# The Simple Pendulum

# Student sample 3

# City College of New York

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# Abstract

# The objective of this lab is to determine the acceleration due to gravity through the use of a simple pendulum. The main components of this lab include a spherical pendulum bob and string. The bob will be held up using the string that is connected to a supporting rod and pendulum clamp. Each trial will consist of displacing the sphere to about 15 degrees about the negative Y-axis and then letting the pendulum vibrate back and forth for 25 seconds. Also, the length of the string will vary for each trial increasing by 15. After recording and calculating all the times and measurements, we were able to obtain a really accurate experimental value for gravity. Gravity has a calculated value of 9.81 m/s2. We were able to calculate gravity with using only the length of the string and the period of oscillation.



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# Introduction

 This experiment is based on the fundamentals of simple harmonic motion. “Simple harmonic motion is the physics of movement back and forth through an equilibrium or central position so that the maximum displacement on one side of this position is equal to the maximum displacement on the other side.” (The Editors of Encyclopedia Britannica, 2017) Through the use of the simple pendulum, we can prove that gravity has an effect on all things on Earth.

Gravity is what will bring the hanging pendulum back to equilibrium/ central position. We can break up the motion of the pendulum into its X and Y components that correspond to gravity. We get these components using Newton’s second law of motion F=ma. In this case, “a”, (acceleration) will be changed into “g” (the gravity constant) because the acceleration in this experiment is due to gravity. Because the pendulum will be displaced about the negative Y-axis to about 15 degrees, Mg is used as the weight of the pendulum and cosine and sine will be used to account for the angle of displacement. We will soon come to realize that the weight of the pendulum will be negligible because this system only depends on the length of the string and the oscillations of the pendulum. The components of the pendulum are mainly used to describe the weight of the pendulum and the tension in the string.

The importance of the length of the string is due to the fact that the length of the string effects the periods of oscillation or the simple harmonic motion. The square root of the length of the string is directly proportional to the period of the pendulum. In this experiment, the equation we will be using to solve for the value of gravity will be $T^{2}=\frac{4π^{2}}{g}L$. The period is equal to T, L is the length of the pendulum, and g is the calculated gravity.

 In this experiment, we will be using the same angle of displacement and also the same time given for oscillations for each trial. Our independent variable in our experiment was the length of the string. This experiment was used to prove the effect of gravity on the pendulum.

**Materials**

* String
* Spherical pendulum bob
* Supporting rod
* Pendulum clamp
* Vernier caliper
* Stop-watch
* Meter stick
* Lab stand

**Procedure**

Set up the supporting rod and the pendulum clamp so that the pendulum bob can hang from the clamp. Using the meter stick, measure the string of lengths 20cm, 35cm, 50cm and 65cm. For trial 1, clamp the string to the pendulum clamp using the 20cm string and attach the other end of the string to the pendulum bob. Measure the diameter of the pendulum bob using the Vernier Caliper and calculate the length of the string and the radius of the bob using the formula L=1-r. Displace the bob about 15 degrees from its center resting point and let the pendulum swing back and forth. Using your stop-watch, record the time it takes the pendulum to make 25 vibrations. Repeat this step for the different lengths of the strings. Once you have recorded all your times for the 25 vibrations, calculate the period T. To calculate T, divide the total time by the number of oscillations. Once you have calculated T for all trials, you can now calculate g by using the formula $g=\frac{4π^{2}L}{T^{2}}$. Take the average of the experimental values for g from the 4 trials.

**Results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Length of string  | Number of Vibrations  |  Total time (t)  |  Period (T)  |  Value of g  |
| + Radius of bob (L)  |  (s) |   |  (m/s2) |
| 20cm | 25 | 22.2 | 0.89 | 9.96 |
| 35cm | 25 | 30.1 | 1.12 | 11.01 |
| 50cm | 25 | 35.2 | 1.38 | 10.36 |
| 65cm | 25 | 39.7 | 1.62 | 9.77 |

Average Experimental Value of g = 10.275 m/s2

Accepted Value of g = 9.81m/s2

Percent error = $\frac{calculated value-accepted value }{accepted value }\*100=\frac{10.275-9.81}{9.81}\*100=4.7\% $

The purpose of this experiment was to calculate a value of gravity using a simple pendulum. I was able to obtain a value of 10.275m/s2 with a percent error of 4.7%. I used the length of the pendulum and the period of oscillation to calculate a value for gravity.

**Discussion**

 The main focus of this experiment was to see how gravity affects everything around us. Gravity is a constant force that holds everything down and is what brought the pendulum to equilibrium every time. Through this experiment, I found out that the main aspect of this experiment was the length of the string. Everything in the lab remained constant and our independent variable was the length of the string. If the length of the string were increased, the period of oscillation would increase as well. If this experiment were done on the moon, where gravity is 1 sixth of the gravity of earth, the period of oscillation would increase drastically.

The length of the string and the angle of displacement do not have an effect on gravity because gravity is constant. The mass of the pendulum bob was neglected because if you recall from Galileo’s experiment of dropping two cannon balls of different weights, their masses were affected at the same rate due to the constant force of gravity. Because gravity acts like a magnet pulling towards the center of the Earth, the pendulum will hang at a 90-degree angle until another force is applied. In our case, the force applied was the displacement of the bob and the force of gravity bringing the bob back to equilibrium. “Other forces act in opposition to the force of the moving pendulum. These forces are air resistance (friction in the air), atmospheric pressure (an atmosphere at sea level, which lessens at higher altitudes) and friction at the point where the top of the wire is connected.” (Reinbold, 2017)

Some possible errors of this lab could have been the movement of the lab stand as the pendulum swung back and forth. This could have caused an error in the period of oscillation. If the period of oscillation were altered, our value of g would not have been constant throughout the lab.

 As engineers, this lab consisted of a simple concept that was easily calculated using a pendulum. Anyone who performs this lab will practice their skills on measurements and the use of scientific tools, such as the Vernier Caliper and a meter stick. When I performed this lab, I needed to be consistent in my timing and my measurements of the string and the spherical pendulum bob.

**Conclusion**

This experiment helps us understand the concept of gravity. On Earth, gravity is constant throughout a given region. Gravity acts as a magnet pulling everything towards the center of the Earth. In this experiment, we were able to calculate an experimental value of gravity using a simple pendulum. We calculated a value for gravity using different lengths of a string and the period of oscillation. Our calculated value of g was 10.275m/s2 with a percent error of 4.7%.

References

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### Audience Profile Sheet

|  |  |
| --- | --- |
| Reader's Name:  |  |
| High school physics students  |
| Reader's Job Title: |  |
| physics student  |
| Kind of Reader: | Primary\_\_\_x\_ Secondary\_\_\_\_\_\_ |
| Student should be enrolled in a physics class of some sort  |
| Reader’s Level of Education: |  |
| High school  |
| Reader’s Professional Experience: |  |
| High school  |
| Reader’s Job Responsibilities: |  |
| Perform lab  |
| Reader’s Personal Characteristics: |  |
|  |
| Reader’s Cultural Background: |  |
|  |
| Reader’s Attitude Toward the Writer (you): |  |
| none  |
| Reader’s Attitude Toward the Position you’re applying to: |  |
| none  |
| Reader’s Expectations for an employee in that position: |  |
| none  |
| Reader’s Expectations about the Résumé and Job Letter (as documents): |  |
|  |
| Reader’s Way of Reading the Document: student will perform lab in their physics lab. Students will need to follow instructions and be able to replicate the results achieved in this lab report  | Skim it \_\_\_ \_ Study it \_\_x\_\_ Read a portion of it \_\_\_ Which portion?Modify it and submit it to another reader\_\_\_\_ |
|  |
| Reader’s Reading Skill: |  |
| high school  |
| Reader's Physical Environment: |  |
| physics lab  |

Reflection

 The hardest part of this assignment was deciding what the lab report was going to be about. My group started discussing some of the labs we had done in high school and, although they were very simple labs, they taught us a lot. That became our main focus in this lab. We wanted to keep it simple but also educational. We wanted the lab to be for high school students learning physics. One of the main topics covered in physics is gravity. We wanted to use that topic as the basis of our lab. We figured out that a pendulum would perfectly fit our needs of demonstrating how gravity woks. The idea of a pendulum was perfect because it was a very simple lab and it would definitely fit in a high school lab setting.

 The audience this lab report is guided towards is high school physics students. The materials used will all be found in a high school lab. The topic of gravity is as a perfect fit because it part of their curriculum throughout the semester. Some professors perform the labs according to what they are teaching in their lecture classes. I felt this lab was simple enough to be done by high school students and also the formulas used weren’t too complex. The lab was a high school level lab overall so I felt it fit perfectly. Students performing this lab should not have an issue with the units because they can be converted to SI Units. Students should have a basic knowledge of how gravity and forces work. Also, students should have basic knowledge of algebra because they will be needed to manipulate the formulas to fit their needs.

 The purpose of this lab was to educate high school students about the topic of gravity. Gravity is something many high school students might have already learned in middle school but this lab is a good was for it to be demonstrated. I wanted to help give a visual representation of how gravity works around us. Also, the purpose of this lab was to help students practice their skills in measuring accurately and practice their consistency throughout the trials.

 The genre of this assignment was a lab report. Some of the key elements of a lab report are the materials, abstract, procedure, results, and conclusion. These elements helped shape my lab report. The lab report format is very different from other genres. The lab report is a manual for an experiment. This lab report will be able to be replicated by other students.

 The media used in this lab report was the persuading the reader to become more intrigued as the lab report went on. Starting with the abstract, the reader will already know what they will encounter throughout the lab. The introduction gave the reader a background of science of the lab. They will able to connect their knowledge learned in class with the components of the lab. Also, they will not only use their knowledge but also but it in practice. Performing a lab is much different than just learning about it. It gives the student a visual representation of what they are learning in their lectures. Each category details a different part of the lab report. The procedure was different from other lab reports I have performed. We were asked to write the procedure in paragraph form instead of numbering the steps. The picture used in the lab will help the student have an idea of how to set up their experiment. Also, the picture details the way the experiment should work.

 The exigence in this lab was to help demonstrate the effect of gravity on objects. I did not just want to talk about it like professors do in their lectures, but to have a visual representation of how gravity works. That was the main aspect I wanted to get across. Students should be able to use the formulas and understand their components in depth. Each term in the formulas used, represent something essential to understanding gravity and the simplicity will help the students learn it better. The components of the lab should help the student understand this topic more in depth. There are other ways to show how gravity works but this lab was interesting enough for students to not get bored or uninterested.

 Through this assignment, I was able to negotiate my own writing goals and audience expectations regarding conventions of genre, medium, and rhetoric situation. I figured out who the audience this lab was intended for and it helped me write this lab according to my audience analysis. As an engineering student, the labs really helped us understand the topic better. We were able to use our skills of measuring and precision when performing labs.