

LOCAL GRAVITY ACCELERATION DETERMINATION USING ONLY A PERSONAL MICROCOMPUTER AND DIGITAL CAMERA

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Abstract. This paper presents, for beginner engineering students, a relatively simple and practical method for determining the local gravity acceleration inside any classroom. In order to measure the local gravity acceleration the method only requires a personal microcomputer with a Windows® operational system along with the video utility Movie Maker® installed, and a digital video camera to capture the movements. The method consists of capturing a free falling object facing a blackboard attached metric scale chart in the classroom. These images are sent to the microcomputer and then analyzed by the program. The Movie Maker® allows the movie to be watched, frame by frame, showing the elapsed time, in seconds, associated to the metric scale chart, so that, through the time equation of the uniformly accelerated motion, the local gravity acceleration can be determined

Keywords: gravity; free fall; engineering education; education with computer, teaching of physics.

1. INTRODUCTION

To explain the concept of acceleration of gravity almost every of physical teachers as well as the early years of university courses in exact sciences such as physics, engineering, mathematics and others, have problems to demonstrate experimentally, even though approximately the values typically used in books for years of fixation. (Lees and Kerwin, 1982, Bork and Peckham, 1979)

There are various devices and equipment for the purpose of determining the acceleration of gravity for sale in stores specialized in teaching science, but also have a high cost to occupy a significant space and are used very little because it is the application solely for this purpose.

But today, both in private schools as public schools are available to the teachers and students to microcomputers with Windows ® operating system, which in turn comes with an application for construction of videos called Movie Maker.

With the use of this software get data from position and time of movement of free-fall to determine the acceleration of gravity, because Movie Maker has a very important characteristic that is split into frames of film from digital cameras, camcorders and cell phones with these accessories.

1.1 What is gravity?

Although the empirical studies on the movement of free fall has started and published by Galileo at the end of the XVI century, the formulation of the theory of universal gravitation only occurred almost a century later, when Newton published his studies in the year 1687. At that time, the knowledge that the Earth is approximately spherical shape was completely distributed, since in 1522 Magellan had completed the first voyage of circumnavigation.

The gravitation is a fundamental property of matter, manifesting itself in any scale of magnitude, from the atomic to the cosmic. The gravitational phenomena are described by Newton's Law, in which two spherical masses m and m_0 with uniform density in their interiors, attract up as described in equation 1 e 2 and figure 1. (Neto et al, 2006)

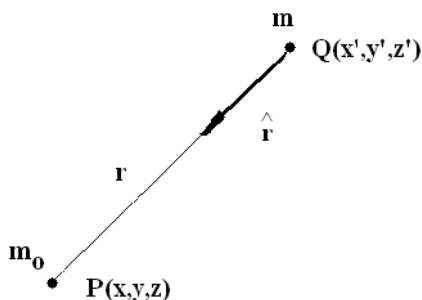


Figure1. The gravitational phenomena are described by Newton's Law

$$F = \frac{G \cdot m \cdot m_o}{r^2} \quad (1)$$

Where r is:

$$r = [(x - x')^2 + (y - y')^2 + (z - z')^2]^{1/2} \quad (2)$$

Both the direction and the intensity of g vary according to position on the earth's surface. Thus, the intensity of g is maximum at the poles and is equal to the component g , decreasing gradually towards the equator, which reaches the minimum value.

1.2 Measuring the gravity

By measuring the gravity field of the Earth was obtained important information about its inside, it was also different in their characteristics, as their shape and interaction with other bodies in the Solar System. The field of gravity associated with each point on the surface of the earth a vector of acceleration of gravity g . This vector is characterized by its intensity, called gravity, and by his direction, called vertical. The severity is measured by means of gravity, while the vertical is obtained by astronomical. In gravimetry, in honor of Galileo, is used as the unit of acceleration Gal.

SI International System in the universal constant $G = 6.67 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$, and g unit is m/s^2 .

Two types of gravity can be used in measures of severity. The absolute gravity measure directly the intensity of gravity at a given point, and the type of free fall the most used nowadays. How are difficult to transport, are installed in the laboratory. Moreover, the gravity differential, are basically a spring balance to determine the exact weight of the mass value of which variation is caused by differences in the value of g . This type of gravity measures the difference of gravity between two different points, and where the value in one of the points is known, one can determine the severity in the other.

1.3 Anomalies gravimetric

On surface of Earth, the average value of gravity is approximately 9.80 m/s^2 or 980 Gal. Due to the rotation and the flattening in the polar region, the value of gravity decreases about 5.3 Gal of the poles to the equator, which is a variation of about 0.5%. Moreover, the attraction exerted by the Moon and the Sun, and the difference in elevation between the points of measurement cause change in the value of gravity.

The biggest change in the value of g is the latitudinal, caused by rotation and flattening land, so the theoretical value of gravity g at sea level is described by the equation 2.

$$g(L) = 978.03118 \cdot [1 + 0.0053024 \cdot \sin^2(L) - 0,0000587 \cdot \sin^2(2L)] \quad (3)$$

where L is the latitude of a point of reference ellipsoid, which is the surface that best fits the Earth geometry.

The experimental procedure is simple and divided into four parts: (Sismanoglu et al, 2009)

1. The footage of the free fall;
2. Gather data of time and space, with the Movie Maker;
3. Calculate of obtaining the acceleration of gravity
4. Analysis and discussion of the method and the results compared with those provided in the publications.

We teachers always look for a way to motivate students for the learning and the learning of significant, said (Laburú and Carvalho, 1993) that: "Serving on these findings, it is to evoke interest, within a more general idea of the education strategy, the use of appropriate experiments to stimulate the student in the classroom, to engage in the content. The idea is to imagine that it is seeking to activate the curiosity of students, in moments of the teaching process, using experiments with captivating format, which attract and keep. In that it is planning to experiment with this approach, beyond the concern of just tailor them to the content or the concept of interest, you can help jolt attitudes of inertia, of inattention, of apathy, a little effort, serving these experiments, including the incentive to link the students to engage in a more effective subsequent to the tasks more difficult and less pleasurable."

This method uses two tools that students have great pleasure and generally easy to use digital camera and the microcomputer. Show them a new use for these devices daily.

2. OBTAINING DATA OF TIME AND SPACE ON FREE FALL

Any environment can be used, just use a ruler to read off a blackboard on the wall or the measures of length. Use a ruler or graph paper can only hinder the viewing later.

The duration of the film is just about 5 seconds, it was observed that the greater the length the greater the precision of the analysis results as well as the quality of the assembly of the apparatus taking care of variations in parallax and size of the object that will fall.

Computer simulations are of particular interest in applications on teaching of physics because it can support powerful modeling physical environments involving concepts and processes. The results presented here show that students working with simulations showed significantly higher scores in the tasks of research. Our findings strongly support computer simulations that can be used as an alternative tool of instruction to help students cope with their cognitive limitations and develop functional understanding of physics. "(Jimoyiannis and Komis, 2001).

After the shooting must use the microcomputer to analyze the details of the fall. After the application is in operation must download the video to the application, the triggers for this menu to capture video, which is shown in figure 2 with the arrow (1) and to have success identifying the video should find the folder or place it was saved and copied the video of the fall, which is shown in figure 2 with the arrow (2).

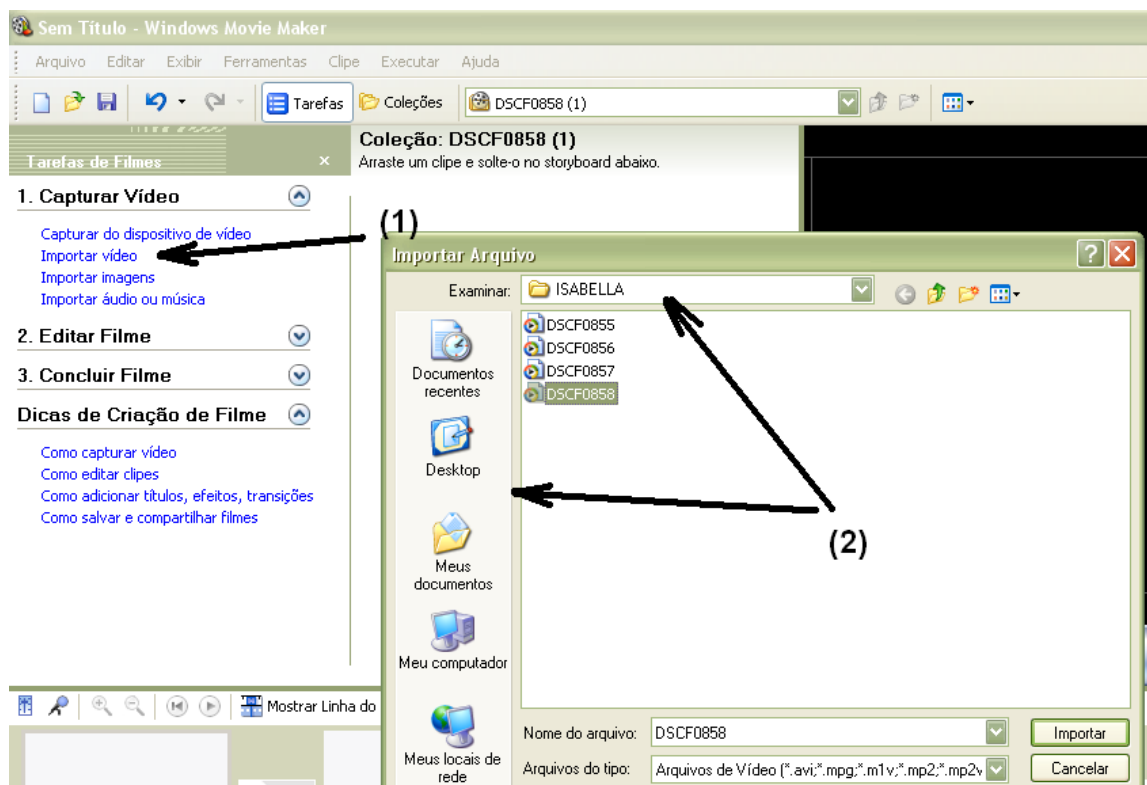


Figure 2 - Command to import the video into the Free Fall (1) and location in (2)

After importing the video is complete an icon will appear with the image of the video in the application called the collection shown by the arrow (3) in figure 3. When activated the video will be available for display in the right side of the application, shown by the arrow (11) in Figure 3.

For the survey of the positions and their time should use the command to control the video. The arrow (4) triggers the movement of the video standard (PLAY), the arrow (5) triggers the (STOP) which aims to stop the video back to the beginning, the arrow (6) is triggering a return to the top, so as the arrow (8) moves to the end of the video, because the buttons (6) and (7) respectively and sweep back and forth frame by frame from the footage.

With the arrow (7), advancing frame by frame, gathering up time in the application, show by the arrow (9). The figure 4 shows five frames, in sequence, from a fall from a rubber school. With the information of the position of rubber in the fall related to the time obtained through the application where the arrow (9) suggests we build a table of position versus time, thus enabling obtaining the value of local gravity.

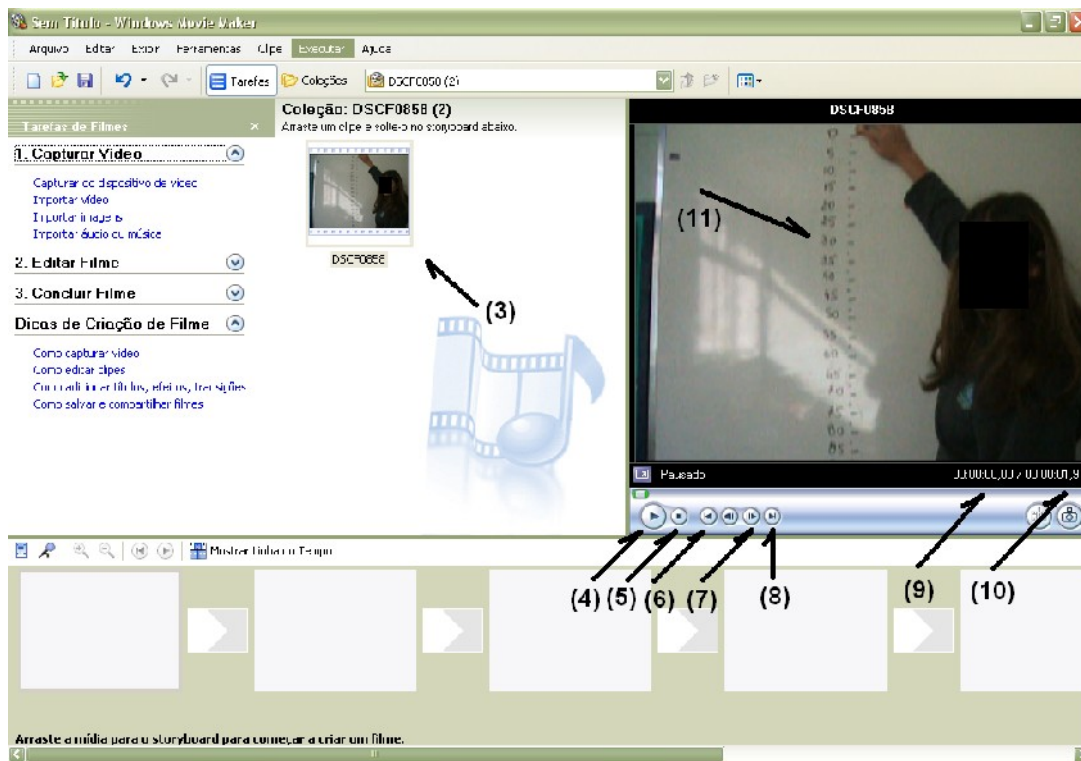


Figure 3 - Command to import the video into the Free Fall (1) and location in (2)

The movie made by students of the First Year of High School Set in São Paulo City produced the tables where you can observe a value of gravity acceptable.

In the experiment to take care of parallax error does not occur, placing the camera in the front drop position.

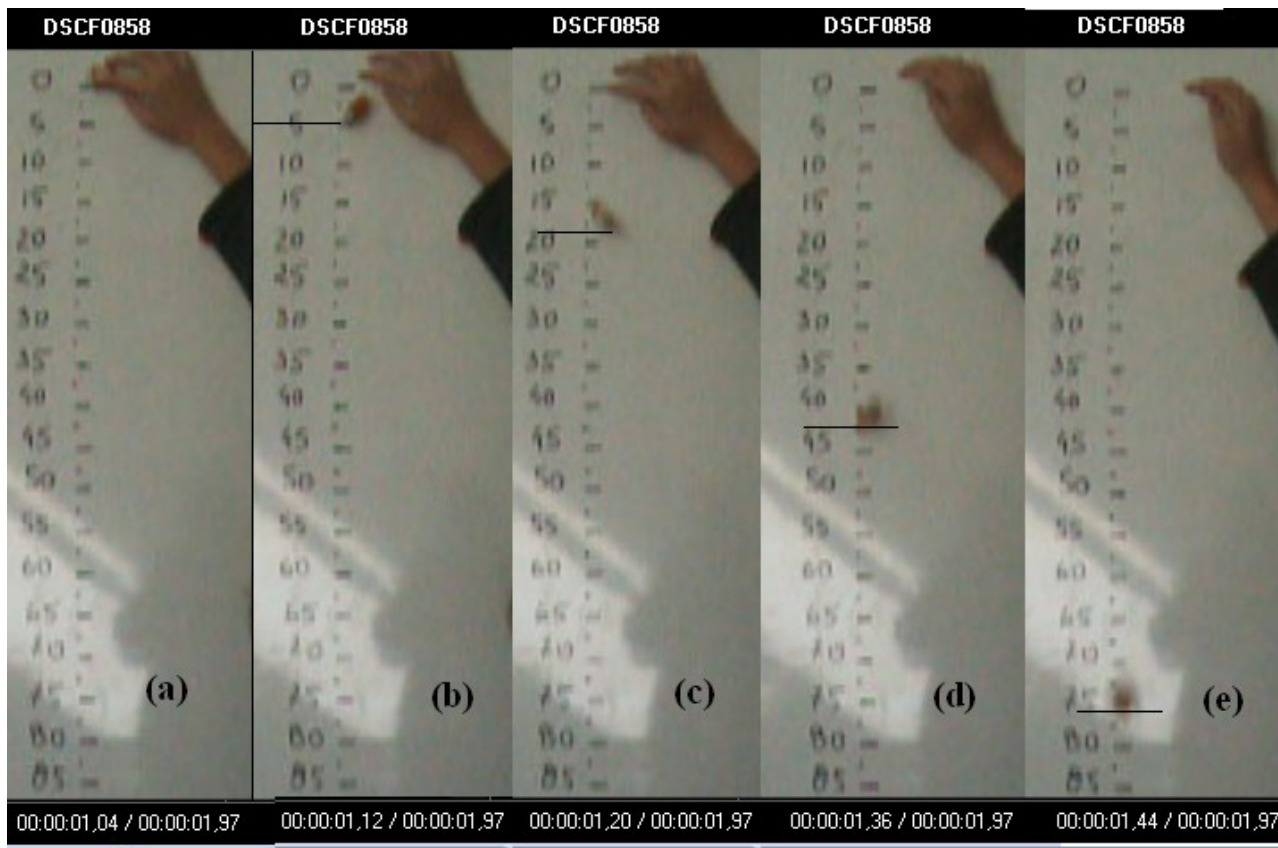


Figure 4 - A sequence of frames showing the free fall of a rubber in front of a blackboard with white markings of scale metric.

The factors that influence the accuracy of the value of gravity is mainly the size of the drop shot, the size of the falling object, the quality metric of the scale used, the number of divisions of frames that the camera has video camera, so the smallest interval of time to capture the image that the camera has.

3. RESULTS

Our approach to the calculation of gravity location for both regular education and for the technical course or for the starting year of graduation from the course exactly as engineering or physics is used basically the isolation of the algebraic variable of g function of time shown in fast motion equation 4.

$$S = S_0 + v \cdot t + \frac{1}{2} \cdot g \cdot t^2 \tag{4}$$

$$g = \frac{2 \cdot \Delta S}{\Delta t^2} \tag{5}$$

As we can see in equation 4 to obtain the dependence of the value of local gravity is only the displacement and the period of time. This is perfectly possible to obtain these variables through the use of Movie Maker, S is the final space, S_0 the initial space, v initial velocity, g is gravity and t is time of fall. For the study it is $S_0 = 0m$ and $v = 0m/s$.

In figure 5 where we have the graph shows the values of gravity by free fall, tests of gravimeter in the mass of high precision (7 decimal places), this device used in the course of Geophysics of the USP, the average values of gravity and the value calculated as equation 3, for the latitude of São Paulo (23:36:51), also in this graph was made the upper and lower limit of 1.5% of average gravity to serve as a measure of accuracy.

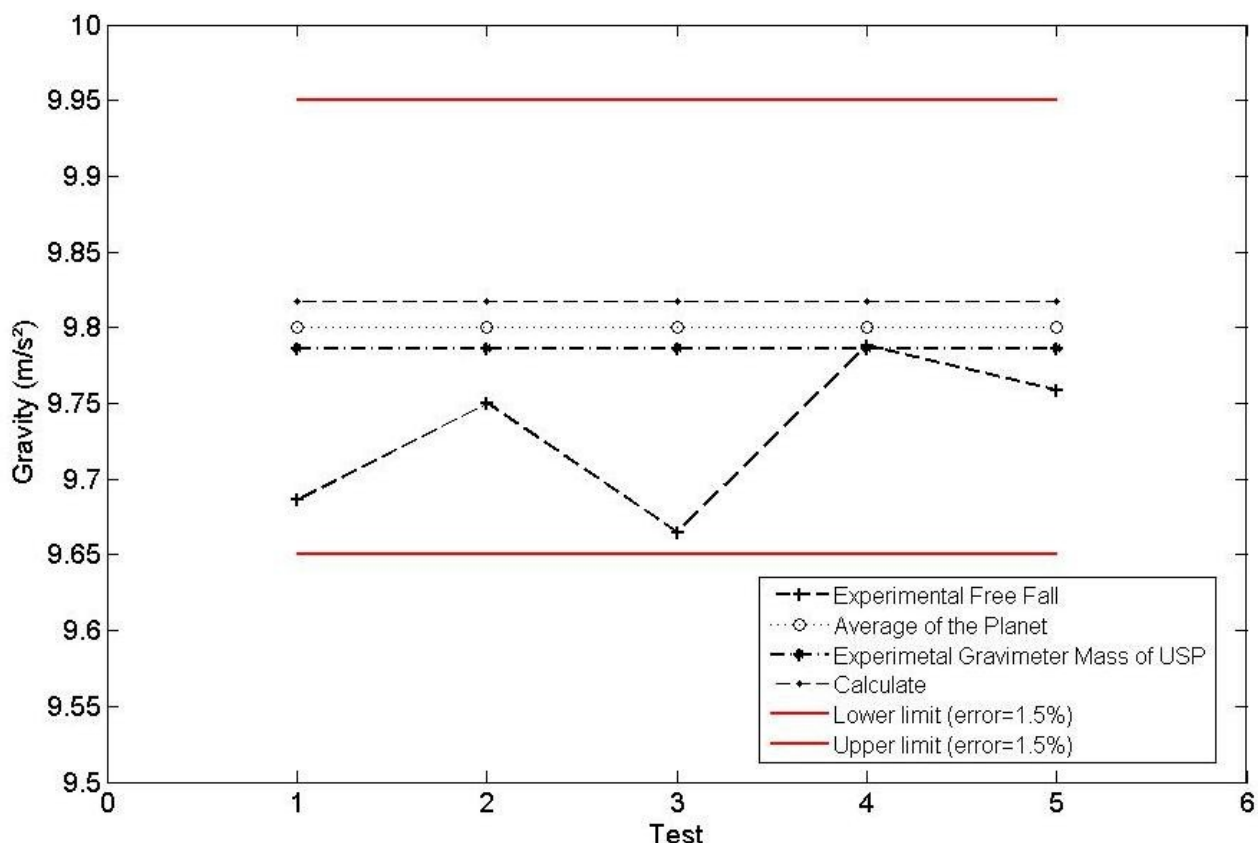


Figure 5 - Graph shows the values of gravity by Free Fall, Gravimeter Mass, Calculated Gravity and Average of the Planet

3. CONCLUSION

Nowadays it is easy to get a video camera, a webcam or a cell phone camera, which are great devices to build a differentiated experience or an activity. The performance of students in the learning process actually produces a significant learning and motivating

The method of measuring the acceleration of gravity using only a digital camera and a microcomputer with software that separates the frames in the film obtained from the free fall of an object associated with a metric scale has a good precision, which is sufficient to obtain an appropriate value experience in a fast of any classroom. The average value of gravity obtained from the experience of free fall is 9.73 m/s^2 and close to the measured mass with gravity 9.78 m/s^2 and the average value of the planet 9.8 m/s^2 , so this method also, such as Cavalcante, who showed in their publication with measurement of free fall with optical sensors, which after checking the reproducibility of results in about 100 entries, earned an average value for the acceleration of fall of 9.79 m/s^2 and a standard deviation for the sample of 0.01 m/s^2 , showing, therefore, total reliability in the proposed method.

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