BLOWPIPE

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PROBLEM STATEMENT

A small, lightweight projectile is shot out of a blowpipe. Investigate and measure the speed of the projectile.

Summary

Theoretical Part

- ✓ Introduction
- ✓ Theory
- ✓ Hypothesis

Experimental Part

- ✓ Material and Methods
- ✓ Results and Discussion

Final Part

- ✓ Conclusions
- ✓ Errors and limitations
- ✓ References
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Theoretical Part

Phenomenon explanation

- There is only one main force that acts on the projectile once it is shot out of the pipe:

✓The force of gravity, that

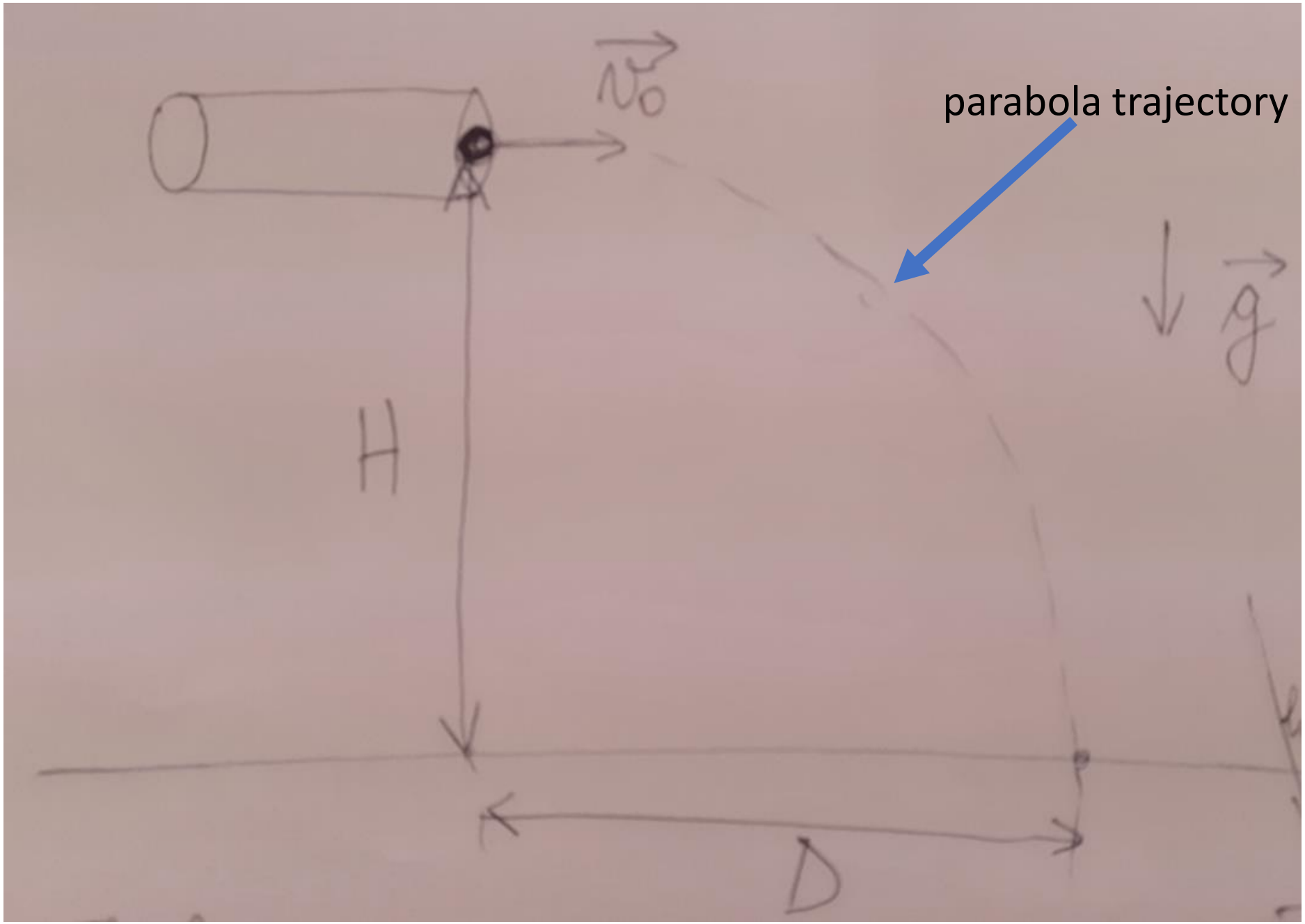
pulls the projectile to the ground

$$W = mg$$

Weight of object = mass of object x acceleration of gravity

The acceleration of gravity depends on:

- ✓ the altitude
- ✓ the latitude


parabola trajectory
$\vec{v_0}$
$\vec{g}$
H
D

Experimental Part

Materials and methods

Hypotheses

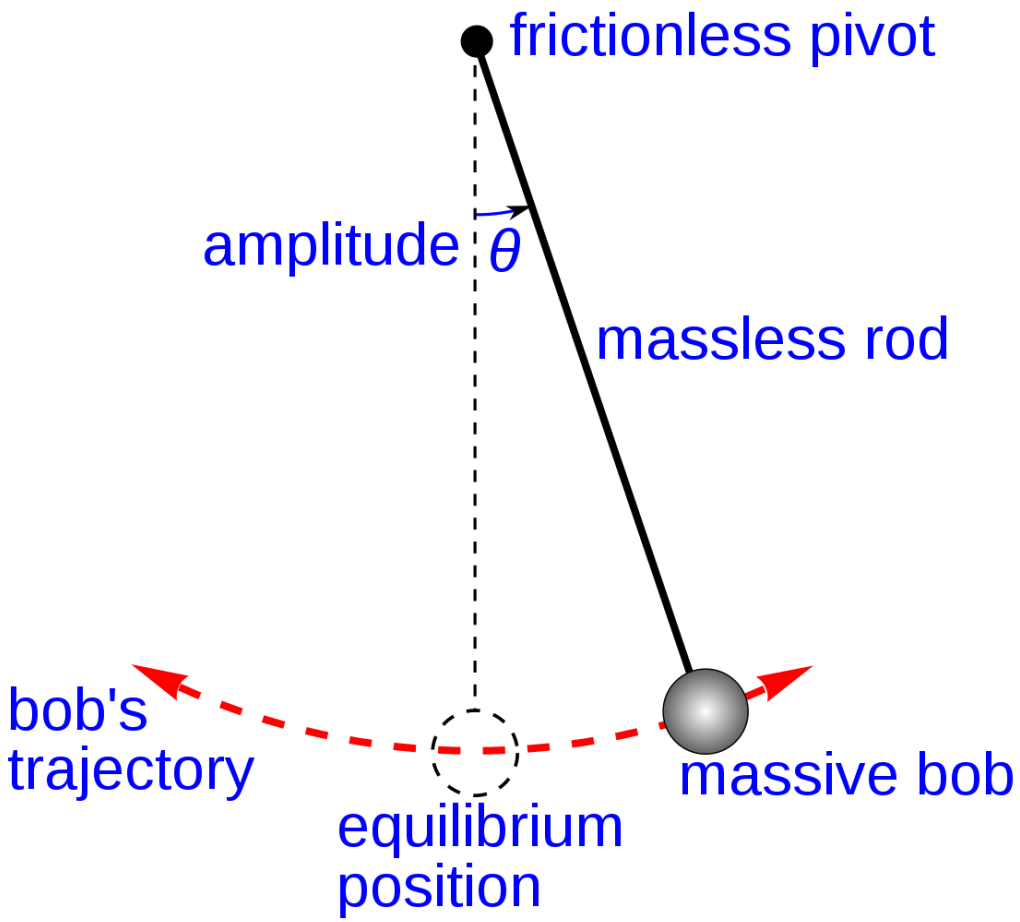
- The acceleration of gravity is around 9, 80 m/s^2.
- The velocity of the projectile would not be very big, at most 5 m/s.

Experiment 1 – determine the acceleration of gravity

Materials used

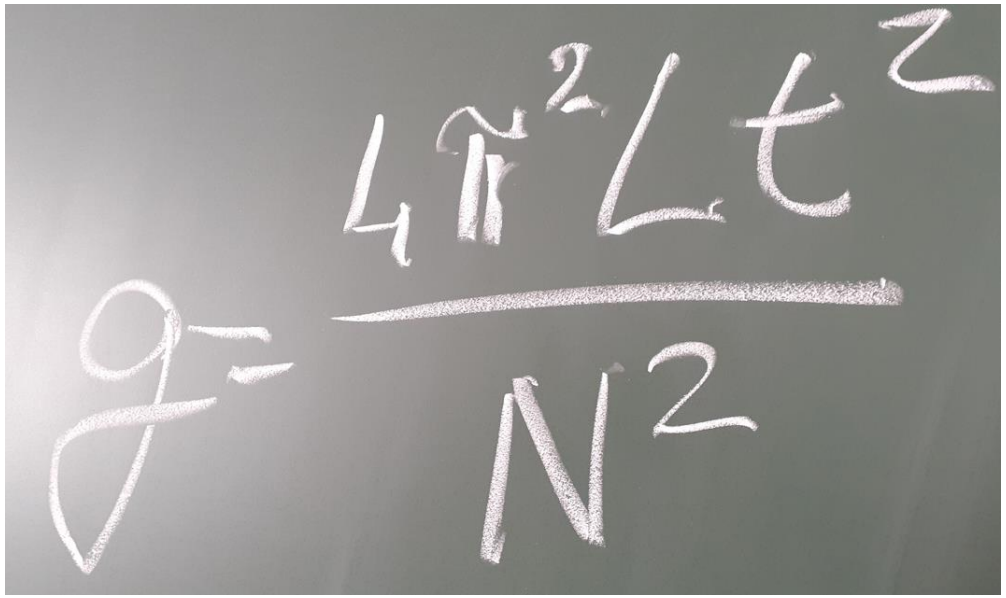
- ✓String of length=50 cm
- ✓Heavy, small object
- ✓Chronometer

We constructed a **gravitational pendulum**



$$g = \frac{4\pi^2 L}{T^2}$$

$$T = \frac{N}{t}$$



The method:

- ✓ We tie the string together with the heavy object;
- ✓ We lift the object at a variable height and let it oscillate around the vertical;
- ✓ We measure the time needed for the object to oscillate 10 times (N=10)
- ✓ We find out the acceleration of gravity and completed the table with the following structure

Time (s)	The number of rotations	Length of the string (m)	Acceleration of gravity (m/s^2)	Average acceleration of gravity (m/s^2)	The errors	Average errors
	10	0.5				

Experiment 2 – determine the velocity of the projectile when is shot out of the blowpipe

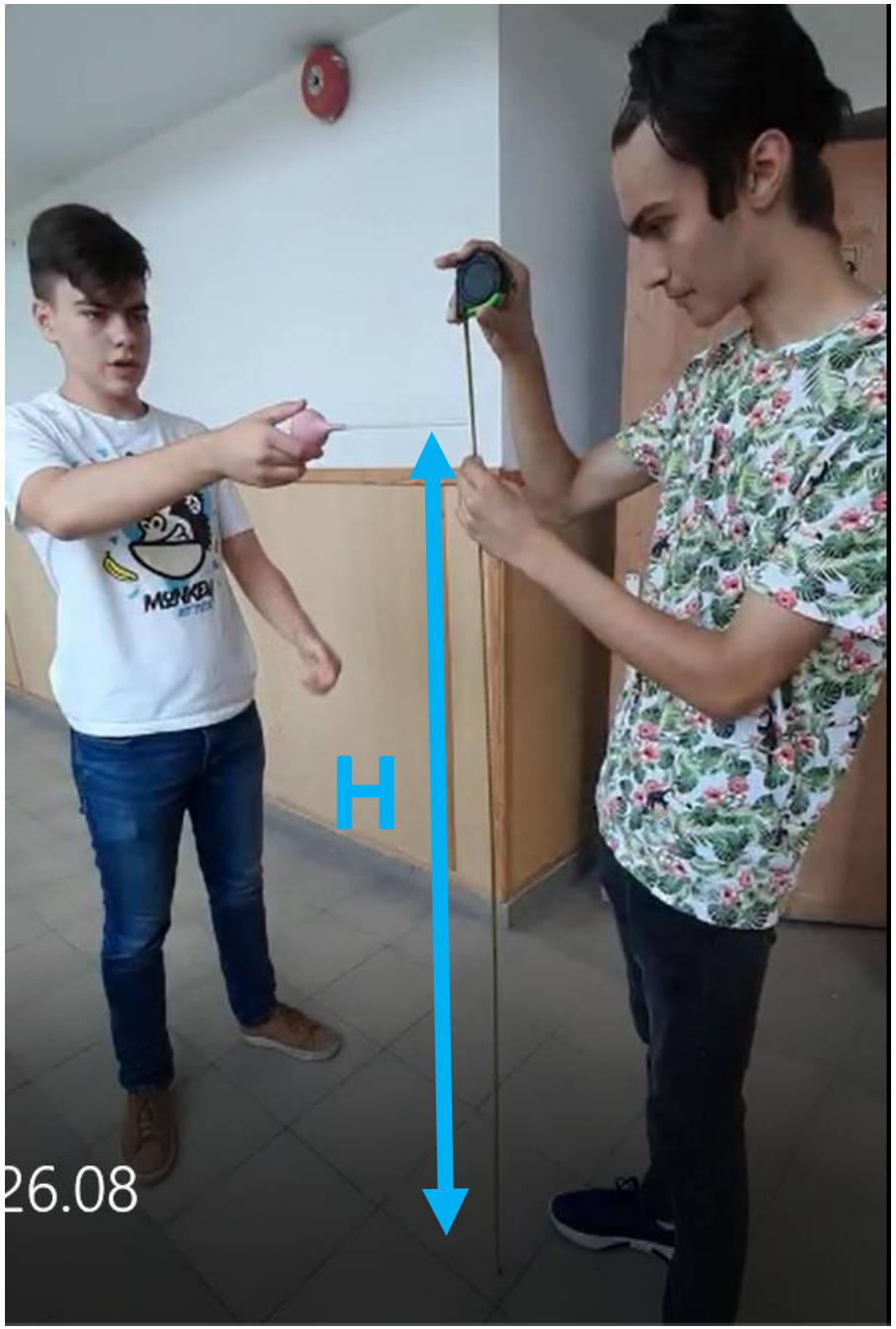
Materials used

We used the following materials:

- ✓Pipe
- ✓Projectile
- ✓Ruler
- ✓Rubber balloons

The method:

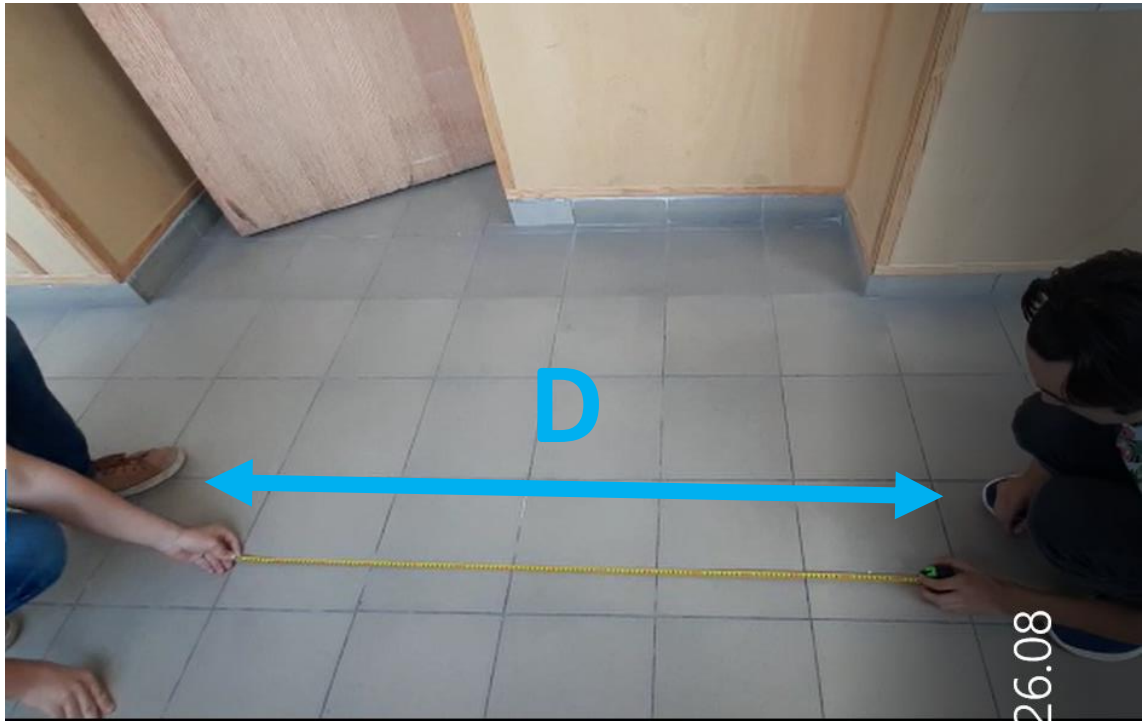
- ✓ We kept the blowpipe horizontal;
- ✓ We measured the initial height H the projectile was, using the tape measure;



- ✓ We pushed the rubber “balloon” with the same force in order for the projectile to have the same initial speed;

- ✓ Someone hold the pipe horizontal with gentleness in order for the pipe not to rebound;

- ✓ We measured the distance D the projectile moves until it touches the ground, using again the tape measure;



✓ We recorded the experimental data in a table of the following structure:

Height (m)	Distance (m)	Initial speed (m/s)	The average initial speed (m/s)	The errors	Average error

The calculation used to determine the initial velocity of the projectile

The laws of motion with constant acceleration:

- On vertical: $y = y_0 + v_{y_0} \cdot t - \frac{gt^2}{2}$ $(a_y = -g)$
- On horizontal: $x = x_0 + v_{x_0} \cdot t$ $(a_x = 0)$

For $y = 0$, $x = D$: $0 = H + 0 \cdot t - \frac{gt^2}{2} \Rightarrow H = \frac{gt^2}{2}$

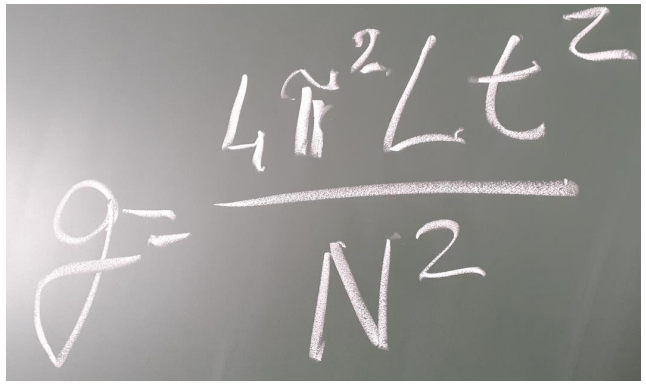
$$D = 0 + v_0 \cdot t \Rightarrow D = v_0 \cdot t$$

So : $H = \frac{gt^2}{2}$, $D = v_0 \cdot t \Rightarrow t = \frac{D}{v_0}$

$$\Rightarrow H = \frac{g}{2} \cdot \left(\frac{D}{v_0}\right)^2 = \frac{gD^2}{2v_0^2} \Rightarrow v_0^2 = \frac{gD^2}{2H} \Rightarrow v_0 = D\sqrt{\frac{g}{2H}}$$

The projectile speed is $v_0 = D\sqrt{\frac{g}{2H}}$ ✓

Results and discussions



π=3.14

Time (s)	The number of rotations	Length of the string (m)	Acceleration gravity (m/s^2)	Average acceleration of gravity (m/s^2)	The errors	Average errors
7, 08	10	0,5	9, 87	9, 81	0, 06	0, 036
7, 07			9,84		0, 03	
7, 05			9,79		0, 02	
7, 06			9,82		0, 01	
7, 03			9, 75		0, 06	

$$g = (9,81 \pm 0,036)\frac{m}{s^2}$$

$$v_0 = \Delta\sqrt{\frac{g}{2H}}$$

g=9.81 m/s^2

Height (m)	Distance (m)	Initial speed (m/s)	The average initial speed (m/s)	The errors	Average error
1,51	1, 03	1, 86	1, 85	0, 01	0, 07
1,30	0, 87	1, 69		0, 16	
1,64	1,06	1, 83		0, 02	
1,02	0, 88	1, 93		0, 08	
1,70	1,15	1, 95		0, 1	

$$v_0 = (1,85 \pm 0{,}07)\,\frac{m}{s}$$

Conclusions

- The acceleration of gravity is approximatively 9, 81 m/s^2, with an error of $\pm$ 0,036, which means an error of 2%. As long as the error was under 5%, meant that the experiment had valid results.
- The velocity of the projectile is approximatively 1, 85 m/s, with an error of $\pm$ 0.07, which means an error of 3%. As long as the error was under 5%, meant that the experiment had valid results.
- Both conclusions confirm the hypotheses.

Errors and limitations

- The possible air friction, but it is too low to consider it in our experiment because the projectile is very small and its shape is pretty much aerodynamic;
- Errors due to the experimenter, when measuring distances or periods of time;

References

Appendices