Physics Project
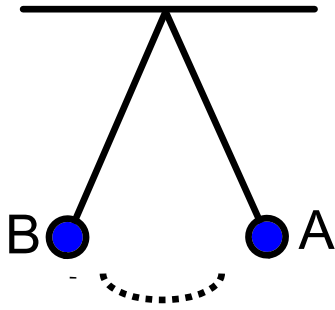
**Investigate and compare the quantitative effects of changing
(i) the pendulum length and
(ii) the mass of the pendulum bob
on the period (time of oscillation) of a simple pendulum
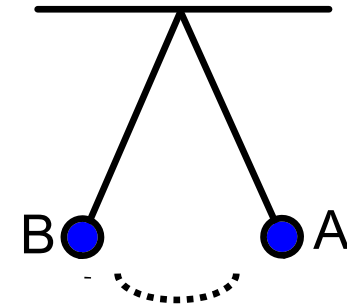oscillating through a small angle.**

B● ●A

www.mrcjcs.com

Background

A pendulum is a weight hung from a fixed point so that it can swing freely. The pendulum bob is a small mass object that is attached to the end of a near weightless thread or string.

The pendulum swings from point A to point B and back again to A. This is counted as 1 oscillation.

The **period** of the pendulum is how long it takes for one oscillation. Changing the length of the string should change the time each oscillation takes to complete.
e.g. A short string has less distance to travel and so completes the oscillation more quickly (small period).

Changing the weight of the pendulum should **not** change the oscillations per second. Gravity acts equally on the different mass bobs.

Google 'Galileo and Pendulums'

More Background

It does not matter what mass the object at the end of the string is — the time for each oscillation (the period) is still the same.

The only factor that significantly affects the swing of a pendulum on Earth is the length of its string.

This can be explained by examining possible effects of each of the three variables: the length of the string, the mass of the bob, and the angle displaced. **The length of the string affects the pendulum's period such that the longer the length of the string, the longer the pendulum's oscillation. This makes that the pendulum with the longer string completes less back and forth cycles in a given amount of time, because each cycle takes it more time.**

The mass of the bob does not affect the period of a pendulum because (as Galileo discovered and Newton explained), the mass of the bob is being accelerated toward the ground at a constant rate — the gravitational constant, g. Just as objects with different masses but similar shapes fall at the same rate (for example, a ping-pong ball and a golf ball, or a grape and a large ball bearing), **the pendulum is pulled downward at the same rate no matter how much the bob weighs.**

Finally, **the angle that the pendulum swings through** (a big swing or a small swing) **does not affect the period of the pendulum** because pendulums swinging through a larger angle accelerate more than pendulums swinging through a small angle. This is because of the way objects fall; when something is falling, it keeps accelerating.

A pendulum swinging through a large angle is being pulled down by gravity for a longer part of its swing than a pendulum swinging through a small angle, so it speeds up more, covering the larger distance of its big swing in the same amount of time as the pendulum swinging through a small angle covers its shorter distance traveled. **https://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/ cub_mechanics/cub_mechanics_lesson09.xml**

<u>Part 1 (Introduction)</u>

(i) Statement or problem to be investigated - What you are going to do **in your own words**

(ii) Background research undertaken - You will have to look up a few websites and books to find information for your investigation. You may even have to ask your teacher or someone at home for information. This is your background research you will need to give **at least 2 pieces** of background research and make sure for these that you mention where you got the piece of information and what you used it for.
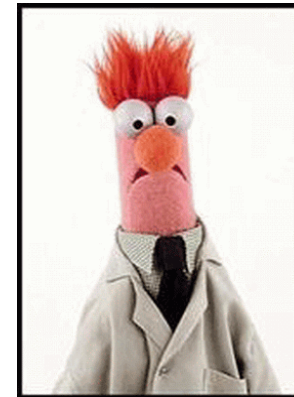
e.g. https://www.youtube.com/watch?v=70onM2HPrzc

**Internet
(Give full link!)**
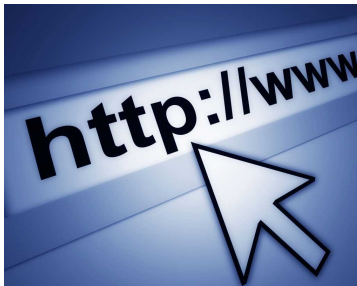
**Books
(Author and Publisher
Page and Details)**

Teacher

Part 2 (Preparation and Planning)

(i) Variables
1. **Independent** Variables
   What I will change? String length and pendulum bob mass.

2. **Dependent** Variable
   What I measure? How long a full swing (Oscillation) takes.
    This is known as the period.

3. **Controls**
   What I will keep the same?
   - **The string/thread type.**
   - **The number of oscillations we count.**

Bob

(ii) Equipment: List every piece of equipment you use.
e.g. Playdough or Blu-Tack, Electronic balance, string or thread, ruler, scissors, retort stand and clamp, stopwatch, calculator, pen and paper.

(iii) Tasks *This is the summary of the steps needed (to-do list)*

e.g.

- We will place a ball of Blu-tack on string suspended from a retort stand.
- We will let it swing from a roughly 45° angle and count 20 full swings (oscillations) and measure how long it takes.
- We will repeat this with 3 balls of different mass and 3 different length strings and record the results for each.
- We will then calculate the averages and the time taken for 1 oscillation (period).
- Finally we will analyse our results and write conclusions based on our results.

Part 3 (Procedures, apparatus etc.)

**(i) Safety** **-** Don't eat the Play Dough! Wash your hands after the experiment.

(ii + iii) Procedure with diagram **- Write it like a recipe.**

1. Weigh out 3 balls of Playdough or Blutack.
   Make the balls 5g, 10g and 15g (example) using the balance.
2. Next cut 3 lengths of string. Attach the string to the retort stand
   and then use a ruler to measure the length required.
   We used 10cm, 20cm and 30cm of string (example).
3. **Using the 10cm** of string attach the smallest (**5g**) ball to the string
   and raise it to 45°. Let it go and count **20 oscillations** for as long as
   it takes. Measure on a stopwatch and note the time taken in seconds.
4. Divide the time taken by 20 to find the time for 1 oscillation.
   Repeat 3 times and calculate an average for the 5g ball.
5. Next use the **10g** ball and repeat this 3 times also.
   Finally use the **15g** ball and find an average of 3 trials also.

(ii + iii) Procedure with diagram - continued

6. **Using the 20cm** of string attach the smallest (**5g**) ball to the string and raise it to 45°. Let it go and count **20 oscillations** for as long as it takes. Measure on a stopwatch and note the time taken in seconds.

7. Divide the time by 20 to find the time taken for 1 oscillation. Repeat 3 times and calculate an average for the 5g ball.

8. Next use the **10g** ball and repeat this 3 times also. Finally use the **15g** ball and find an average of 3 trials also.

9. **Using the 10cm** of string attach the smallest (**5g**) ball to the string and raise it to 45°. Let it go and count **20 oscillations** for as long as it takes. Measure on a stopwatch and note the time taken in seconds.

10. Divide the time by 20 to find the time taken for 1 oscillation. Repeat 3 times and calculate an average for the 5g ball.

5. Next use the **10g** ball and repeat this 3 times also. Finally use the **15g** ball and find an average of 3 trials also.

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A to B to A = 1 Oscillation
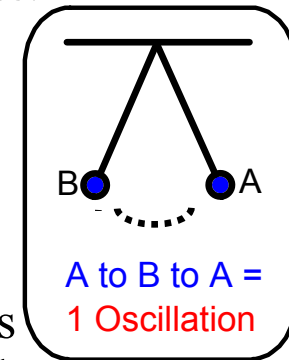
(iv) Data and observations –

Record all the results from each experiment in a table like below.
Make a data table **before** you start your experiment so you can record your measurements as soon as you observe them.

Make sure to give your tables and graphs a name or number.
e.g. 20 oscillations took 14 seconds = 14/20 = 0.70 seconds for each oscillation.

Table No. 1 - 10cm string

	Trial 1	Trial 2	Trial 3	Average Sec/Osc (Period)
5g bob	14/20	14/20	14/20	0.70
10g bob	14/20	14/20	14/20	0.70
15g bob	14/20	14/20	14/20	0.70

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A to B to A =
1 Oscillation
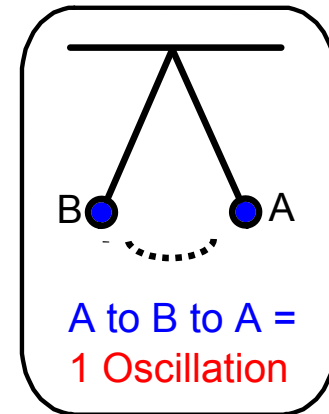
Table No. 2 - 20cm string

	Trial 1	Trial 2	Trial 3	Average Sec/Osc (Period)
5g bob	18.5/20	18.5/20	18.5/20	0.93
10g bob	18.5/20	18.5/20	18.5/20	0.93
15g bob	18.5/20	18.5/20	18.5/20	0.93

Table No. 3 - 30cm string

	Trial 1	Trial 2	Trial 3	Average Sec/Osc (Period)
5g bob	23/20	23/20	23/20	1.15
10g bob	23/20	23/20	23/20	1.15
15g bob	23/20	23/20	23/20	1.15

Graph No. 1 - Period vs Bob Mass

Legend:
- = 10cm (green)
- = 20cm (blue)
- = 30cm (red)

Period in seconds (s)

Y-axis: 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8

X-axis: 5g, 10g, 15g

Mass of bob (grams)

This shows how the mass of the bob does not affect the period (time taken) for per oscillation.
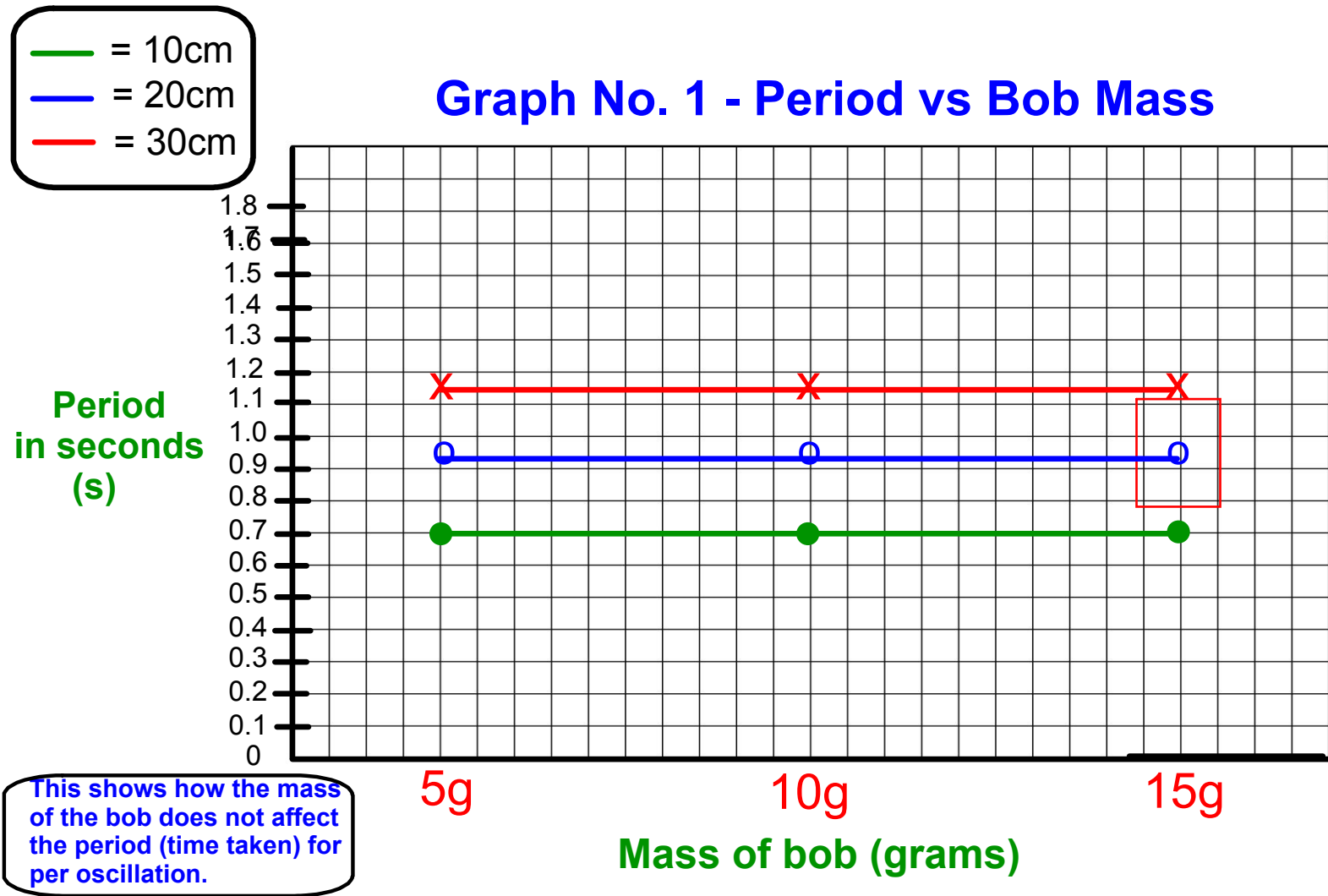
As the mass does not affect the oscillation period, we have just drawn one line to represent the mass.

Graph No. 2 - Period vs String Length

Period of Oscillation in seconds (s)

1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

10cm   20cm   30cm
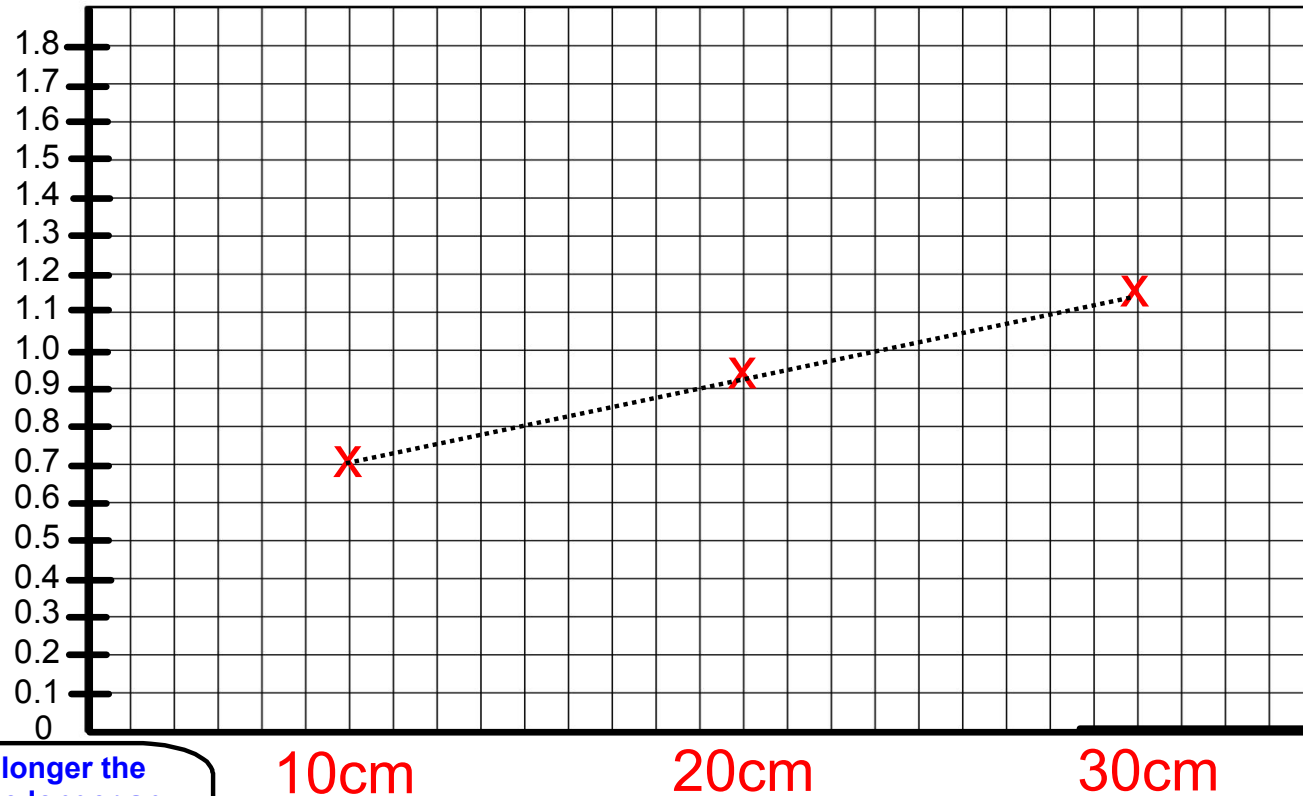
String Length - cm

This shows the longer the string length, the longer an oscillation takes. The bob has further to travel in one oscillation.

Results

Now, analyze your data, and see if the mass of the ball and/or the string length affects the time taken per oscillation (period) of the pendulum.
Basically, describe your results in words.

Mass of Ball
In Table 1 we can see that the time taken per oscillation is the same for each ball, (0.70 seconds to complete an oscillation for the 3 different mass balls).
This pattern is repeated in Table 2 (0.93 sec/osc) and Table 3 (1.15 sec/osc) where the mass **doesn't** affect the period (time taken for each oscillation).
See also Graph number 1 - Period vs Bob mass.

Length of String
Changing the length of the string **does** change the time for an oscillation.
In table 1, at string length of 10cm, we see the average is 0.70 oscillations/sec.
At 20cm it is 0.93 oscillations/sec and at 30cm it is 1.15 oscillations/sec.
See also Graph number 2 - Period vs String Length.

Part 4 (Analysis)

(i) Calculations and Data Analysis -
Make sure you outline any calculations (e.g. finding averages)
We recorded how long 20 oscillations took in seconds and then divided our answer by 20 to get the time for each individual oscillation - Tables 1, 2 and 3.
To find the average for each ball at each string length we did 3 trials and found the average.

(ii) Conclusion and Evaluation of result
Some useful sentence starters in this section are:
· I can see from my results that …………………………..
· When I changed ………………….., ………………….. changed by…………………..
· From the graph I can see that ……………………………………………….

Answer some of the following questions in your written report.
· Do your results answer the question you were asking at the start?
· Were the results as you expected?
· Is there a trend in your results or did anything unusual happen?
· If you got an unusual result why do you think this happened?

Conclusions

Mass of Ball

I expected the heavy ball to swing more quickly, but in Table 1 we can see that the time for each oscillation (period) is the same for each ball. This pattern is repeated in Table 2, 3 and Graph 1. This shows that the mass of the ball doesn't affect the time taken for each oscillation.

I think this happens because gravity affects the 3 balls in the same way.

Each ball is pulled down at the same rate no matter what the mass is.

Length of String

Changing the length of the string **does** change the time for an oscillation.

In Table 1, at string length of 10cm, we see the average is 0.70 oscillations/sec.

This increases to 0.93 osc/sec at 20cm and increased again to 1.15 osc/sec at 30cm.

This shows that as the string gets longer so does the distance the bob has to travel to return to the start. This takes a longer time and increases the period.

Graph 2 shows that the period vs string length creates a straight line graph.

Perhaps they are inversely proportional.

Overall - I was expecting the string length to affect the time for each oscillation the way it did but I was surprised that the mass of the ball didn't seem to matter.

Part 5 (Comments)

(i) Refinements, extensions and sources of error

Were you expecting these results?

Possible errors?

Was there anything that might have affected your results?
 Maybe the string could have moved more freely?
 Maybe using a very thin thread would give less friction and weight?
The pendulum moved in a circle during oscillation.
 Measuring less or more oscillations?

Could you develop your experiment further, how?
 Try different threads/strings and perhaps more varied lengths of string to investigate if the linear pattern in the graph continues.

Many thanks to Maura Byrne for spotting errors in the original version of this sample project.