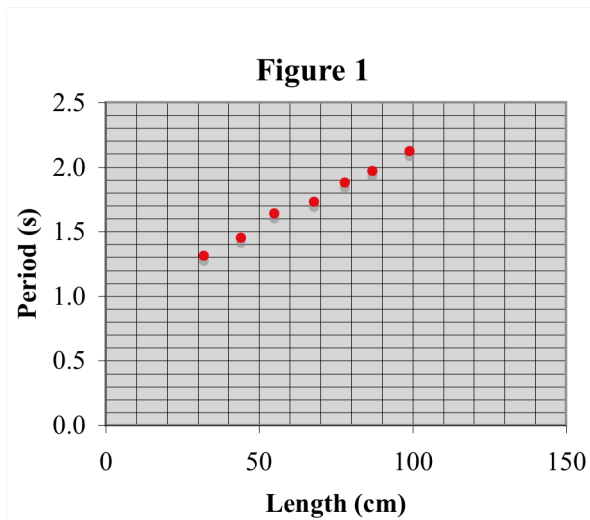


The Period of a Pendulum

A **simple pendulum** consists of a light string tied at one end to a pivot point and attached to a mass at the other end. The **period** of a pendulum is the time it takes the pendulum to make one full back-and-forth swing. A group of students are investigating the factors that might affect the period of a pendulum. They conduct three different controlled experiments.

Experiment 1

In the first experiment, the students make a pendulum by hanging a 200.0-gram mass on the end of a string. They pull the mass back such that it makes an angle of 30° with its usual vertical orientation. They then release the mass, allowing it to swing back and forth. They use a stopwatch to measure the time it takes the pendulum to complete five full swings. They use this time to determine the period. They vary the length of the string while keeping the mass and angle constant. A plot of their data is shown in **Figure 1**.

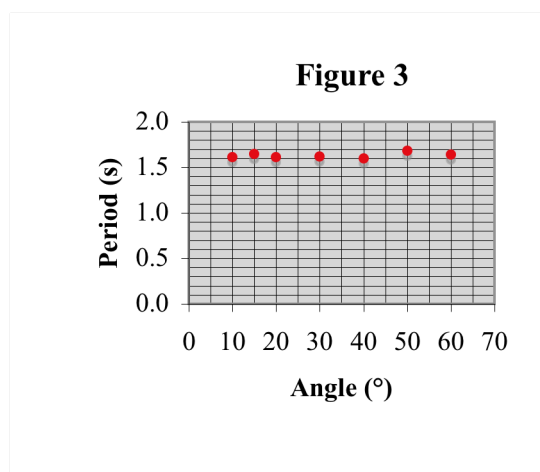
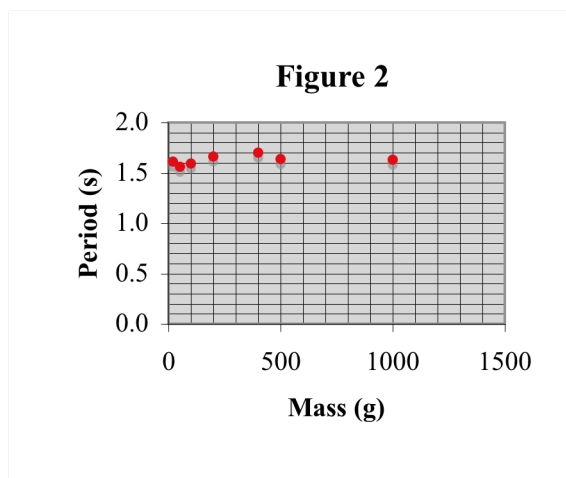


Experiment 2

The students make a pendulum by hanging masses on the end of a string to create a pendulum length of 65 cm. They release the mass from rest after pulling it back 30° from its vertical orientation. They conduct several trials using varying amounts of mass hanging on the end of the string. A plot of their data is shown in **Figure 2**.

Experiment 3

The students make a pendulum by hanging a 200.0-gram mass on the end of a string to create a pendulum length of 67 cm. They conduct several trials while varying the angle that the string makes with the vertical orientation. A plot of their data is shown in **Figure 3**.



Questions:

1. Which statement describes the purpose of this collection of three experiments?
 - a. To vary several properties of a pendulum.
 - b. To use a pendulum in order to determine its period.
 - c. To investigate the effect of mass, angle and length upon a pendulum's period.
 - d. To measure the time for five complete swings so as to calculate a pendulum's period.
2. Based on the three experiments, what conclusion can be made about the factors that affect the period of a pendulum?
 - a. The mass and angle are the only factors that affect the period of a pendulum.
 - b. The mass, the angle and the length are the three variables affecting the period.
 - c. Given the many variables, it is impossible to tell which one(s) affect the period.
 - d. Mass and angle have little effect; the length is the main factor affecting the period.
3. Why did the students measure the time for five complete swings?
 - a. The period is the time it takes to make five complete swings.
 - b. The experiment doesn't take much time and they didn't want to be idle.
 - c. Since each experiment included five trials, they needed to be consistent by timing five complete swings.
 - d. Calculating the period from the time for five swings reduces error by providing an average of five periods.
4. What was the control variable(s) in **Experiment 1**?

a. Length	b. Period
c. Length and period	d. Mass and angle
5. Which statement describes the effect of increasing length upon the period of a pendulum?
 - a. An increase in the length has no effect upon the period of a pendulum.
 - b. An increase in the length causes the period of a pendulum to increase.
 - c. An increase in the length causes the period of a pendulum to decrease.
 - d. As length increases, the period of a pendulum first increases and later decreases.
6. Use **Figure 1** to estimate the period of a pendulum with a length of 90 cm and a mass of 200.0 grams that is released from an angle of 30° .

a. 1.88 seconds	b. 2.00 seconds
c. 2.14 seconds	d. 2.90 seconds
7. A 130-cm length pendulum consisting of a 200.0-gram mass is released from an angle of 30° . Assume the relationship between length and period shown in **Figure 1** can be extrapolated beyond a length of 100 cm. What is a reasonable estimate of this pendulum's period?

a. 2.12 seconds	b. 2.55 seconds
c. 3.30 seconds	d. 3.40 seconds

8. What was the independent variable(s) in **Experiment 2**?
- Mass
 - Period
 - Mass and period
 - Length and angle
9. What would be the most appropriate conclusion statement for **Experiment 2**?
- A pendulum can be used to determine if mass affects the period.
 - By systematically varying the mass, one can determine if its affects the period.
 - Large variations in mass have little to no effect upon the period of the pendulum.
 - If the period of a pendulum is changed, there will be no resulting change in its mass.
10. Use **Figure 2** to estimate the period of a pendulum with a length of 65 cm and a mass of 400.0 grams that is released from an angle of 30° .
- 0.81 seconds
 - 1.30 seconds
 - 1.63 seconds
 - Nonsense! It is impossible to make such an estimate since no pattern exists.
11. What was the dependent variable(s) in **Experiment 3**?
- Angle
 - Period
 - Angle and period
 - Length and mass
12. A pendulum consists of a 100-gram mass suspended on a string to make a 50.0-cm length pendulum. The pendulum is released from an angle of 20° . Why is it or is it not possible to use the data provided in these experiments to estimate the period of such a pendulum?
- A trial was not performed with these three parameters; so it is not possible to estimate the period.
 - There is no clear pattern as to how the period depends upon the mass and the angle; and so the period cannot be determined.
 - Length is the only variable that has any appreciable effect upon the period; so the 50.0 cm length can be used to determine the period from **Figure 1**.
 - Separate graphs are provided for each of the three values; so each value can be used to determine three separate periods and then the average value can be calculated.
13. Consider the following values for mass, length and release angle for a simple pendulum. Which pendulum would have the largest period?
- mass = 200 grams; length = 100 cm; release angle = 20°
 - mass = 500 grams; length = 50 cm; release angle = 50°
 - mass = 1000 grams; length = 80 cm; release angle = 50°
 - mass = 1000 grams; length = 80 cm; release angle = 20°