EUROSTRONOMIA 2017-2020

Acceleration due to gravity on Earth

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Within the framework of the Erasmus+ Project “Eurostronomia” during October 2017 8 groups of students worked on determining of Earth Acceleration. They had 4 different tasks. Every group was formed from 2 students. Two groups worked on same task. Students were first, second and third year.

During the early part of the seventeenth century, Galileo experimentally examined the concept of acceleration. One of his goals was to learn more about freely falling objects. Our students have more precise equipment and 4 different tasks.

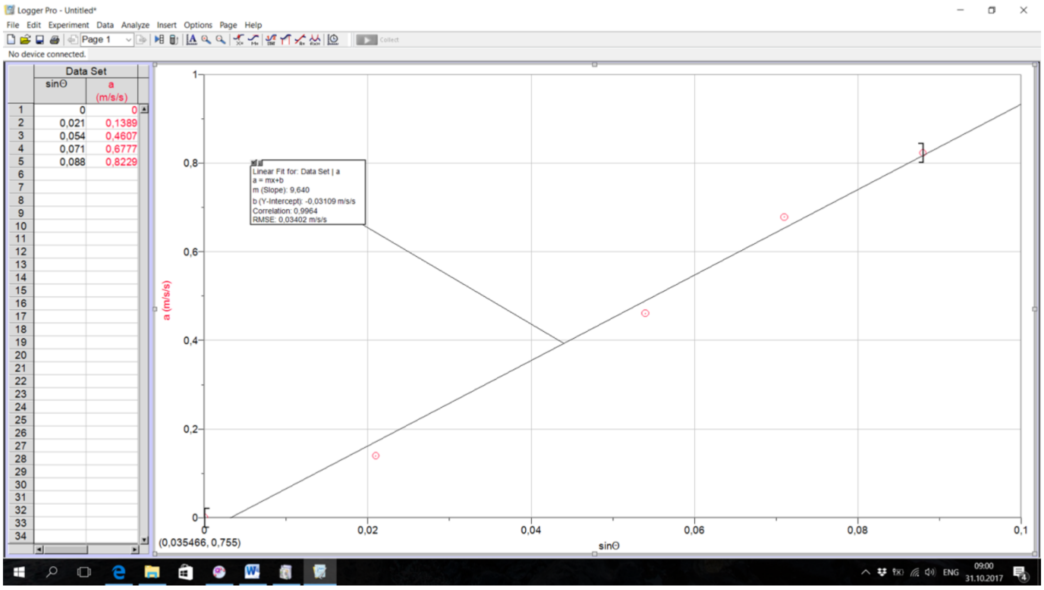
Task of first group was: Determining g on an Incline

In this experiment, students investigated how the acceleration of a rolling ball or cart depends on the incline angle. Then, they used their data to extrapolate to the acceleration on a vertical “incline;” that is, the acceleration of a ball in free fall.

If the angle of an incline with the horizontal is small, a cart rolling down the incline moves slowly and can be easily timed. Using time and position data, it is possible to calculate the acceleration of the cart. When the angle of the incline is increased, the acceleration also increases. The acceleration is directly proportional to the sine of the incline angle, α. A graph of acceleration versus $\sin\alpha$ can be extrapolated to a point where the value of $\sin\alpha$ is 1. When $\sin\alpha$ is 1, the angle of the incline is 90°. This is equivalent to free fall. The acceleration during free fall can then be determined from the graph.

Galileo was able to measure acceleration only for small angles. Students collected similar data. Can these data be used in extrapolation to determine a useful value of g, the acceleration of free fall? Students saw how valid this extrapolation can be. Rather than measuring time, as Galileo did, students used a Motion Encoder System to determine the acceleration. They made quantitative measurements of the motion of a cart rolling down inclines of various small angles.

The results are:



Task of second group was: Picket Fence Free Fall

We say an object is in free fall when the only force acting on it is the Earth's gravitational force. No other forces can be acting; in particular, air resistance must be either absent or so small as to be ignored. When the object in free fall is near the surface of the earth, the gravitational force on it is nearly constant. As a result, an object in free fall accelerates downward at a constant rate. This acceleration is usually represented with the symbol, g.

Students measured the acceleration due to gravity using a wide variety of timing methods. In this experiment, they had the advantage of using a very precise timer and a Photogate. The Photogate has a beam of infrared light that travels from one side to the other. It can detect whenever this beam is blocked. Students dropped a piece of clear plastic with evenly spaced black bars on it, called a Picket Fence. As the Picket Fence passes through the Photogate, the interface measures the time from the leading edge of one bar blocking the beam until the leading edge of the next bar blocks the beam. This timing continues as all eight bars pass through the Photogate. From these measured times, the software calculates and plots the velocities and accelerations for this motion.

After measurements results were:

Trial	1	2	3	4	5	6
Slope (m/s^2)	9.744	9.789	10.10	9.804	9.768	9.853

	Minimum	Maximum	Average
Acceleration (m/s^2)	9.744	10.103	9.8

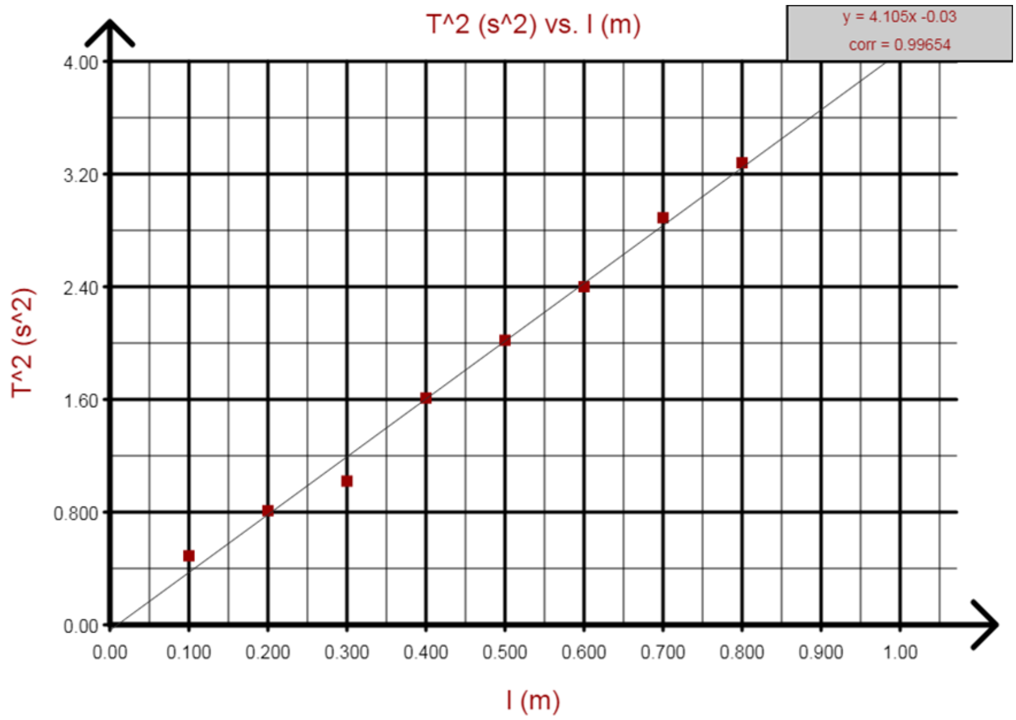
Acceleration due to gravity, *g*	($9.8 \pm$ 0.1)	m/s^2
Precision	1%	

Task of third group was: Determining g with Pendulum

There are at least three things students could change about a pendulum that might affect the period (the time for one complete cycle):

- the amplitude of the pendulum swing
- the length of the pendulum, measured from the center of the pendulum bob to the point of support
- the mass of the pendulum bob

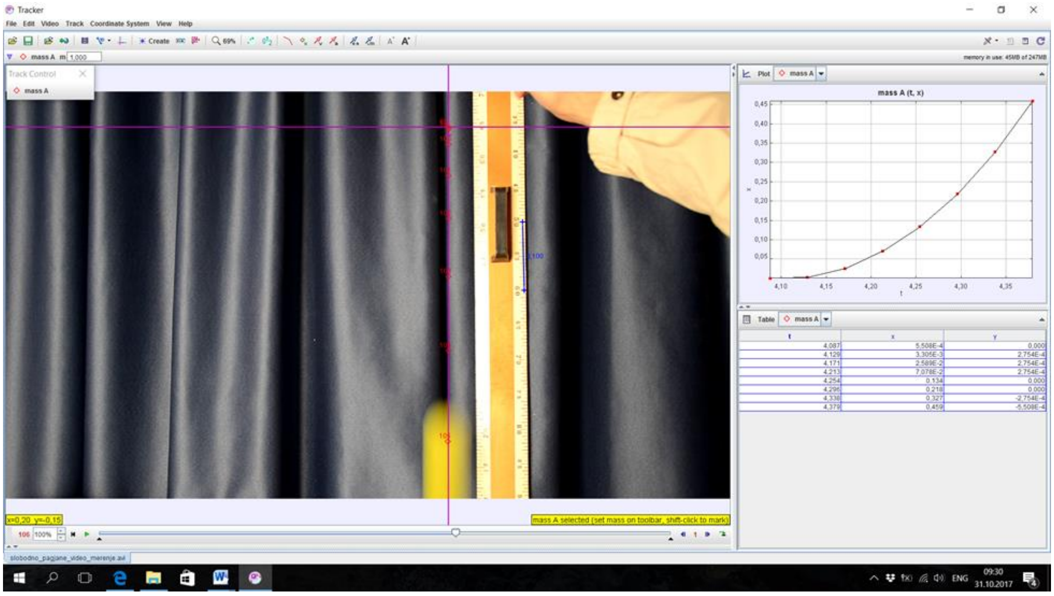
Students had measured the period of a pendulum as a function of length and from your graph of T 2 vs. *l*, they determined a value for g

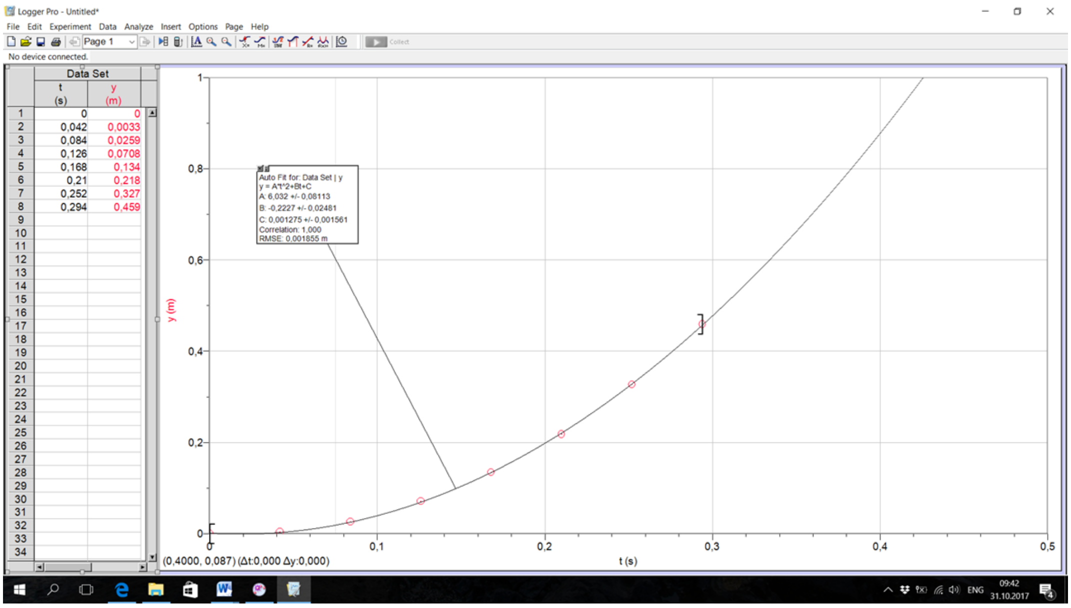


Acceleration due to gravity, *g*	(9.84± 0.15) m/s^2
Precision	1,5%

Task of fourth group was: Determining g with Video Analysis

In this experiment, students used Video Analysis (Tracer) to measure the actual free fall of a ball. After that they compared the results of their task with the measurement for free fall.





Acceleration due to gravity, *g*	(12.06 ± 0.16) m/s^2
Precision	1,3%

After finishing the tasks students compared their results.