eTwinning	TEAM: 5	
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Smashing! Real-world clashes into physics classes	Italy	Rambelli Alessia Sartoni Elena Sartoni Serena
EXPERIMENT: The collision of a tennis ball		

1. ORIENTATION

1.1. Research question:

- If we hit a tennis ball once with a tennis racket, once with our hands and once with a baseball bat, which equipment will cause the biggest impact on the ball?

Sub-questions:

- How come is the impact the greatest with that equipment?
- What is the difference in speed before and after the collision with that equipment?
- Is there a difference in momentum?
- Is the energy preserved?

1.2. Hypothesis

We think that the impact of the tennis ball will be greatest with the tennis racket, because a tennis racket is specially designed for a tennis ball to make it go fast. because the racket has strings, we can give more powerful strokes and more controlled. We think the speed after the collision will be bigger than the speed before. So there will definitely be a difference in momentum. The energy will be preserved.

2. PREPARATION

(Belgium / Italy)

2.1. **Material**:

- 1 tennis ball (mass=6,6x10^{-2}kg) (mass= 5,7x10^{-2} kg)
- 1 tennis racket (mass=2,18x10^{-1}kg) (mass= 20,8x10^{-2} kg)
- 1 cricket bat (mass=3,40x10^{-1}kg) (mass= 69,1x10^{-2} kg)
- a hand
- a scale
- Software Tracker

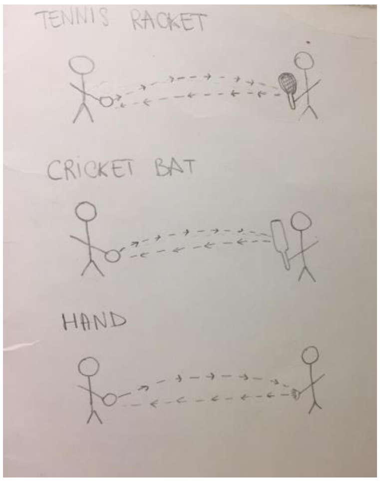

tennis ball


cricket bat


tennis racket

2.2. **Method:**

1. Weigh all the materials with the scale.
2. Make a video of sequence 2-5.
3. Throw the tennis ball with a hand making a parabolic motion.
4. Hit the tennis ball with the tennis racket, possibly making a straight motion.
5. Repeat the action once with the cricket bat and once with the hand.
6. Repeat it many times until the initial speeds of the ball are as similar as possible in all the three cases.
7. Finally calculate the speeds of the tennis ball, the tennis racket, the cricket bat and the hand before and after the collision, using the Software Tracker and select the videos with similar initial speed.
8. Discuss the conservation of total momentum and the impulse-momentum theorem.
9. Discuss in which of three cases the momentum transfer to the ball is largest.



3. DATA ANALYSIS and DISCUSSION

3.1. Observations and Measurements by Italians:

Measured data:

- Mass M(kg)
- Initial Speed Vi(m/s) by Tracker
- Final Speed Vf(m/s) by Tracker
- Time of interaction Δt_{inter}(s): It represents the interaction of time in which the two objects keep touching.
  We choose the time of interaction t_{inter}= 0,01s. Infact using tracker you can see that at the time t= 0,56s the ball is some dm away from every object and at the time t= 0,64s the ball has already gone away from every object. That means the t_{inter} <<0,04s, so you can estimate t_{inter}= 0,01s (rather rough estimate).

Calculated data:

- Acceleration a(m/s^2) = $\Delta V/\Delta t$
- Initial Momentum pi(kg*m/s) = M*Vi
- Final Momentum pf(kg*m/s) = M*Vf
- Difference of Momentum Δp(kg*m/s) = pf-pi
- Resulting Force Fm(N) = a*M
- Difference of Kinetic Energy $\Delta K(J) = 1/2 \cdot M \cdot Vf^2 - 1/2 \cdot M \cdot Vi^2$

The ball and the Tennis Racket

object	M(kg)	Vi(m/s)	Vf(m/s)	pi(kg*m/s)	pf(kg*m/s)	Δp(kg*m/s)	Δt_{inter} (s)	ΔK(J)
Ball	0,066	-5,0	12,4	-0,33	0,82	1,2	0,01	4,3
Tennis racket	0,218	6,0	6,0	1,3	1,3	0	0,01	0

I = Δp = 1,2N*s

object	ΔV(m/s)	Δt(s)	a(m/s^2)	F_{ris}(N)
Ball	17,4	0,01	1740	114,8
Tennis racket	0	0,01	0	0

Experiment

$F_b = a*m$ } Formulas derived from the

$F_{risTR} = a*m$ } Second Principle of Dynamics

$(\rightarrow)\ F_{risTR} = F_{hand} - F_b$

$F_{hand} = F_{risTR} + F_b = 0N + 114{,}8N = 114{,}8N$

Software Tracker: the ball and the tennis racket

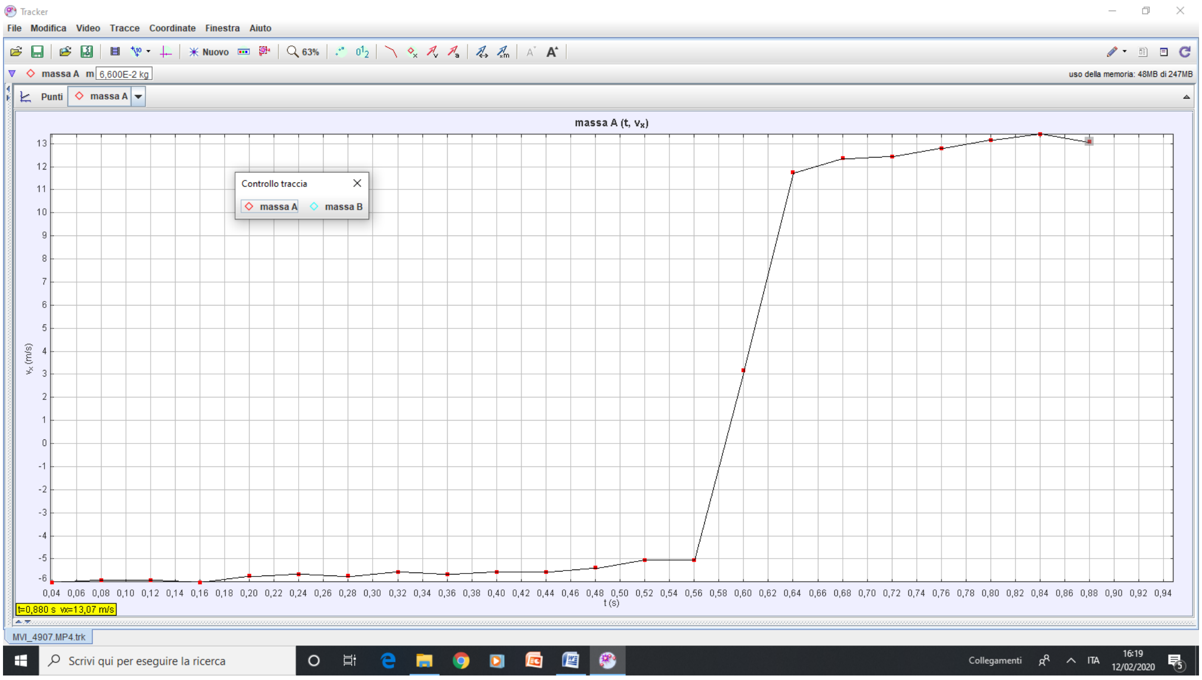


Diagram: Speed of the ball hit by the tennis racket

Experiment

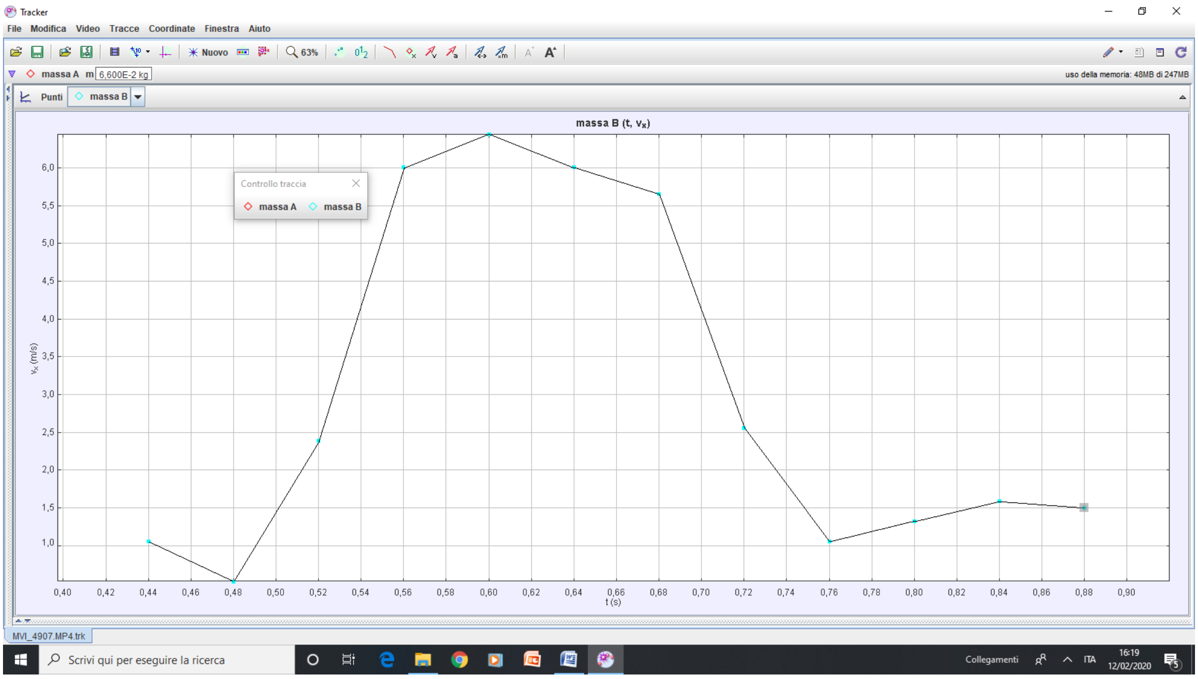


Diagram: Speed of the tennis racket

The ball and the Cricket Bat

object	M(kg)	Vi(m/s)	Vf(m/s)	pi(kg*m/s)	pf(kg*m/s)	Δp(kg*m/s)	Δt_{inter}(m/s)	ΔK(J)
Ball	0,066	-4,7	9,1	-0,3	0,6	0,9	0,01	2,0
Cricket Bat	0,340	6,6	6,1	2,2	2,1	0,1	0,01	1,1

I = Δp = 0,8N*s

object	ΔV(m/s)	Δt(s)	a(m/s^2)	F_{ris}(N)
Ball	13,8	0,01	1380	91,1
Cricket Bat	-0,5	0,01	-50	-17

Fb = a*m } Formulas derived from the
F_{risCB} = a*m } Second Principle of Dynamics

(→) $F_{risCB} = F_{hand} - Fb$

$F_{hand} = F_{risCB} + Fb = -17N + 91,1N = 74,1N$

Experiment

Software Tracker: The ball and the Cricket Bat

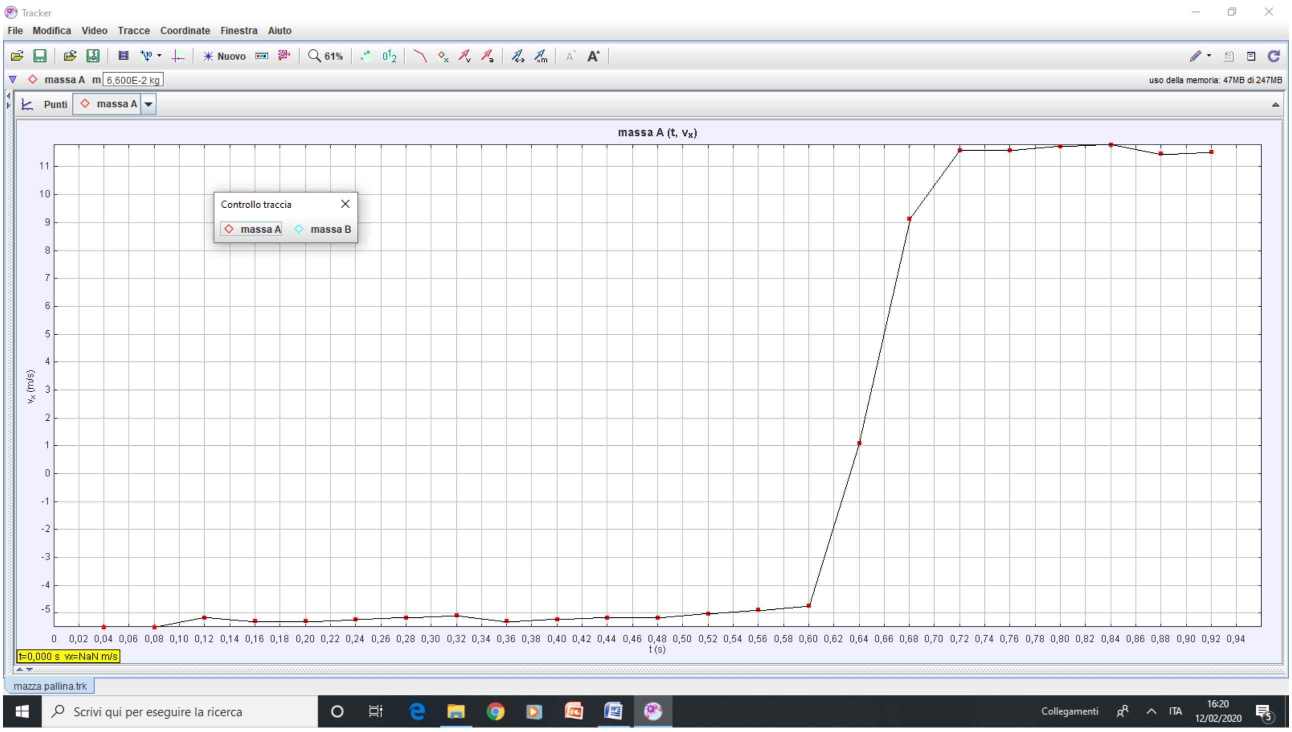


Diagram: Speed of ball hit by the cricket bat

Experiment

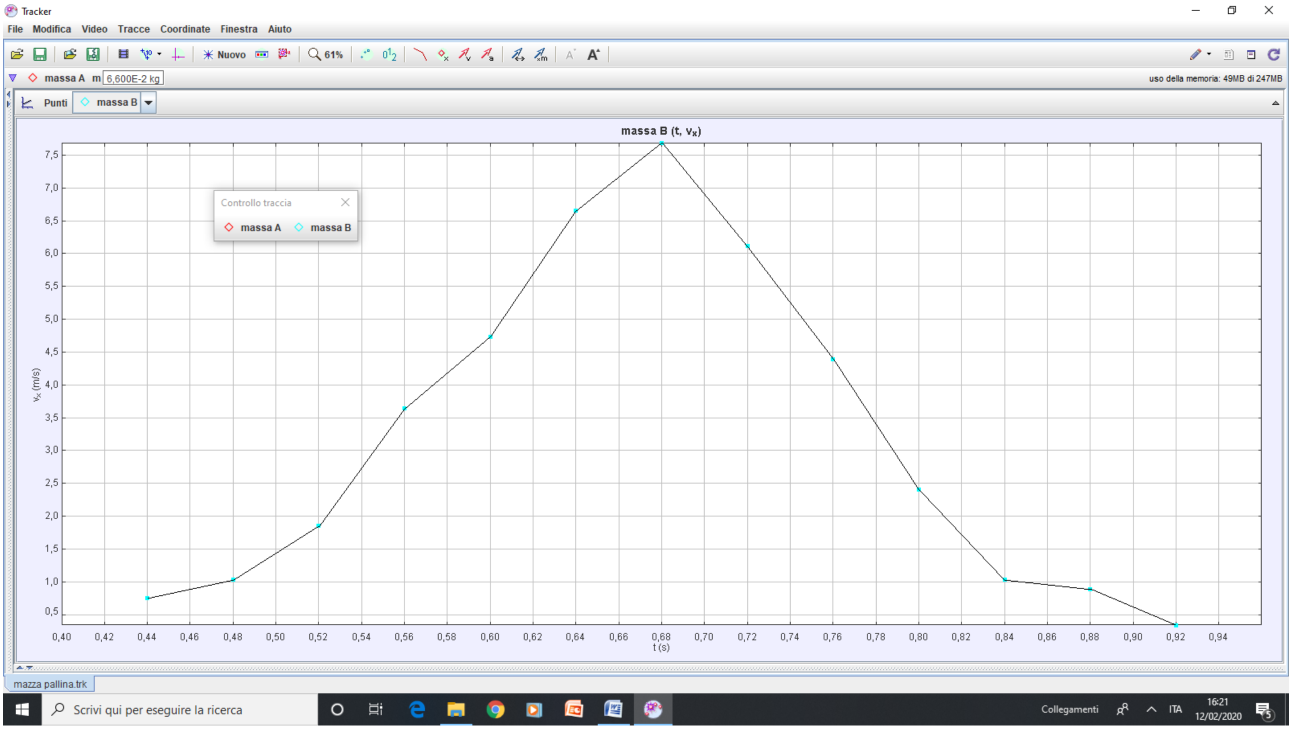


Diagram: Speed of the cricket bat

The ball and the Hand

object	M(kg)	Vi(m/s)	Vf(m/s)	pi(kg*m/s)	pf(kg*m/s)	Δp(kg*m/s)	Δt(m/s)	ΔK(J)
Ball	0,066	-4,5	6,2	-0,3	0,4	0,7	0,01	0,6
Hand	0,350	4,4	4,6	1,5	1,6	0,1	0,01	0,3

$I = \Delta p = 0{,}8 N*s$

object	ΔV(m/s)	Δt(s)	$a(m/s^2)$	$F_{ris}(N)$
Ball	10,7	0,01	1070	70,6
Hand	0,2	0,01	20	7

$Fb = a*m$ } Formulas derived from the

$F_{ris} = a*m$ } Second Principle of Dynamics

$(\rightarrow)\ F_{ris} = F_{arm} - Fb$

Experiment

$F_{arm} = F_{ris} + Fb = 7N + 70,6N = 77,6N$

Software Tracker: The ball and the hand

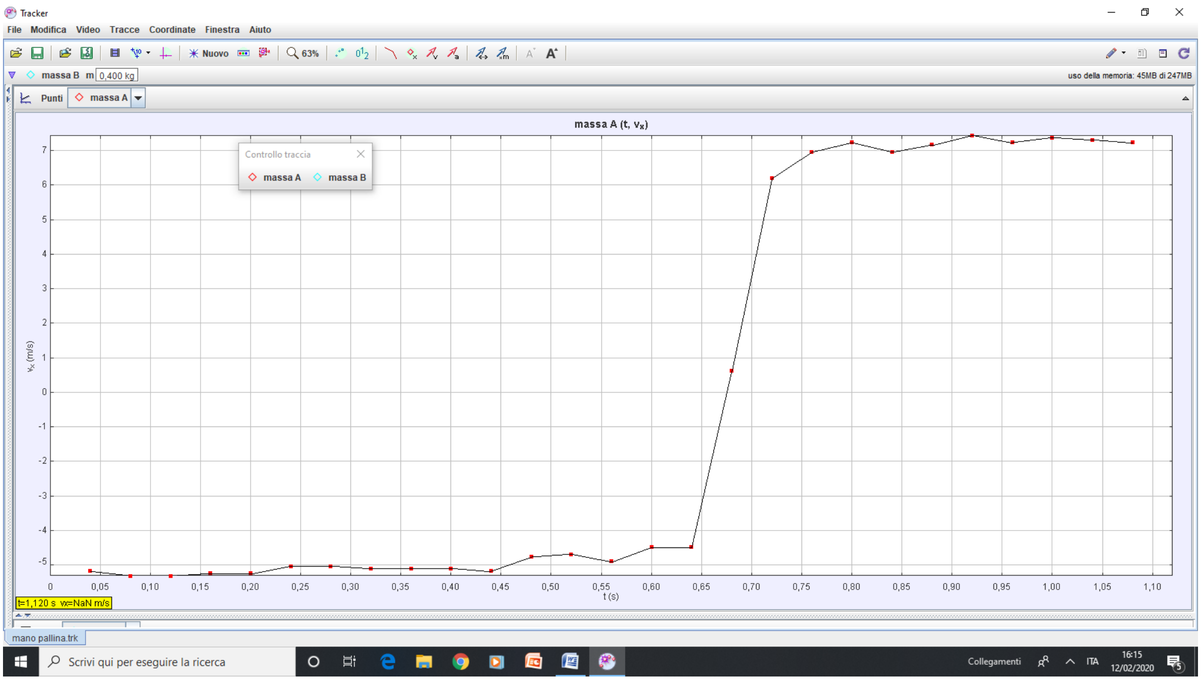


Diagram: Speed of the ball hit by the hand

Experiment

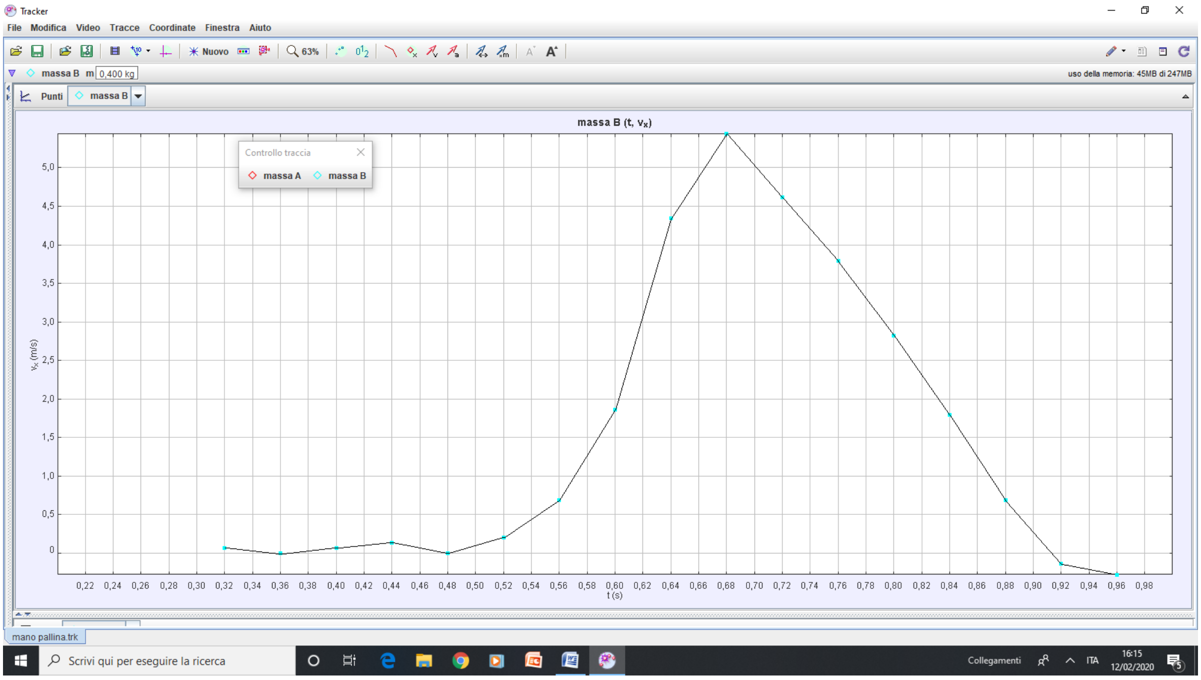
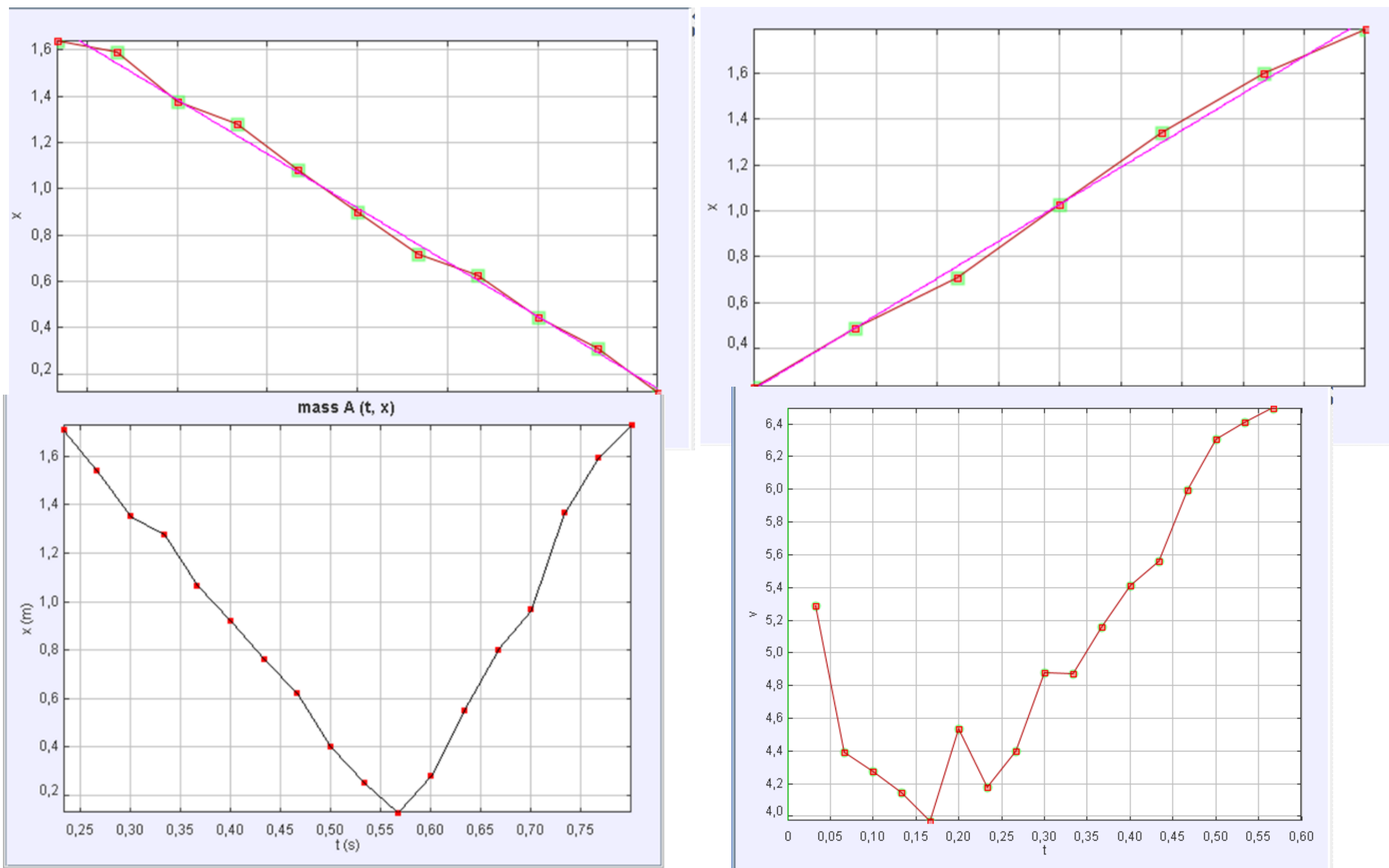


Diagram: Speed of the hand

3.2. Observations and measurements by Belgians

1. Tennis racket



Graph 3: x(t) graph whole movement

Graph 1: x(t) graph before collision:

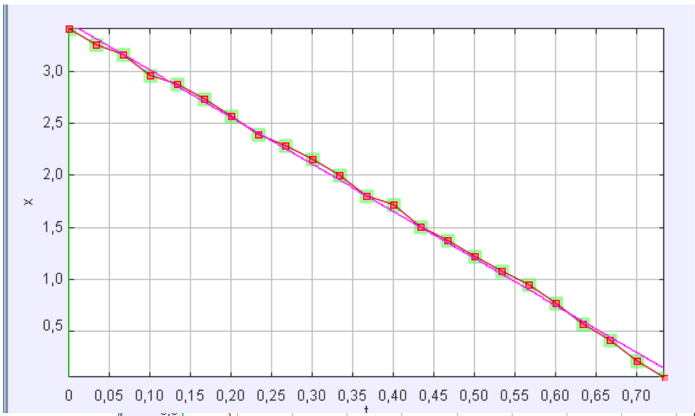
x = - 4,7t + 2,8

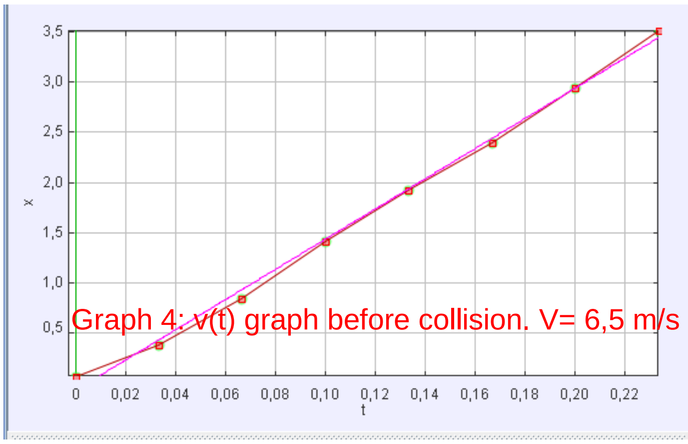
Graph 2: x(t) graph after collision:

x = 8,0t – 4,6

Graph 5: v(t)-graph after the collision v=9,9 m/s

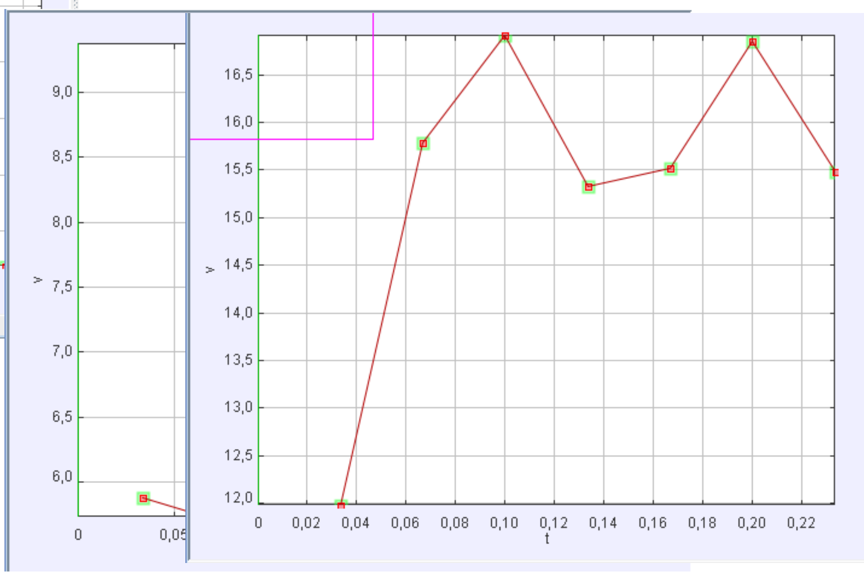
2. Baseball Bat





Graph 4: v(t) graph before collision. V= 6,5 m/s

Graph 6: x(t)-graph before collision



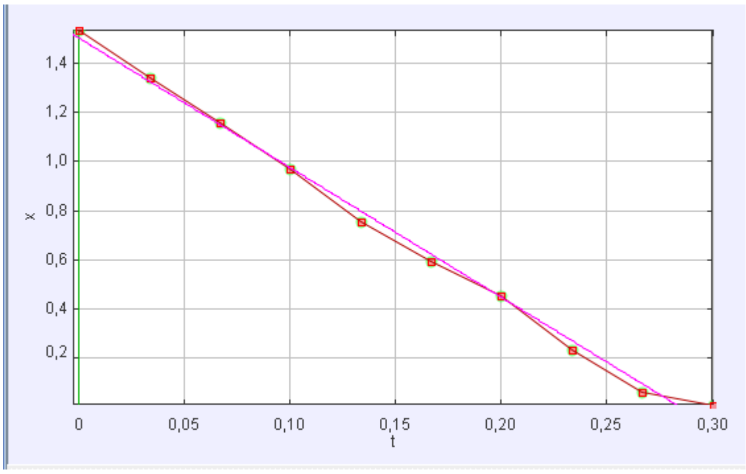
Experiment

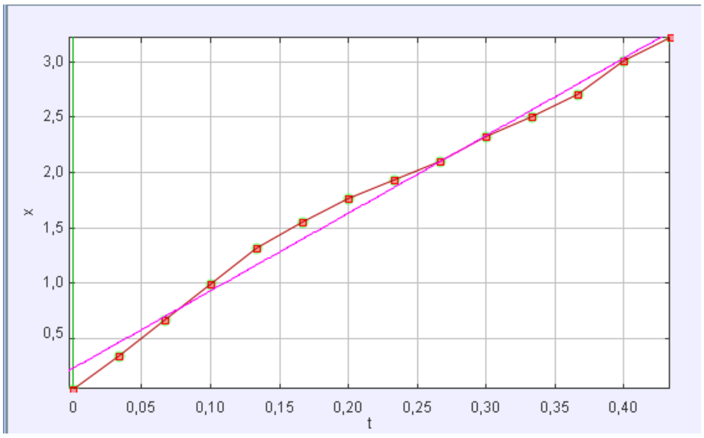
Graph 7 : x(t)-graph after collision

Graph 8: V(t)-graph before collision

Graph 9: V(t)-graph after collision

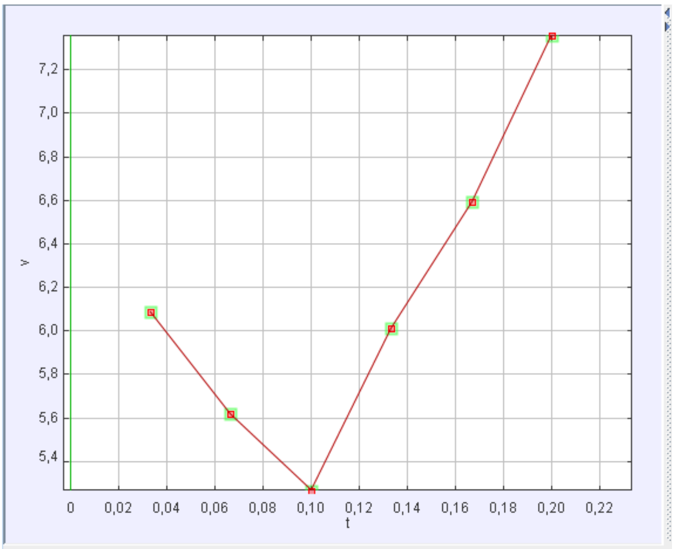
3. Hand





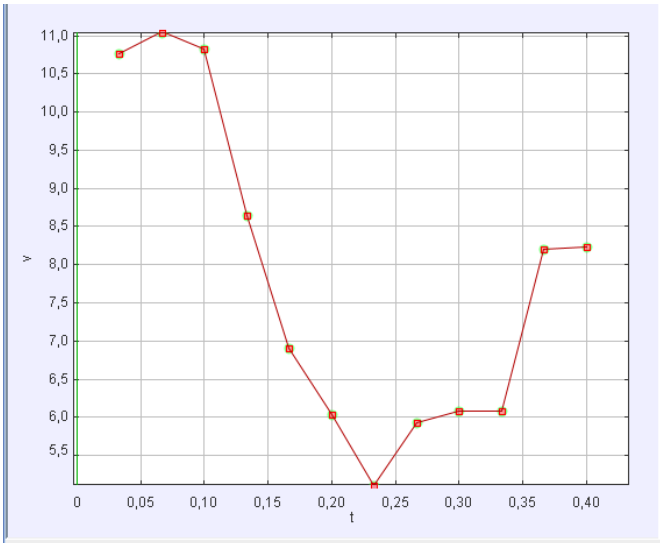
Experiment

Graph 10: x(t) graph before collision



Graph 12: v(t) graph before collision

Graph 11: x(t)-graph after collision



Graph 13: V(t) graph after collision

3.3 Discussion

(momentum = m*v)

Mass tennis ball = $5{,}7 \times 10^{-2}$ kg

Tennis racket:
- Speed before: 6,5 m/s
- Speed after: 9,9 m/s
- Momentum before = $6{,}5 * 5{,}7 \times 10^{-2} = 0{,}37$
- Momentum after= $9{,}9 * 5{,}7 \times 10^{-2} = 0{,}56$
- Difference in momentum = 0,19

Baseball bat:
- Speed before: 9,3 m/s
- Speed after: 12 m/s
- Momentum before= $9{,}3 * 5{,}7 \times 10^{-2} = 0{,}53$

Experiment

- Momentum after= 12 * 5,7x10^{-2} = 0,68
- Difference in momentum = 0,15

Hand:
- Speed before: 7,5 m/s
- Speed after: 10,8 m/s
- Momentum before: 7,5 * 5,7x10^{-2} = 0,43
- Momentum after: 10,8 * 5,7x10^{-2} = 0,62
- Difference in momentum = 0,19

As we can see in our graphs, the difference in speed before and after the collision is the greatest with the tennis racket. This also means that the difference in momentum is the greatest with the tennis racket.

As we can see in the table, the biggest impact is the one made with the Tennis Racket, for this reason the Tennis Racket is the best object to use to hit a tennis ball.

4. REFLECTION

4.1. Conclusion

The difference in speed is the greatest with the tennis racket. It was especially made to make us able to put a great force on a tennis ball. The speed after the collision is bigger than the speed before the collision. The energy is preserved because of the law of the law of conservation of energy.

4.2. Comparison

We can both conclude after our experiment that the tennis racket is the best equipment to use.

4.3. Reflection:

We were able to communicate well and the collaboration went smoothly.

5. REFERENCES

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