

Name: _____ Date: _____

Student Exploration: Pendulum Clock

Vocabulary: bob, calibrate, controlled experiment, gravity, mass, pendulum, period, variable

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. A **pendulum** is a **bob**, or weight, hung from a fixed point so that it can swing back and forth. What are some objects that swing like a pendulum? (List as many as you can.)
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2. The **period** of a pendulum is the amount of time that it takes a pendulum to complete one full back-and-forth swing. How do you think you could make the period longer or shorter?
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Gizmo Warm-up: Tick, Tock, Click

1. On the *Pendulum Clock* Gizmo™, a pendulum swings back and forth. The second hand of the clock moves forward one tick every time the pendulum swings across.
 - Choose an **arrow** from the purple bar on the left. Drag it next to the pendulum bob as shown.
 - Click **Play** (▶) and watch as the bob swings away from the arrow then back to it.
 - Click **Mark time** every time the bob touches the arrow. The numbers tell you how many seconds are between each click, the period of the pendulum.
 2. Estimate the period of this pendulum. _____
 3. Something is wrong with this clock! To keep the proper time, the pendulum period should be exactly 2 seconds. Will this clock run too fast or too slow?
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Activity A: Length	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Click Reset (). 	
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Question: How does the length of a pendulum affect its period?

1. **Observe:** Drag the pendulum **bob** to change the length of the pendulum. Click **Play** and observe. Try several different lengths.
2. **Form hypothesis:** How do you think the pendulum's length affects its period? _____

3. **Experiment:** Set up a **controlled experiment** to test your hypothesis. Everything but the **Length** should be kept the same in all tests. (The factor that changes is the **variable** you are testing.)

Choose 5 lengths to test, and measure the pendulum period for each length.

Test	Length (cm)	Starting angle	Mass (kg)	Pendulum period (seconds)
1				
2				
3				
4				
5				

4. **Draw conclusions:** What did you discover? _____

Was your hypothesis correct? _____

5. **Extend your thinking:** Measure the pendulum period for the following pairs of lengths:

Length	50 cm	200 cm	60 cm	240 cm
Pendulum period				

6. **Find a pattern:** Compare the 50 cm and 200 cm pendulums. Then compare the 60 cm and 240 cm pendulums. Complete the sentence:

If you multiply the length by _____, the pendulum period is multiplied by _____.

Activity B:
Mass, angle, and gravity

Get the Gizmo ready:

- Click **Reset**.



Question: How do mass, angle, and gravity affect the period of a pendulum?

1. Observe: Experiment with the different variables available in the Gizmo.
 - Drag a new **bob** to the pendulum to change its **mass**. (Mass is the amount of matter in an object.)
 - Drag the **rod** of the pendulum left or right to change the starting angle.
 - Change the **Location** to **Jupiter** to increase the **gravity**, or force, on the pendulum.

2. Form hypotheses: How will each factor affect the period of the pendulum?

- A. Mass: _____
- B. Starting angle: _____
- C. Gravity: _____

3. Experiment: Use the Gizmo to find the effect of each variable on the pendulum. Make sure that each experiment is *controlled*—only the variable you are testing should be changed. If the variable is mass, then the length and starting angle should be the same in each test.

Record all results on separate sheets of paper or in your science notebook.

4. Summarize: Describe your results below. How does each variable affect the period?

- A. Mass: _____

- B. Starting angle: _____

- C. Gravity: _____

5. Draw conclusions: Which factor had the biggest effect on the pendulum period? Explain.

Activity C: Calibrate the clock!	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Click Reset. Under Location, select Earth. 	Pendulum clock time 4:00:22 PM Actual time 4:03:53 PM
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Goal: Build a clock that will keep accurate time.

1. **Calibrate:** To **calibrate** a clock means to make changes until the clock is accurate. Using what you have learned so far, calibrate the clock so that its period is 2 seconds.

What settings are you using for your clock?

Mass: _____ Starting angle: _____ Length: _____

2. **Test:** Click **Reset**, and then click **Play**. The **Actual time** and the **Pendulum clock time** are displayed in the upper left corner. Wait for about five minutes, and then click **Pause** ().

What is the **Actual time**? _____ What is the **Pendulum clock time**? _____

3. **Revise and repeat:** Based on your test, make further adjustments to your clock. What are your settings now?

Mass: _____ Starting angle: _____ Length: _____

4. **Test:** (Optional.) If possible, leave your clock running for an hour or two, and then click **Pause**. How accurate is your clock now? _____

5. **Predict:** What settings do you think will result in an accurate clock on **Jupiter**?

Mass: _____ Starting angle: _____ Length: _____

6. **Calibrate:** Follow the same steps as above to calibrate the clock on Jupiter. What were the settings when your clock was calibrated?

Mass: _____ Starting angle: _____ Length: _____

7. **Extend your thinking:** If possible, compare the settings you used to those of other students. Is there more than one way to create an accurate clock? Explain.
