Fingerprinting Gravity

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Aim at 3 segments with a handout for each student at the end.

Supplies: A 2-m long piece of light string; a mass (can be any small object e.g. some coins), measuring tape, stop watch, nail, roll of scotch tape.

(The following concepts will be introduced interactively with students as main participants)

Part 1: Problem introduction (7 minutes)

Hello everybody, my name is Bashar Lahlouh, and I am a professor of physics at the University of Jordan.

As you may all know, every one of us has his own weight. Some of us may weigh more or less than others. Also, most of us get tired when we go uphill and we feel a force pulling us down when we go downhill. I think we may all say that all these observations are due to gravity!

Well, what do you think of gravity? Does it exist? What's your evidence of its existence? **(Discuss this interactively with the students, and let the students give you more examples on gravity effects)**

Pause for 2 minutes Discussion between the teacher and the Students.

Ok, since you realize that gravity is a force, just like other forces then it should obey Newton's second law, is this true? This means since gravity is acting on all objects on or near earth then, according to Newton, it will contribute to the acceleration of these objects.

Now, I need your help on this, what is the magnitude of the acceleration due to this force of gravity? **(Write this value on the board)**

Is this value constant everywhere on earth? **(Write the tally of this on the board)**

To answer these simple questions let us try to measure g in our class room and you will try to measure it at your homes.

This simple experiment first requires some background on one very special type of motion that depends primarily on gravity. This type of motion is known as the simple pendulum.

Well, can you help me in constructing such a simple pendulum? What do we need to make this simple pendulum?

Ok guys, I will leave you for few minutes so you may discuss your suggestions with your teacher and among yourselves.

Part 2: Problem Statement (5 minutes)

Hello again, so this how we can construct a simple pendulum. First of all you need four similar coins **(Show the coins),** then we make a small knot at one end of the string and insert the knot between the four coins with the knot squeezed between the coins **(Show this step).** Now go ahead and tightly tape the coins together around knot **(Show this step).** Using the measuring tape, measure a length of 1.5-m from the center point of the coins to the other end of the string. Now, tie the other end of the string to the nail and check that the distance from the center of the coins to the nail is 1.5-m (call this distance L) **(Show this step and use the board to sketch a diagram).** The last step in the construction of our simple pendulum is to fix the nail to a door frame or at any high point, but we need to keep in mind that the coins are free to oscillate.

Ok, now we can start our search for the g-value in our school and our homes using this simple device. So, the question that we need to answer here is what is the magnitude of g in my school (or at my home)?

To answer this question I want you to help me in counting and timing the oscillations of our simple pendulum. For your help to be efficient, first you need to help me to define what do we mean by one full oscillation? **(Show this concept on the diagram)**

Here we will also define the time of one full oscillation and we will give it a special name. We will call this time the period of the oscillation and we well assign it the symbol T.

Now we need to start to prepare a live demonstration for this experiment.

Part 3 Demonstration of the Measurement (19 minutes Total)

a) Pendulum Construction (6 minutes)

Hello again. Now, since we have all the stuff we need to construct our pendulum and we know how to count oscillation, then we can start our experiment to find the g-value.

First, we need to make four small groups. Now, each group will construct their own simple pendulum. I will be back soon.

(Let each group construct a pendulum with different length, during this time the teacher will draw the table shown below)

b) Performing the experiment (8 minutes)

Ok everybody, now to minimize the errors in our experiment we will first start with the pendulum of L = 1.5 m and we will count the time for fifteen full oscillations. So as you can

see will measure the time for 15 periods and, in order to get the time for one period, we will divide the reading we get on our stop watch by 15.

One more thing that you have to keep in mind, the angle that the string makes with the normal should not exceed 15 degrees (Shall be small). This is important since the equation we will use to find g is for the case of small angles only.

(Start an oscillation and let the students count 15 oscillations while timing this motion. Compare the times measured by you and your students and average the time measurement.)

Now use the pendulum of L = 1.3-m and repeat the previous step.

Again, use the pendulum of L = 1.1-m and repeat previous step.

Again, use the pendulum of L = 0.9-m and repeat previous step.

Again, use the pendulum of L = 0.8-m and repeat previous step.

One the board, register the experiment results in the table:

L (in Meters)	Time (in seconds) for 15 Osc.	Average time (in seconds) for 15 Osc. (t)	T (period) (in seconds) = t / 15	g (in m/s^2) from the equation below
1.5	Teacher and students values.			
1.3				
1.1				
0.9				
0.7				

c) Finding the g-value (5 minutes)

From the numbers above, we can use the following equation that relates g, L, and T.

$T = 2\pi * \sqrt{L/g}$

This means that

$g = (4\pi^2 L)/ T^2 = 39.48\ L / T^2$

Now, you can calculate the magnitude of g.

(Let each group calculate its g-value, but first do the L=1.5-m as an example)

Ok guys, now, when you go home today, try to measure g in your homes and next time we will have more g calculations.

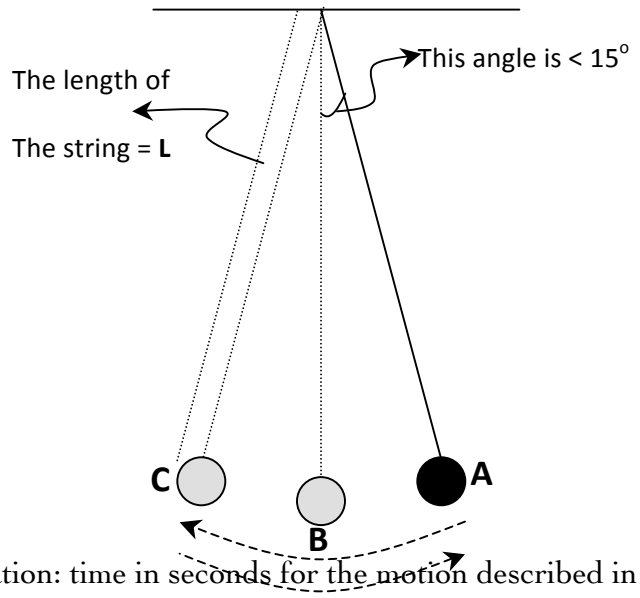
With my values here and your values from your homes we can calculate the average value of g in our city. Isn't that cool.

Soon we will also provide you with other cities g-value so may construct a map of the g values in our country, and then we will clearly see if g is constant everywhere in our country. We may also come to a point where we can see how g varies from country to country as soon as we get similar maps from other countries.

Have fun and try to enjoy physics.

The necessary definition and sketches on the board:

1) Full oscillation: on the graph below, the coins start at A go to C through equilibrium position B and then back to A.



2) Period of oscillation: time in seconds for the motion described in 1 above.

Time to go from A to C through B then back to A.