

Physics Workshop

Teacher's Notes

Pendulum: Factors Affecting Frequency

Main Topic	Motion
Subtopic	Periodic Motion
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Test the length, mass, and amplitude of a pendulum to see which variables affect the frequency.

Required Equipment	Workshop Stand, Pendulum, Bolt, String, Pinch Clamp, Meterstick, Stopwatch, Balance (triple-beam or electronic).
Optional Equipment	

Educational Objectives

- Determine which variable affects the frequency of a simple pendulum.

Concept Overview

A pendulum can be described in terms of its mass, length, and amplitude. In this experiment, mass refers to the mass of the pendulum bob (the cylinder hung at the end of the string.) Length is the length from the top of the string to the center of the bob. Amplitude is the amount the pendulum swings away from equilibrium, measured in degrees. Each pendulum has a characteristic period (the amount of time for one cycle, back and forth) and frequency (the number of cycles in a certain time).

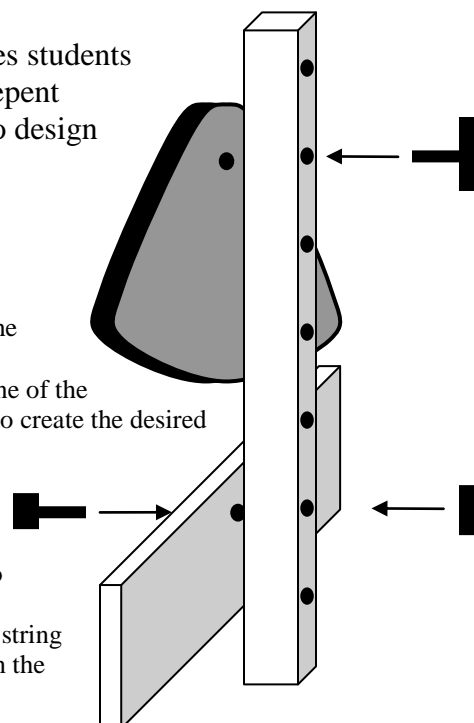
Students will separately test three variables; length, mass, and amplitude; to see which affects the frequency of a simple pendulum. They will find that only changing the pendulum length can change the frequency. (The strength of gravity also affects the pendulum's period. If students had a way to vary the acceleration due to gravity, they would find that it has an affect as well.)

Lab Tips

There are two versions of this lab. The first guides students through each step, identifying dependent and independent variables for them. The second allows students to design their own experiment.

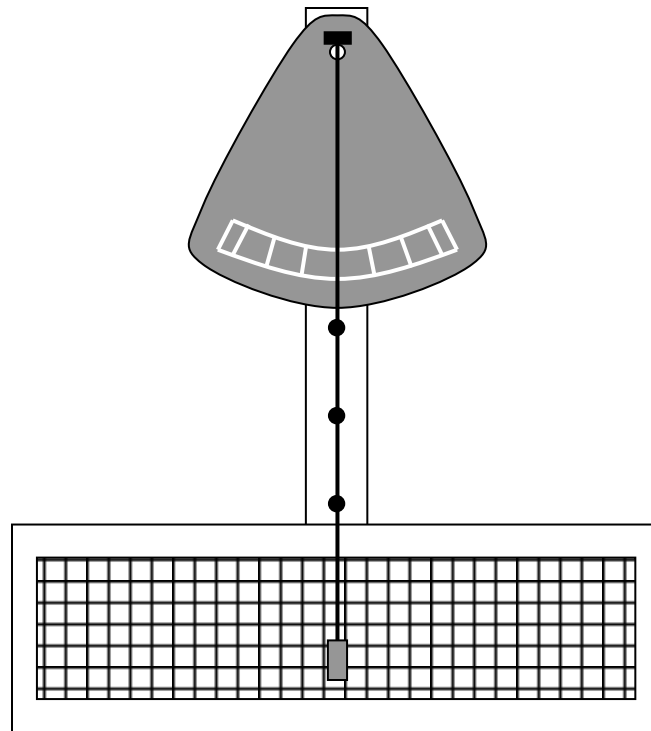
Assembly:

1. Push the attachment bolt through the top hole of the Workshop Stand.
2. Screw the bolt into the back of the Pendulum, so that the printed side faces out.
3. Use the pinch clamp to support the string, and attach one of the cylindrical bobs to the string. Adjust the pinch clamp to create the desired pendulum length.
4. Grid Board (for selected experiments): Push the attachment bolt through the Grid Board, then through the stand, at a height that accommodates the entire swing of the pendulum. Screw the nut onto the back to fasten.
5. Align the Pendulum Face and Grid Board by using the string as a plumb bob. Face the stand, close one eye, and turn the



Pendulum: Factors Affecting Frequency

pieces as needed so that the vertical lines are aligned with the string. Adjust the stand leveling screws if necessary.



Pendulum:

Name: _____

Factors Affecting Frequency

Class: _____

Pendulum: Factors Affecting Frequency

Objective: To determine which variables affect the frequency of a pendulum.

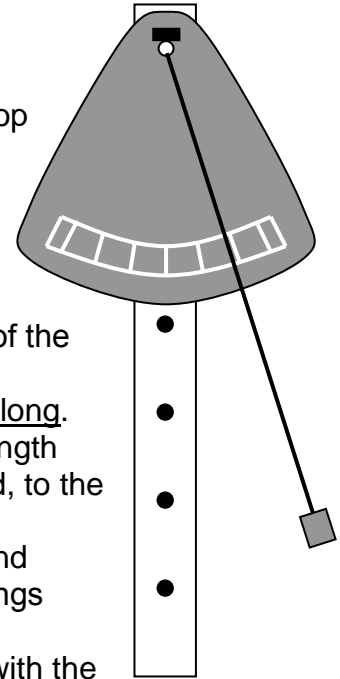
Materials: Workshop Stand, Pendulum, Bolt, String, Pinch Clamp, Meterstick, Stopwatch, Balance (triple-beam or electronic).

Background:

A pendulum can be described in terms of its mass, length, and amplitude. In this experiment, mass refers to the mass of the pendulum bob (the cylinder hung at the end of the string.) Length is the length from the top of the string to the center of the bob. Amplitude is the amount the pendulum swings away from equilibrium, measured in degrees. Each pendulum has a characteristic period (the amount of time for one cycle, back and forth) and frequency (the number of cycles in a certain time).

Procedure:

1. Use the bolt to attach the Pendulum plate to the Workshop Stand at the highest point.
2. Measure and record the mass of the aluminum cylinder.
_____ Transfer this mass into the "Mass" column of the table below, in the lines marked "Al."
3. Measure and record the mass of the steel cylinder.
_____ Transfer this mass into the "Mass" column of the table below, in the line marked "St."
4. Use the Pinch Clamp to create a pendulum that is 60cm long. Hang the aluminum cylinder at the end. (Measure the length from the bottom of the support, where the string will bend, to the bottom of the hanging cylinder.)
5. Stand directly in front of the Pendulum, close one eye, and make sure the "0" mark is aligned with the string as it hangs straight down. Turn the Pendulum plate as necessary.
6. Hold the aluminum bob out so that the string is lines up with the line marked 20. (20° away from the center.)
7. Release the bob and simultaneously start a stopwatch.
8. Count the number of complete cycles (over and back) the pendulum completes in 30 seconds. How many cycles did the pendulum complete in 30 seconds? _____
9. To find the frequency, divide the number of cycles by the number of seconds (30). What is the frequency of this pendulum? _____cycles/second.
10. To find the period of the pendulum, divide the number of seconds by the number of cycles. What is the period of this pendulum? _____seconds/cycle.



Pendulum:

Name: _____

Factors Affecting Frequency

Class: _____

11. Transfer the results from #8 and #9 to the table on the next page, in the rows that list the Aluminum mass, 60cm length, and 20° amplitude. This arrangement will be the control for three different experiments, in which you will vary the pendulum's mass, length, and amplitude. (Notice that, in each experiment, only the variable being tested is changed. Everything else is kept constant.)

12. Predict what will happen in each of the following tests:

- When the mass increases, the frequency will (increase/decrease).
- When the length increases, the frequency will (increase/decrease).
- When the amplitude increases, the frequency will (increase/decrease).

13. Complete the data table, using the stated quantities in each trial.

	Mass	Length	Amplitude	Cycles in 30 seconds	Frequency (cycles/sec)
Mass	Al:	60cm	20°		
	St:	60cm	20°		
Length	Al:	60cm	20°		
	Al:	80cm	20°		
	Al:	40cm	20°		
Amplitude	Al:	60cm	20°		
	Al:	60cm	10°		
	Al:	60cm	30°		

14. Does changing the mass change the frequency? _____

15. Does changing the length change the frequency? _____

16. Does changing the amplitude change the frequency? _____

Questions:

- If a clock that uses a pendulum to keep time runs too fast, what should you change? Explain.

Pendulum:

Name: _____

Factors Affecting Frequency

Class: _____

Pendulum: Factors Affecting Frequency (Experiment Design)

Objective: To determine which variables affect the frequency of a pendulum.

Materials: Workshop Stand, Pendulum, Bolt, String, Pinch Clamp, Meterstick, Stopwatch, Balance (triple-beam or electronic).

Background:

A pendulum can be described in terms of its mass, length, and amplitude. In this experiment, mass refers to the mass of the pendulum bob (the cylinder hung at the end of the string.) Length is the length from the top of the string to the bottom of the bob. Amplitude is the amount the pendulum swings away from equilibrium, measured in degrees. Each pendulum has a characteristic period (the amount of time for one cycle, back and forth) and frequency (the number of cycles in a certain time).

Procedure:

1. Use the bolt to attach the Pendulum plate to the Workshop Stand at the highest point.
2. Use the Pinch Clamp to create a pendulum. Hang the aluminum cylinder at the end. (Measure the length from the bottom of the support, where the string will bend, to the bottom of the hanging cylinder.)
3. Stand directly in front of the Pendulum, close one eye, and make sure the "0" mark is aligned with the string as it hangs straight down. Turn the Pendulum plate as necessary.
4. Before you experiment, make predictions regarding the effects of length, mass, and amplitude on the pendulum's frequency.
 - a. As the pendulum's length increases, its frequency will _____.
 - b. As the pendulum bob's mass increases, its frequency will _____.
 - c. As the pendulum's amplitude increases, its frequency will _____.
5. Design an experiment to determine the effect of length, mass, and amplitude on the frequency of the pendulum. Be sure to identify the constants and variables in each part of your experiment. Use the data table on the following page, or create your own data table to attach.

