Measuring g (gravitation acceleration)

Introduction

To begin with, we would like to introduce ourselves . We are a small group of 2 students of our school's Science Club. Our school is **2nd Lyceum Eleftheriou - Kordelio**, located in the city of Thessaloniki (Greece). Together with our physics teacher **Nikos Kyriazopoulos**, we are very happy to participate in this truly interesting and engaging etwinning project. We are in the age of sixteen years old and our names are **George Kousis** and **Evi Marioula**.

Measuring process

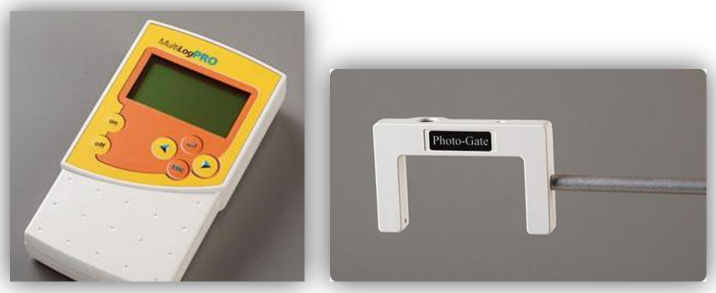
For the measurement of the gravitational acceleration **g** in our location, we decided to use a classic method suited to contemporary measurement tools and data acquisition process . Thus, we chose the oscillation (for small amplitude θ) of a simple pendulum . The simple pendulum is a device which consists of a smal point mass tied in one free end of a massless string whose length can be varied.

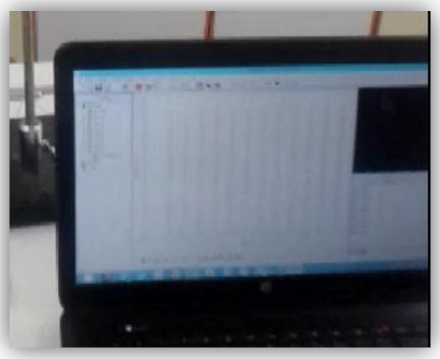
More specifically, our target was to estimate the constant value of the acceleration g by measuring the period **T** of the oscillation. Knowing that the period **T** of this motion is related by the length of the string l (for small swings) with the formula $T = 2\pi\sqrt{\frac{l}{g}}$ from which the linear function $T^2 = \frac{4\pi^2}{g} l$ (1) can be calculated.

For 4 different lengths of the string, the relevant periods were recorded. Then, analysing the data on Microsoft Excel, we produced the xy (scatter) graph of the function (1). A first order linear fit was performed on the data. The value of the slope corresponded to the constant value of the gravitational acceleration.

Pic. 1: Performing the measurements

As we know the time period **dt** for two successive passes of the point mass from its equilibrium position is equal to T/2. In order to record 2 successive times (t_1 and t_2) of this pass, we used a photogate connected with a data logger (MultiLogPRO of Fourier Systems), (Pic. 2). The data from the photogate were processed by MultiLab software (Pic. 3).





Pic. 2 The Data Logger (left) and the photogate (right)

Pic. 3 Screenshot of the Multilab software

Results and conclusion

For varying string lengths, the different experimental values of the oscillation periods were calculated. As mentioned, for them the measured time between the two passes from the equilibrium state were used, since dt = T/2.

A summary of the measured data with the calculated oscillation period values is presented on Table 1.

t_1 (sec)	t_2 (sec)	Δt (sec)	T (sec)	T^2 (sec)	l (m)
3,17	2,25	0,92	1,84	3,3856	0,802
2,45	1,62	0,83	1,66	2,7556	0,71
0,84	0,12	0,72	1,44	2,0736	0,495
2,37	1,81	0,56	1,12	1,2544	0,3

Table 1: Recorded time periods and calculated oscillation values

In the scatter graph, the T^2 values were plotted against the length of the string as shown in Fig. 1. The next step, was to perform the linear fit using Equation 1.

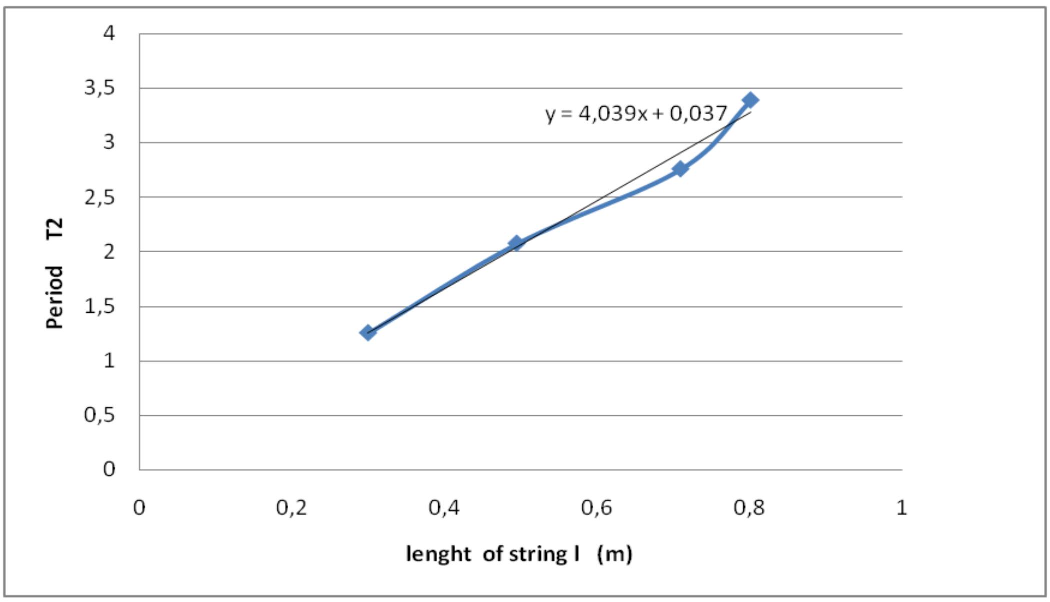


Fig 1: Plot of T^2 against the length of the string with the linear fit

The result value of slope is 4,093 and from Eq. 1 this is equal to

$$4{,}093 = \frac{4\pi^2}{g} \Rightarrow g = \frac{4\pi^2}{4{,}093} \Rightarrow \boldsymbol{g = 9{,}77\ m/s^2}$$

The value of g that we differs from the expected value from theory.. The geographical coordinates of our city (Thessaloniki –Greece) are 40.65°N 22.9°E. For those coordinates the theoretical value of gravitational acceleration (at sea level) is approximately 9.80 m/s^2 .

The small difference between our experimental value and the theoretical can be attributed to several parameters. Initially, the measurements were performed for a small amount of strings with varied length. Such limited statistics introduce statistical uncertainties. Additionally, systematic uncertainties on method to record the two times can affect the final result. These are related to precision of the photogate and the precision of the readout system.

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