<table>
<tr><td rowspan="4">DE BRON</td><td>NR: 8, 15, 20, 21, 22</td><td>NAME: Kobe Scherpereel, Henri Van Holm, Chelsea Vervaeck, Matisse Vlaeminck, Lies Vroman</td></tr>
<tr><td colspan="2">CLASS: 6WEW6b</td></tr>
<tr><td colspan="2">NAMETEACHER: Els Merveillie</td></tr>
<tr><td>DATE: February 2020</td><td rowspan="2">We work together with: Amy, Magdalena, Michela Gambetti</td></tr>
<tr><td>VRIJE ASO.SCHOOL</td><td></td></tr>
<tr><td colspan="3">PRACTICUM: Impulse of a collision between two cars</td></tr>
</table>

# 1. ORIENT

## 1.1. Research question:

How does a different mass from a car driving downhill influence the impulse of the collision with the car standing at the end of the slope?

**Sub-questions:**

How does a different mass influence the speed of the moving car?

How does a different mass influence the distance covered by the car at the bottom of the slope?

## 1.2. Hypothesis:

The heavier the moving car is, the bigger the impulse of the collision will be.

The heavier the moving car is, the higher his speed will be.

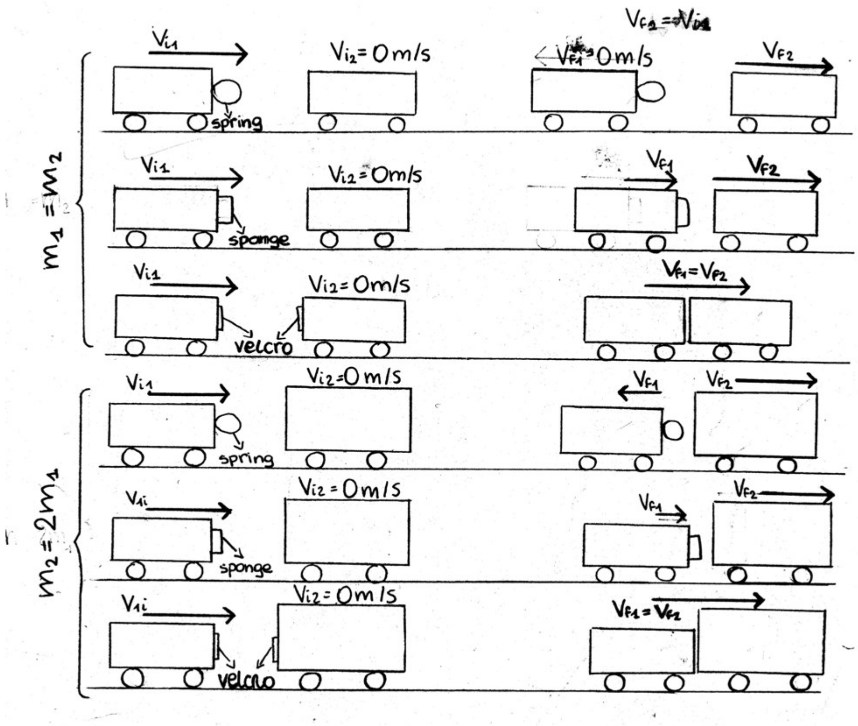
The heavier the moving car is, the bigger the distance covered by the car at the bottom of the slopewill be.

# 2. PREPARE

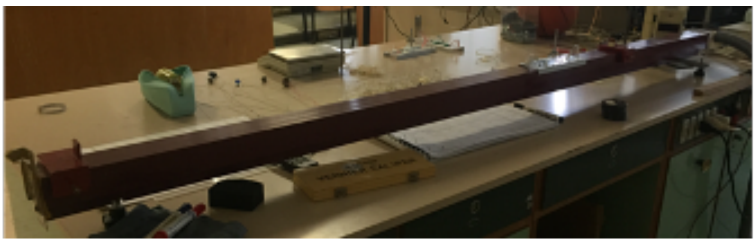
## 2.1. Required material:

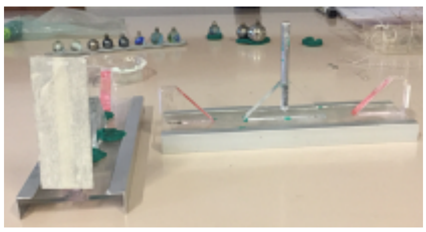
- scale,
- carts,
- masses,
- spring,
- sponge,
- binary air cushion,
- motion sensor

**2.2. Method:** For the experiment we will represent the impact between two carts neglecting the friction. We have chosen to do three types of collisions: elastic, anelastic and totally anelastic, but we are going to do two collisions for each one, changing the mass. In every attempt, one of the two carts will have the initial speed equal to 0 m/s. In the first three collisions we will use the same mass for every carts while in the next three collisions, one of the masses will be doubled (see figure).




To do the test we will use the binary air cushion and with a motion sensor we will measure the speeds.



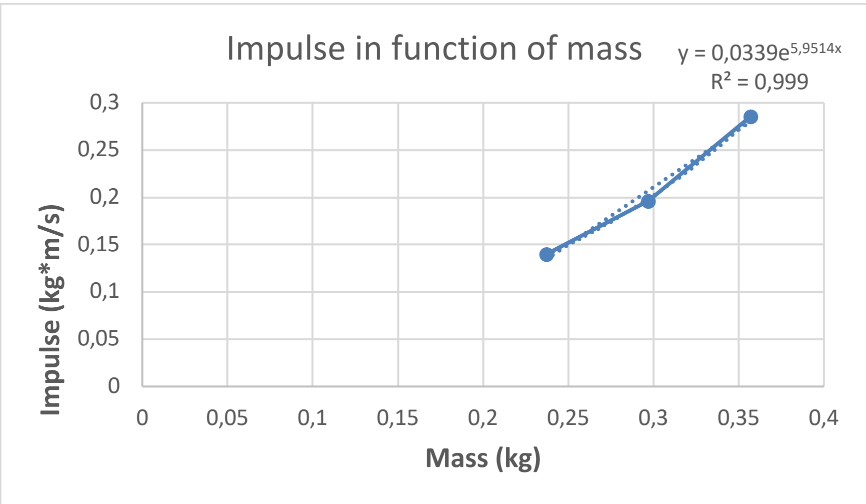


For the elastic collision we use a spring, for the inelastic collision a sponge and for the totally inelastic collision we use velcro.

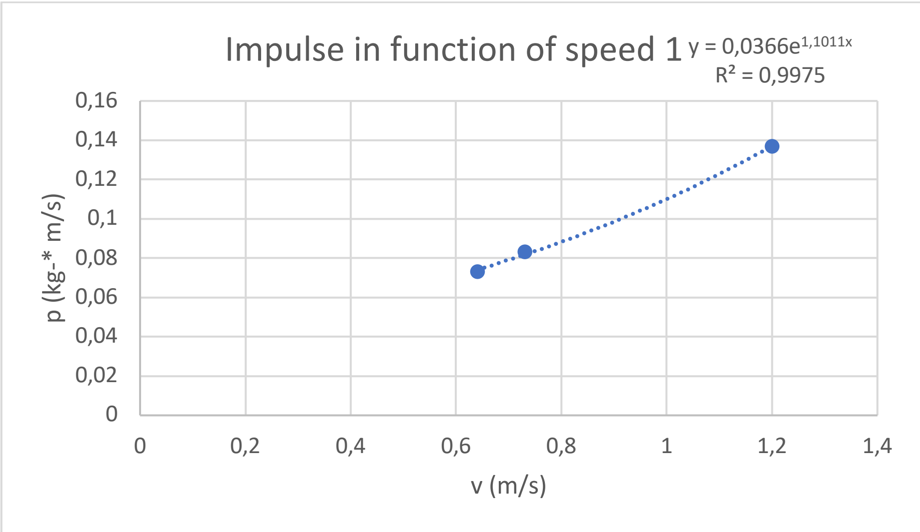
**Belgium:** Due to lack of material, we had to come up with another method to complete the experiment. We chose to analyse the impact between two cars. One moving down the slope and the other standing still at the end of it. During the experiment we increase the mass of the car on the slope and look what the differences are.
First you place one car down the slope and the other at the top. (Always at the same height so the car generates the same velocity) Be sure you placed the motion sensors in the same direction as the cars. Let the car on the slope go and let them collide. We attached a rope to the car moving downhill, so he can't push the car down the slope after the collision. Now you have to compare the results of the sensors and look for a connection.

# 3. CARRY OUT

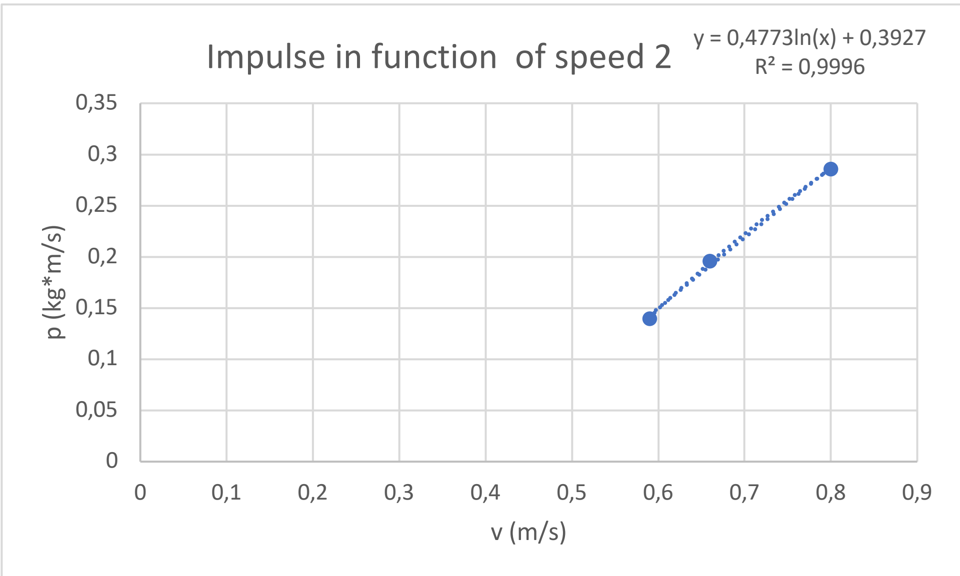
## 3.1. Measurementresults:



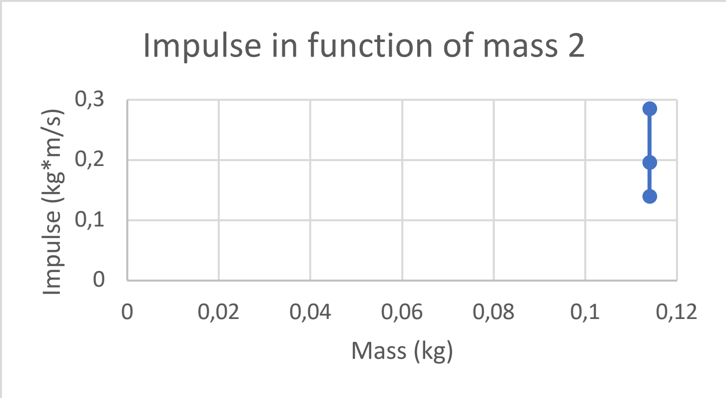

| m(kg) | p (kg*m/s) |
|---|---|
| 0,237 | 0,13983 |
| 0,297 | 0,19602 |
| 0,357 | 0,2856 |



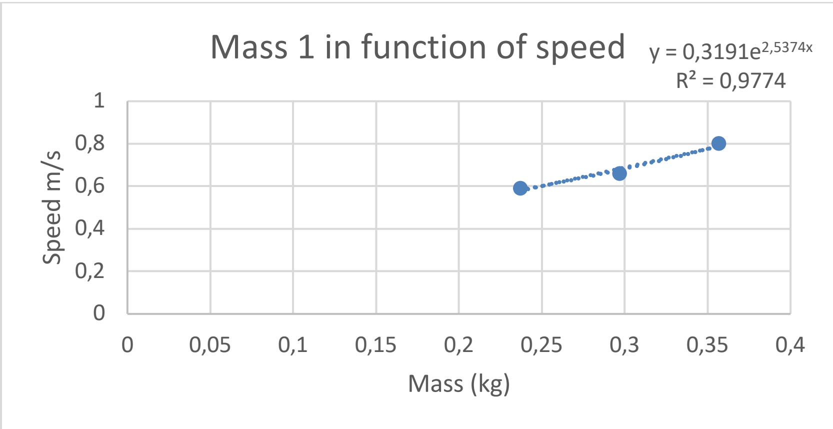

| **v (m/s)** | **p(kg* m/s)** |
|---|---|
| 0,64 | 0,07296 |
| 0,73 | 0,08322 |
| 1,2 | 0,1368 |



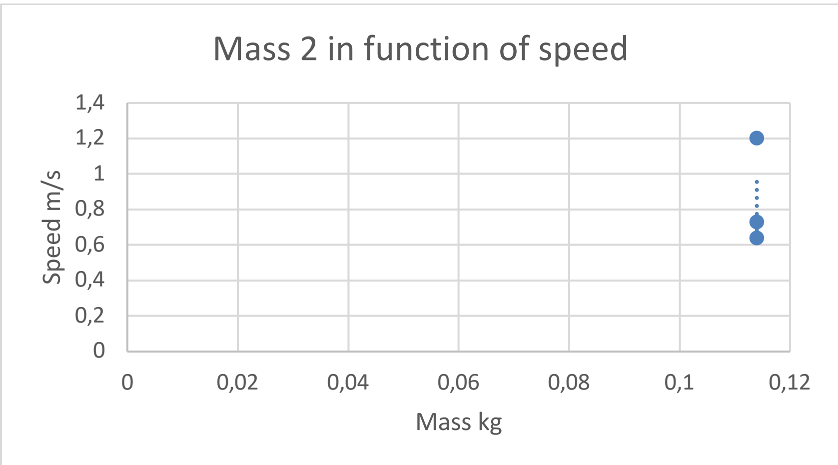

| **v(m/s)** | p (kg*m/s) |
|---|---|
| 0,59 | 0,13983 |
| 0,66 | 0,19602 |
| 0,8 | 0,2856 |




| m (kg) | p (kg*m/s) |
|---|---|
| 0,114 | 0,13983 |
| 0,114 | 0,19602 |
| 0,114 | 0,2856 |




| m(kg) | v(m/s) |
|---|---|
| 0,237 | 0,59 |
| 0,297 | 0,66 |
| 0,357 | 0,8 |




| m(kg) | v (m/s) |
|---|---|
| 0,114 | 0,64 |
| 0,114 | 0,73 |
| 0,114 | 1,2 |

Practicum: Impulse of a collision between two cars

### 3.2. Processing:

The impulse of the moving car increases if you increase the mass of the car. This is the same for the speed. Because of this we can concluded that the impulse that something creates, depends on the speed and the mass of that moving object. There's a proportionate relationship between the speed, mass and impulse. When the mass increases then the speed will do the same.

The bigger the impulse between both cars is, the more velocity the car in rest will have. The same if you increase the speed or mass of the moving car, the more distance the car at the end of the slope will cover. There can be concluded that the impulse in this case is being influenced by the other car. How bigger the mass of the moving car, how bigger the impulse. The speed of the car will increase but the mass stays the same. The speed increases because the speed when the moving car touches this car will be higher. So the impact will be bigger with a higher speed because the mass and the speed increase, so the impulse will also increase. The speed of the second car will be higher than the one of the first car because before and after the crash are the same. So because the mass of the second car stays the same, the speed must increase to stay the same as the impulse before the crash. The displacement of the second car is also bigger because the speed is higher so it takes longer to stop because the speed is higher and the friction stays the same because the mass stays also the same.

### 3.3. Review:

## 4. REFLECT

### 4.1. Conclusion:

- The bigger the mass of the car moving downhill, the bigger impulse he'll create when he hits the car at the end of the slope.
- If you increase the mass of the car moving down the slope. He is going to generate more speed.
- The distance that the car at the end of the slope covers, due to the collision, depends on the impulse that the moving car creates. The bigger the mass, the bigger the impulse will be. So the car standing still is going to cover more distance.

**4.2.** *Do your decisions agree with the hypothesis that you have made? Why yes/not?*

Yes, because we already know some stuff about 'impulse' from the physic lessons.

**4.3. Evaluation:** *Are you content with your approach and cooperation?*

Yes, everybody did his part.

## 5. ORIENT

### 1.3. **Research question:**

How does a different mass from a car driving downhill influence the impulse of the collision with the car standing at the end of the slope?

**Sub-questions:**

How does a different mass influence the speed of both cars?

How does a different mass influence the distance covered by the car at the bottom of the slope?

### 1.4. **Hypothesis:**

The heavier the car is, the bigger the impulse of the collision will be.

The heavier the car is, the higher the speed of both cars will be.

The heavier the car is, the bigger the distance covered by the car at the bottom of the slopewill be.

## 6. PREPARE

### 6.1. **Required material**:

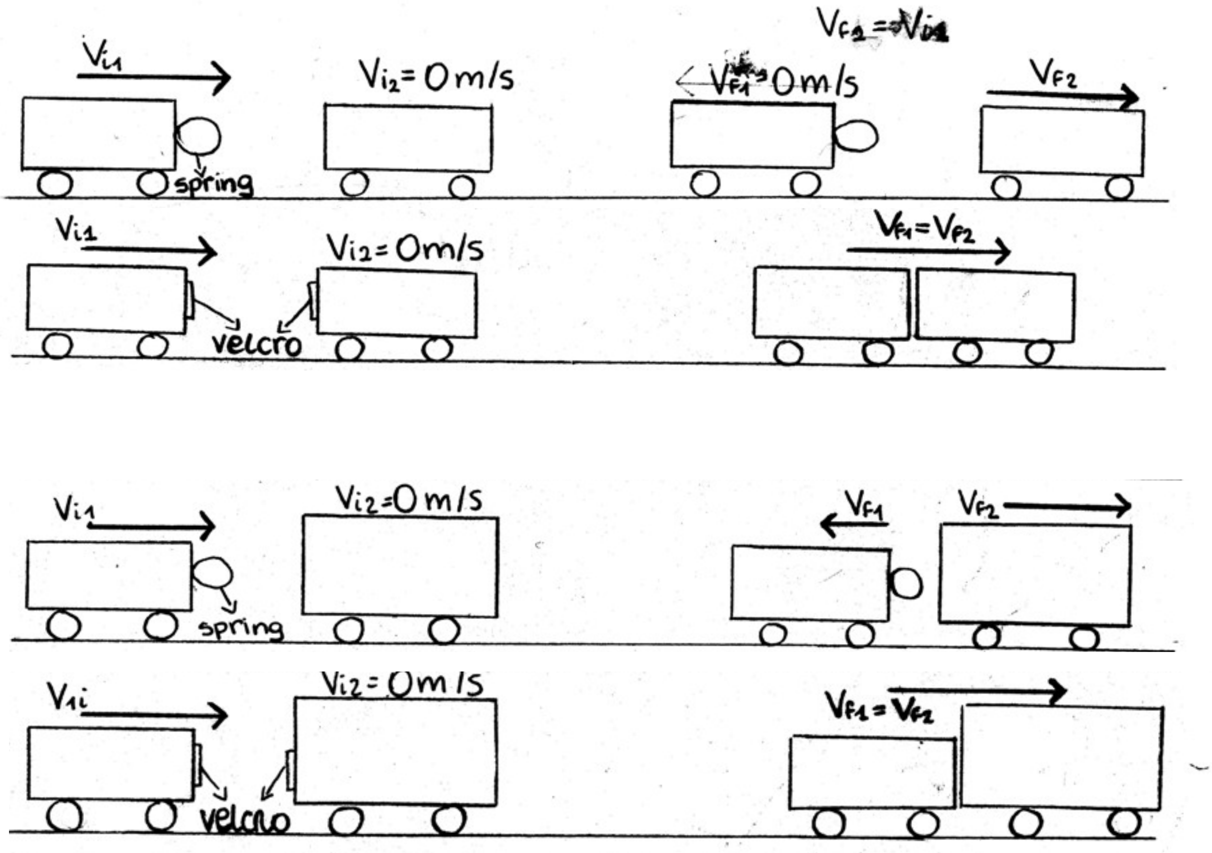
- scale
- carts
- masses
- spring
- sponge

- binary air cushion
- motion sensor

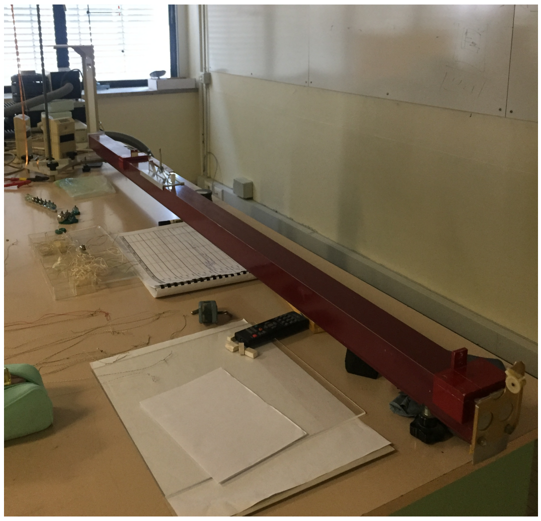
**6.2. Method:** For the experiment we will represent the impact between two carts neglecting the friction. We have chosen to do two types of collisions: elastic and totally inelastic, but we are going to do two collisions for each one, changing the mass. In every attempt, one of the two carts will have the initial speed equal to 0 m/s. In the first two collisions we will use the same mass for every carts while in the next collisions, one of the masses will be doubled (see figure).

$m_1=m_2$

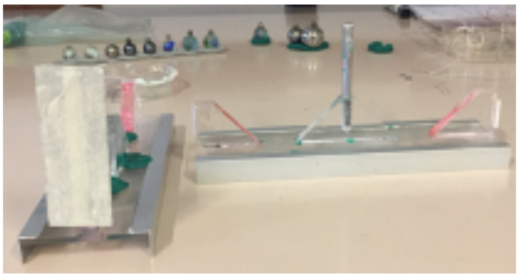
$m_2=2m_1$

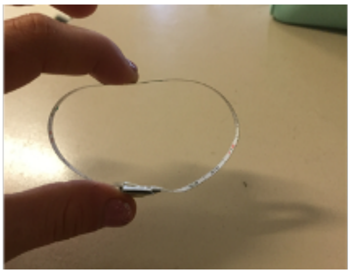


To do the test we will use the binary air cushion and with a motion sensor we will measure the speeds.



For the elastic collision we use a spring and for the totally inelastic collision we use velcro.



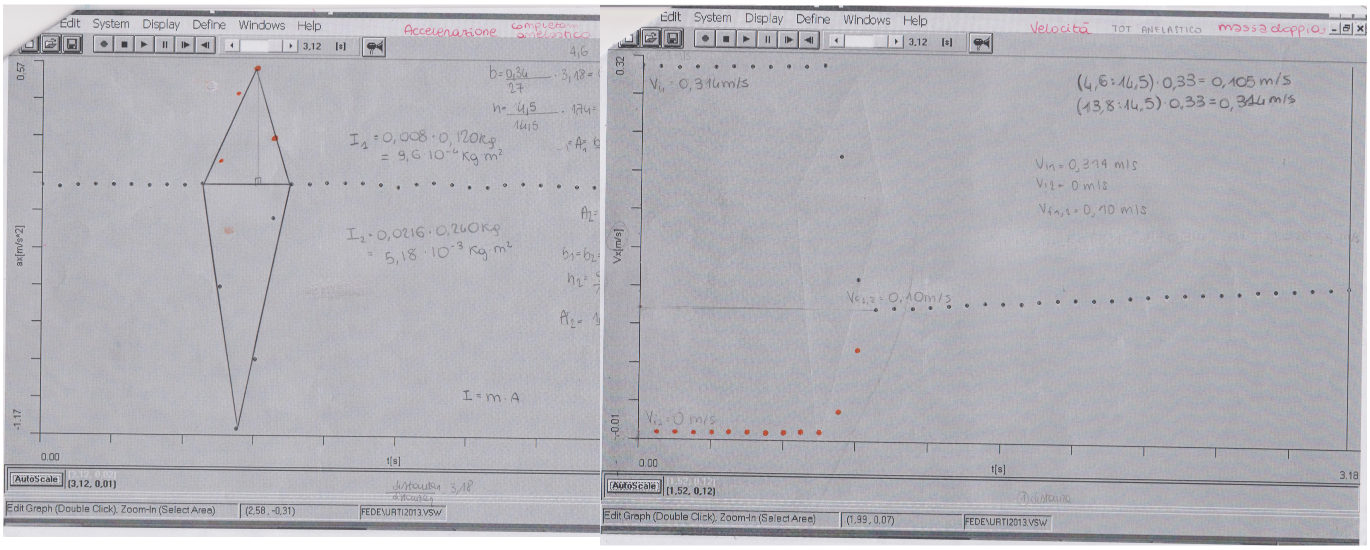


# 7. CARRY OUT

## 7.1. Measurementresults:

We have measured the positions of the carts with a motion sensor and then a computer made acquisition system. The software produced velocity vs time and acceleration vs time graphs. Thanks to the velocity graphs we have estimated the velocities before and after the collisions. With the acceleration one we found the impuses from the areas of the graph multiplied by the mass.

Here are the graphs of one inelastic collision:




And these are the values we found from the graphs:

totally inelastic

| | $V_{1i}$ | $V_{1f}$ | $V_{2i}$ | $V_{2f}$ | $I_1$ | $I_2$ |
|---|---|---|---|---|---|---|
| $m_1=m_2$ | 0,328 m/s | 0,164 m/s | 0 m/s | 0,164 m/s | -0,0217 | 0,0227 |
| $m_2=2m_1$ | 0,314 m/s | 0,10 m/s | 0 m/s | 0,10 m/s | $-9{,}6\cdot10^{-4}$ | $5{,}18\cdot10^{-3}$ |

elastic

| | $V_{1i}$ | $V_{1f}$ | $V_{2i}$ | $V_{2f}$ | $I_1$ | $I_2$ |
|---|---|---|---|---|---|---|
| $m_1=m_2$ | 0,324 m/s | 0,0117 m/s | 0 m/s | 0,317 m/s | -0,0432 | 0,0456 |
| $m_2=2m_1$ | 0,311 m/s | -0,10 m/s | 0 m/s | 0,202 m/s | -0,024 | 0,098 |

## 7.2. Processing:

Kinetic energy:

*Totally inelastic with equal mass*

$K_{1i}$= 1/2·0,120kg·(0,328m/s)$^2$=0,00645 J
$K_{1f}$= 1/2·0,120kg·(0,164m/s)$^2$=0,00161 J
$K_{2i}$= 1/2·0,120kg·(0m/s)$^2$=0 J
$K_{2f}$= 1/2·0,120kg·(0,164m/s)$^2$=0,00161 J

*Totally inelastic with different mass*

$K_{1i}$= 1/2·0,120kg·(0,314m/s)$^2$=0,00591 J
$K_{1f}$= 1/2·0,240kg·(0,10m/s)$^2$=0,0006 J
$K_{2i}$= 1/2·0,120kg·(0m/s)$^2$=0 J
$K_{2f}$= 1/2·0,240kg·(0,10m/s)$^2$=0,0012 J

*Elastic with equal mass*

$K_{1i}$= 1/2·0,120kg·(0,324m/s)$^2$=0,00629 J
$K_{1f}$= 1/2·0,120kg·(0,0117m/s)$^2$=0,00000821 J
$K_{2i}$= 1/2·0,120kg·(0m/s)$^2$=0 J
$K_{2f}$= 1/2·0,120kg·(0,317m/s)$^2$=0,00603 J

*Elastic with different mass*

$K_{1i}$= 1/2·0,120kg·(0,311m/s)$^2$=0,00580 J
$K_{1f}$= 1/2·0,240kg·(0,10m/s)$^2$=0,0006 J
$K_{2i}$= 1/2·0,120kg·(0m/s)$^2$=0 J
$K_{2f}$= 1/2·0,240kg·(0,202m/s)$^2$=0,00489 J

Momentum:

*Elastic with equal mass*

$\Delta p_1 = m_1(V_{1f} - V_{1i})$= 0,120 kg( 0,0117m/s – 0,324 m/s) = -0,0374 kgm/s $I_1 = \Delta p_1$
$\Delta p_2 = m_2(V_{2f} - V_{2i})$= 0,120 kg( 0,317 m/s – 0 m/s) = 0,03804kgm/s $I_2 = \Delta p_2$

*Elastic with different mass*

$\Delta p_1 = m_1(V_{1f} - V_{1i})$= 0,120 kg( -0,10 m/s – 0,314 m/s )= -0,04968kgm/s
$\Delta p_2 = m_2(V_{2f} - V_{2i})$= 0,240 kg(0,202 m/s – 0 m/s )= 0,04848 kgm/s

*Totally inelastic with equal mass*

$\Delta p_1 = m_1(V_{1f} - V_{1i})$= 0,120 Kg (0,164 m/s – 0,328 m/s)= -0,01968 kgm/s
$\Delta p_2 = m_2(V_{2f} - V_{2i})$= 0,120 kg (0,164 m/s – 0 m/s )= 0,01968 kgm/s

*Totally inelastic with different mass*

$\Delta p_1 = m_1(V_{1f} - V_{1i})$= 0,120 kg (0,10 m/s- 0,314 m/s) = -0,02568 kgm/s
$\Delta p_2 = m_2(V_{2f} - V_{2i})$= 0,240 kg (0,10 m/s – 0 m/s)= 0,024 kgm/s

**$p_{1i}+p_{2i}=p_{1f}+p_{2f}$**

*elastic with equal mass*

p_tot,i =0,120kg·0,324m/s+0,120kg·0m/s=0,0389kgm/s
p_tot,f = 0,120kg·0,0117m/s+0,120kg·0,317m/s=0,0394kgm/s

*Elastic with different mass*

p_tot,i =0,120kg·0,311m/s+0,240kg·0m/s=0,0373kgm/s
p_tot,f =0,120mg·(-0,10m/s)+0,240kg·0,202m/s=0,0365kgm/s

*Totally inelastic with equal mass*

p_tot,i =0,120kg·0,328m/s+0,120kg·0m/s=0,0394kgm/s
p_tot,f =0,120kg·0,164m/s+0,120kg·0,164m/s=0,0394kgm/s

*Totally inelastic with different mass*

p_tot,i =0,120kg·0,314m/s+0,240kg·0m/s=0,0377kgm/s
p_tot,f =0,120kg·0,10m/s+0,240·0,10m/s=0,036kgm/s

The total momentum is conserved but it isn't exactly the same because of some inaccuracies maybe in the calculation of the velocities from the graph

| | K_tot,i | K_tot,f | K_tot% |
|---|---|---|---|
| Inelastic $m_1=m_2$ | 0,00645 | 0,00322 | 100*(0,00645-0,00322)/0,00645=50,077% |
| Inelastic $m_2=2m_1$ | 0,00591 | 0,0018 | 100*(0,00591-0,0018)/0,00591=69,5% |
| Elastic $m_1=m_2$ | 0,00629 | 0,00604 | 100*(0,00629-0,00604)/0,00629=3,98% |
| Elastic $m_2=2m_1$ | 0,00580 | 0,00549 | 100*(0,00580-0,00549)/0,00580=5,34% |

| | $\Delta p_1$ | $\Delta p_2$ | p_tot,i | p_tot,f |
|---|---|---|---|---|
| Inelastic $m_1=m_2$ | -0,01968 | 0,01968 | 0,0394 | 0,0394 |
| Inelastic $m_2=2m_1$ | -0,02568 | 0,024 | 0,0377 | 0,036 |

| | | | | |
|---|---|---|---|---|
| Elastic $m_1=m_2$ | -0,0374 | 0,03804 | 0,0389 | 0,0394 |
| Elastic $m_2=2m_1$ | -0,04968 | 0,04848 | 0,0373 | 0,0365 |

### 7.3. Review:

## 8. REFLECT

### 8.1. Conclusion:

After calculating the speeds and the impulse of the carts we soe that there is a relation between their mass,speed and impulse because if the mass of the cart increase also the impulse and speed increase.We can say that they are linked by a proportionate relationship. Looking also at the results of the initial and final momentum during the impact, we soe that they are very similar and also oppsite following the Newton third's law;so we can concluded that they are preserved during the impact. Also the Kinetic energy is preserved during the impact, even if the results aren't totally equal, as a result of some error in the calcolations.

**8.2.** *Do your decisions agree with the hypothesis that you have made?Why yes/not?*

**8.3. Evaluatie:** *Are you content with your approach and cooperation?*