**PENDULUMS- LENGTH AND FREQUENCY**

 ** **

**Vocabulary:**

**1. Pendulum-** A weight hung from a fixed point so that it can swing freely backward and

Forward

**2. Period-** One swing back and forth of a pendulum

**2. Frequency-** The number of back and forth swings in a fixed time span, such as one minute

**Background:** Galileo is often credited with having discovered the principles of the

 pendulum when he observed the swinging chandeliers in Pisa cathedral. Some

 uses of pendulums are in grandfather clocks to regulate the movement of the

 escape wheel and in metronomes to count the beats in playing music. Further,

 they are used in seismometers, which measure seismic activity caused by

 earthquakes and other movements of the Earth. Pendulums are also used in

 other scientific instruments.

 Some different factors that could affect the frequency of a pendulum might

 include: thickness of the string, size of the washer, mass of the washer, material

 of which a string is composed, or length of the string. Can you think of others?

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**Materials:**

Ball of string or yarn

Scissors

Large washer for each student

Stopwatch or clock with seconds

Masking tape

Centimeter ruler and meter stick

**Objective:** To determine the relationship between length and frequency for a pendulum.

**Hypothesis:**  Do you think there will be a relationship between length and frequency? \_\_\_\_\_\_\_

 If you think this is the case, do you predict that a pendulum with a longer string

 will have a shorter or higher frequency? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 If you do NOT think this is the case, how could you test your hypothesis as to

 what might affect the frequency of a pendulum? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Procedure:**

1. Take a piece of string or yarn between 5 cm and 110 cm in length. Each student should have a string of a different length.
2. Tie a washer to one end of the string. Tie a knot close to the other end.
3. Hold the knot and make sure that the washer is free to swing. The string and washer make a pendulum.
4. Have someone be the timekeeper and call out the beginning and end of one minute.
5. Each person should silently count the number of complete back-and-forth swings (periods) his or her pendulum makes in one minute. This is the frequency.
6. Measure and record the frequency of your pendulum three times. Find the average frequency.
7. Using a chart on board or computer, each student should add their average frequency to the correct length.
8. Next, a graph should be made of the class data. The x-axis (independent variable) will show the length of the string. Units can be in units of 5 or 10, or what best fits on the graph available; (units are in cm). The y-axis (dependent variable) will show the frequencies. Units can be in units of 5 or 10 (swings per minute), or what best fits on the graph.
9. If time permits, an additional activity can be done that will place the pendulums on the board based on frequencies. Each student should mark the frequency and of his or her pendulum on a piece of masking tape placed below the knot on the string.
10. A horizontal line should be drawn near the top of the chalkboard and numbered with units of 5 starting at 0 and ending above highest student frequency. Label the line Frequency (swings per minute).
11. Using masking tape, each person should stick his or her pendulum to the chalkboard so the knot is on the line at the proper frequency. Notice the pattern.

**Source:** Unknown, modified from a pre- 1973 Junior High Physical Science textbook.

**Student Data Sheet**

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_\_\_

A. Length of your pendulum = \_\_\_\_\_\_\_ cm

B. Complete this chart for your three trials and find the average frequency:

|  |  |
| --- | --- |
| Trial | Frequency (swings per minute) |
| 1 |  |
| 2 |  |
| 3 |  |
| Average  |  |

C. Class Data: (Skip some lengths, but use a range from 5 to 110 for smaller classes)

|  |  |
| --- | --- |
| Length of string (cm) | Average Frequency (swings per minute) |
| 0 |  |
| 5 |  |
| 10 |  |
| 15 |  |
| 20 |  |
| 25 |  |
| 30 |  |
| 35 |  |
| 40 |  |
| 45 |  |
| 50 |  |
| 55 |  |
| 60 |  |
| 65 |  |
| 70 |  |
| 75 |  |
| 80 |  |
| 85 |  |
| 90 |  |
| 95 |  |
| 100 |  |
| 105 |  |
| 110 |  |

D. Label the numbers for x and y axes by 5’s or 10’s (to fit all data), and write correct titles and

 units for each. Then graph the class data.

Graph of Frequency vs. Length of String



**Analysis:** Answer the following questions:

1. Do you see any pattern with this data? \_\_\_\_\_\_\_ Explain: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. Do the longest pendulums have the lowest or highest frequencies? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Do the shortest pendulums have the lowest or highest frequencies? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Do you see any individual results that perhaps should be tested again? \_\_\_\_\_\_ Which

 length(s)?

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5. If someone has results that are twice as high as expected, what might that person have done

 incorrectly? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. Explain the relationship between the length of a pendulum and the frequency. \_\_\_\_\_\_\_\_\_\_\_

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7. Is this a direct or inverse relationship? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Why?

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8. Do you think other variables like size of washer or thickness of string might affect the

 results? \_\_\_\_\_\_\_\_\_ Explain your answer. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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9. Did the experimental data support your original hypothesis?

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. Did your class have a chance to tape the pendulums to the graph on the board? \_\_\_\_\_\_

11. If so, what pattern did you observe? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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