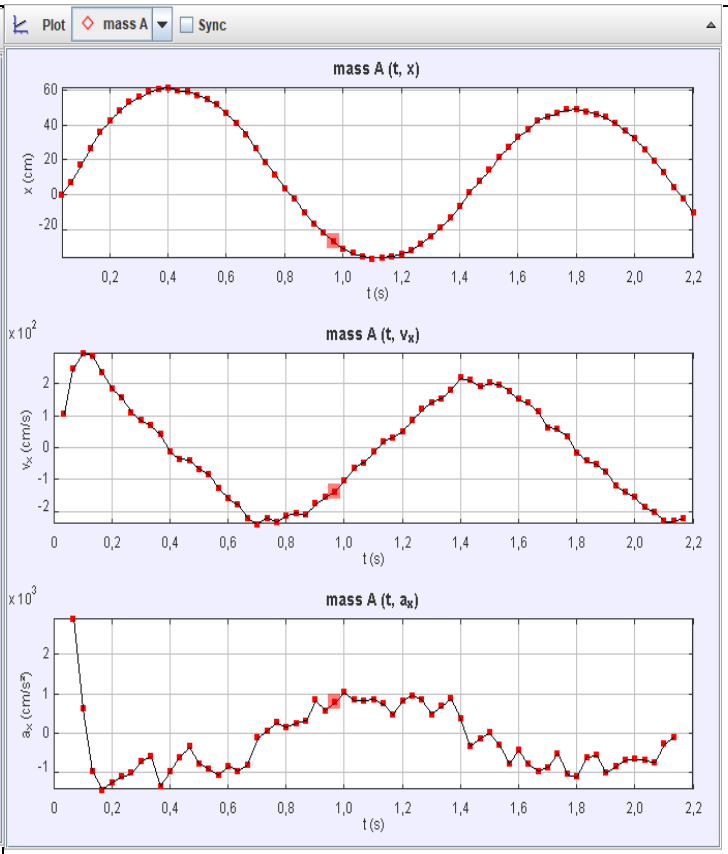
$x(t)= 1.75*10 \sin(-4.5*10^{-12}t+3.53*10^{-2})$

$v(t)= 1.84*10^{3} \sin(-2.95*10^{-2}t+3.08*10^{-2})$

$a(t)= 4{,}84*10^{2} \sin(-1{,}21*10^{-1}t - 2{,}71*10^{-1})$



Graph 1: results from the experiment with scarf.



Graph 2: results from the experiment without scarf.

Table mass A

t (s)	x (m)	y (m)	v_x (m/s)	a_x (m/s²)
0,033	1,227E-2	1,636E-2		
0,067	8,181E-3	1,091E-2	0,000	
0,100	1,227E-2	6,818E-3	8,181E-2	0,701
0,133	1,364E-2	6,818E-3	2,045E-2	-1,227
0,167	1,364E-2	6,818E-3	0,000	-0,351
0,200	1,364E-2	6,818E-3	0,000	0,000
0,233	1,364E-2	6,818E-3	0,000	0,000
0,267	1,364E-2	6,818E-3	0,000	0,000
0,300	1,364E-2	6,818E-3	0,000	0,000
0,333	1,364E-2	6,818E-3	0,000	0,000
0,367	1,364E-2	6,818E-3	0,000	0,000
0,400	1,364E-2	6,818E-3	0,000	0,351

Table 1: results from the experiment with scarf

mass A

t (s)	x (cm)	y (cm)	v_x (cm/s)	a_x (cm/s²)
0,667	34,98	7,978	-220,6	-798,3
0,700	26,59	5,364	-238,6	-112,0
0,733	19,07	2,532	-220,6	70,03
0,767	11,89	1,116	-232,0	280,1
0,800	3,606	0,353	-212,4	168,1
0,833	-2,276	0,353	-204,2	266,1
0,867	-10,01	1,443	-210,8	322,1
0,900	-16,33	2,641	-174,8	854,3
0,933	-21,67	3,512	-153,6	588,2
0,967	-26,57	6,018	-137,3	784,3

Table 2: results from the experiment without scarf

3.1. **Observations and Measurements**: Italian students

1.	Hmax (m)	Vi fist (m/s)	Vfball (m/s)	K i (J)	U f (j)	Aball (m/s^2)	Fball (N)	Δt (s)	Δp (kgm/s)	I (N s)
No glove	0,7	2,6	3,7	2,9	3,0	36,9	15,7	0,1	1,6	1,6
glove	0,5	2,8	3,4	2,4	2,2	33,3	14,2	0,1	1,4	1,4

m=0,427 kg

Hmax=the maximum variation of the ball's height, measured with a meter

Vi fist= estimated with tracker

Vf ball= estimated with tracker

Δt= the time it takes to the ball to reach the maximum velocity, estimated with tracker

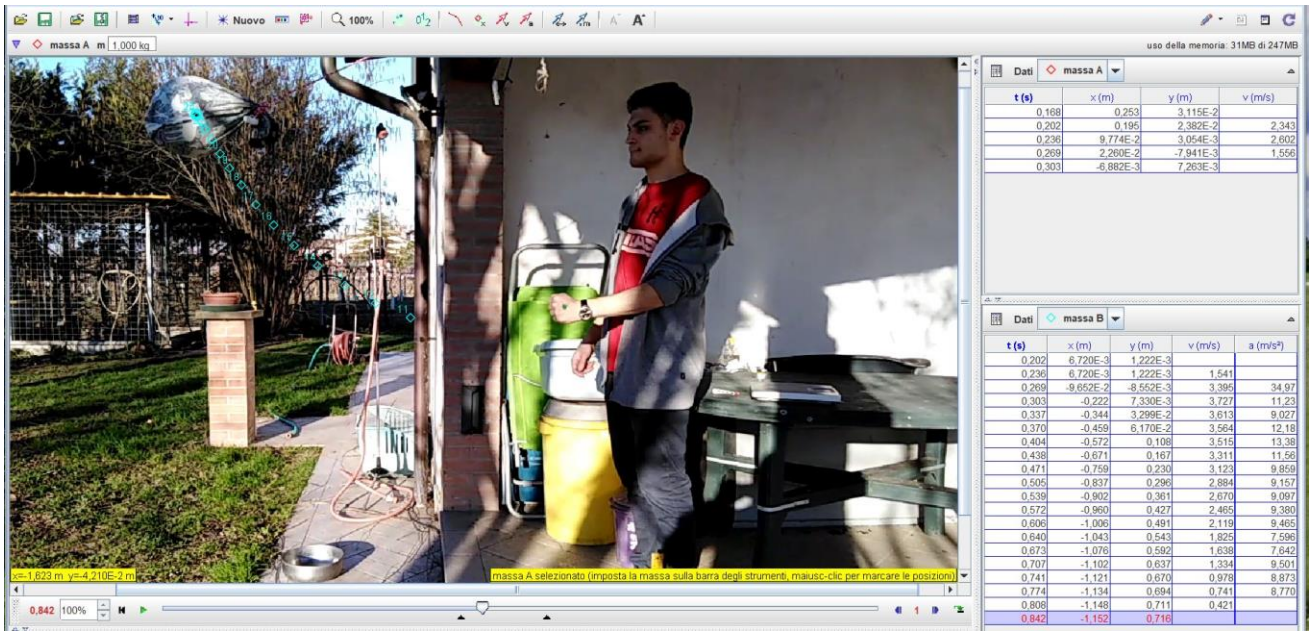
K= ½·**m**·**v²**

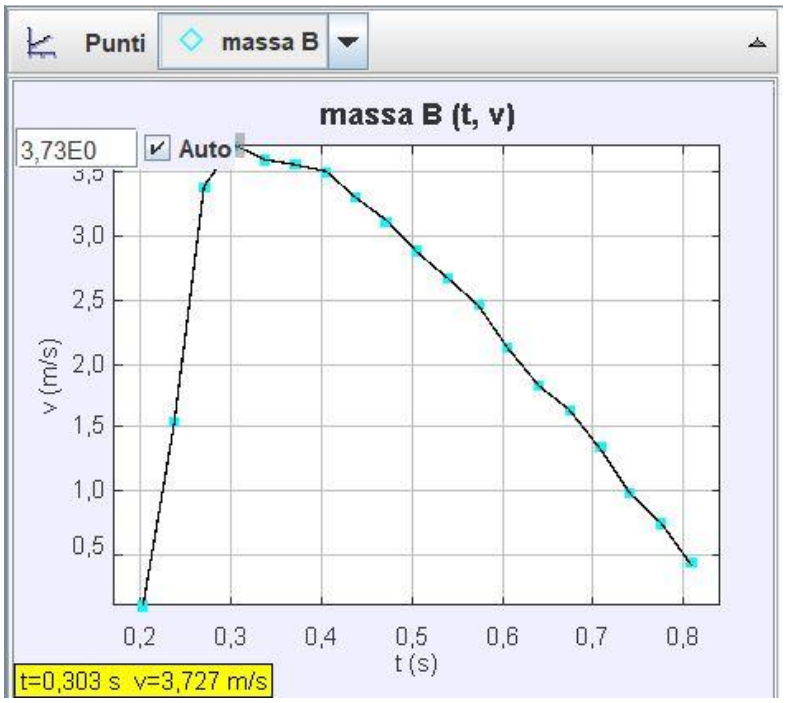
U= m· g· h

Aball= Δv/ Δt but you can also estimate it with tracker

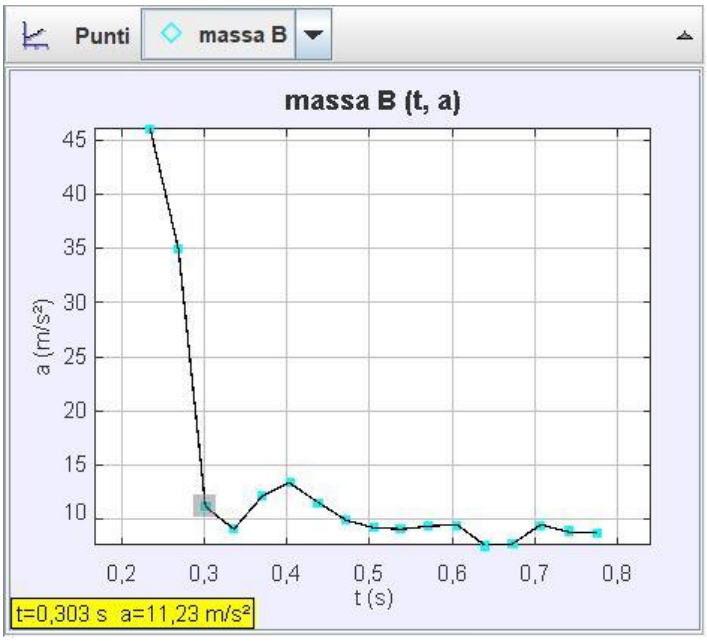
F ball= m · a

I= F · Δt

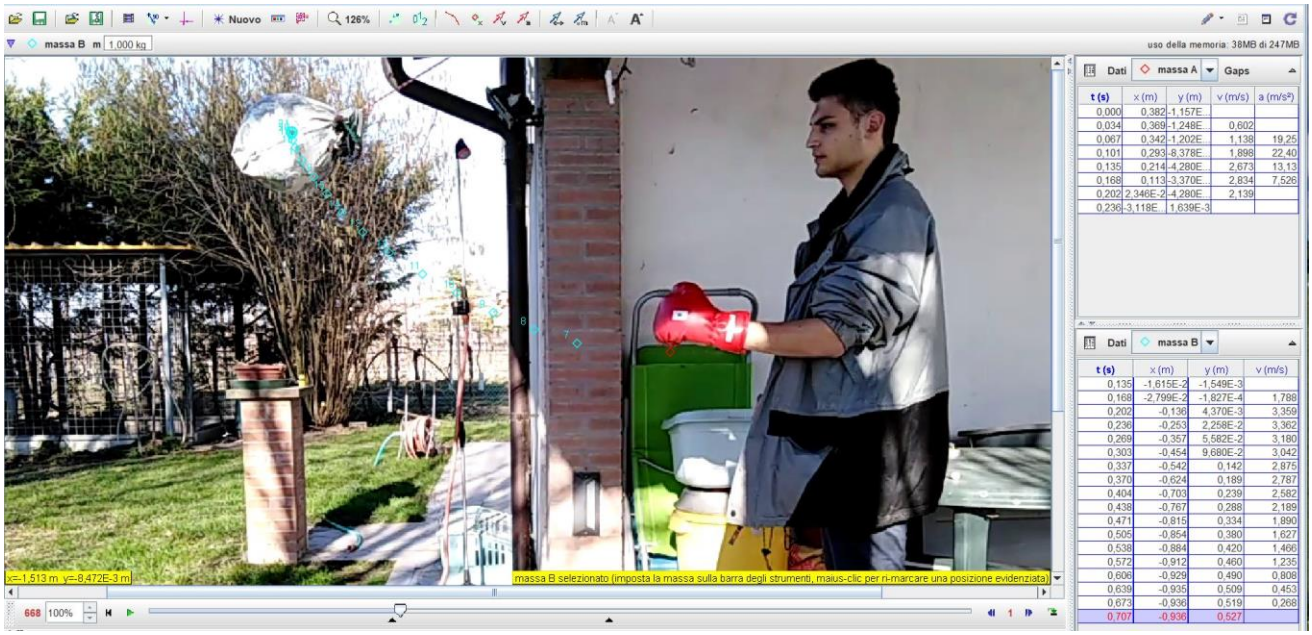


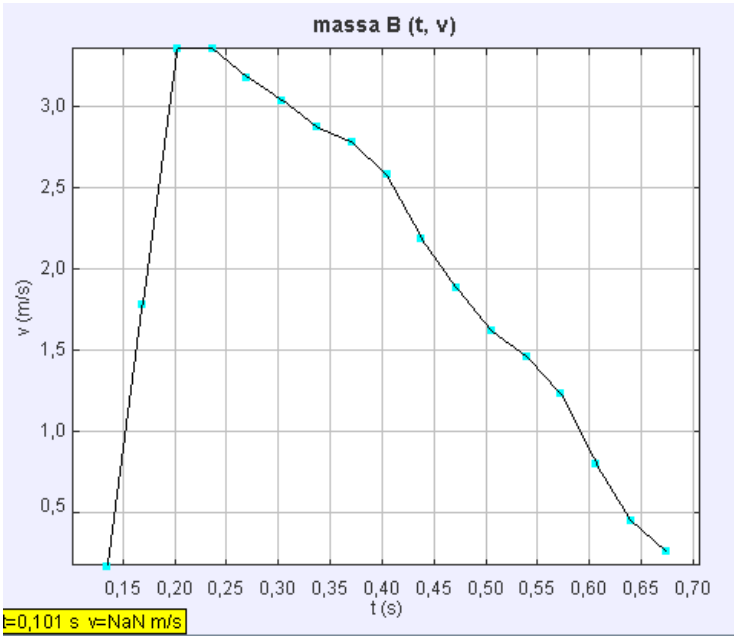


Graph Velocity vs. time without the glove

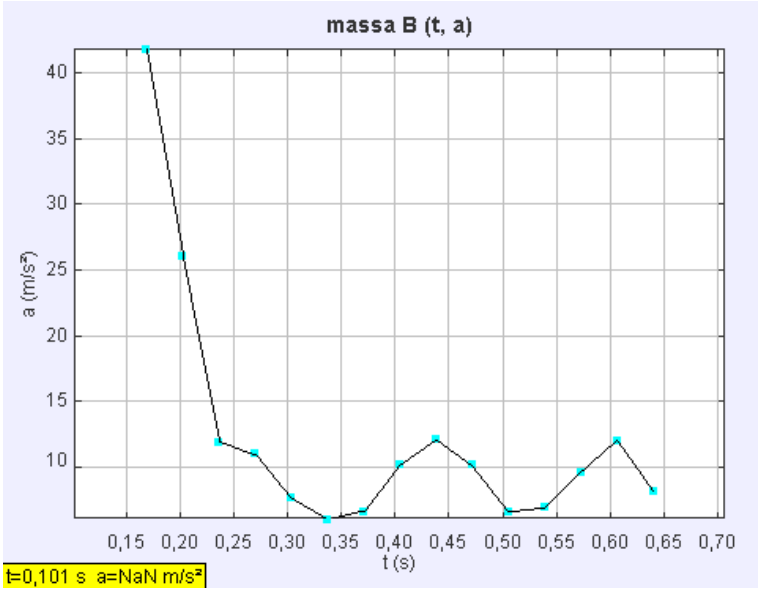


Graph Accelleration vs. time without the glove





Graph Velocity vs. time with the glove



Graph Accelleration vs. time with the glove

The hit with the glove creates less movement because of the shape of the ball. In fact with the glove the energy is shared on a bigger area but part of the energy is wasted because you hit just with a part of the glove.

With the glove the hit is less elastic in fact it absorbs part of the energy making the hit more anaelastic.

3.2. Discussion:

The graphs from both experiments are a sine functions. The sack makes a maximum deviation, then it goes through the equilibrium state. Then it goes to a negative maximum deviation. The amplitude of the function gets smaller and smaller. The bag slowly comes to a standstill. The same happens when you punch it with or without scarf. When comparing the two graphs, they seem to be quite the same. We do not notice any big differences. The v(t) graph is the derivative of the x(t) graph. The a(t) graph is the derivative of the v(t) graph.

4. REFLECTION

Conclusion: There is no big difference when the ball is hit with or without gloves. Now with our personal data we can verify the Impulse-Momentum theorem experimentally, in fact:

$F \cdot \Delta t = I$

No glove: $(15{,}76\ \text{Kg m/ s2}) \cdot (0{,}101)\ \text{s} = 1{,}592\ \text{N s}$

With glove: $(14{,}21\ \text{Kg m/ s2}) \cdot (0{,}101)\ \text{s} = 1{,}435\ \text{N s}$

$F\Delta t = m \cdot \Delta v = m \cdot (v_2 - v_1) = m \cdot v_2 - m \cdot v_1 = p_2 - p_1 = \Delta p$

4.1. Comparison: Our results are approximately the same.

4.2. Reflection: The experiment was not easy. At first it was not clear what to do. When started with Tracker, there were some problems. The graphs do not seem 100% correctly and so do the derivatives. In the first table the distance (x) is given in meter and in the second in cm. The first table also doesn't show the numbers of the velocity and acceleration, which makes it impossible to compare the two punches. It is also impossible to hit the bag two times with the exact same power by human hand, which makes the experiment useless.