Name: _____ Date: _____

Student Exploration: Simple Harmonic Motion

Vocabulary: controlled experiment, harmonic motion, oscillation, pendulum, period, spring, spring constant

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

1. A bungee jumper launches herself off a bridge. How would you describe her motion?

   _____

2. A child goes to the playground and gets on a swing. How would you describe his motion?

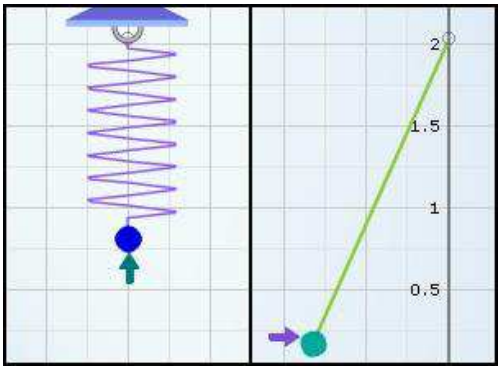
   _____

3. What do the motions of the bungee jumper and swinger have in common? _____

   _____

Gizmo Warm-up

Harmonic motion is repeating back-and-forth or up-and-down movement. The *Simple Harmonic Motion* Gizmo™ allows you compare the harmonic motions of a **spring** and a **pendulum**.



To begin, open the **POINTER** tray on the bottom of the Gizmo. Drag one arrow to the bottom of the spring so that the weight just touches the tip of the arrow, as shown. Drag a second arrow so that the pendulum just touches the tip of the arrow when it swings to the left.

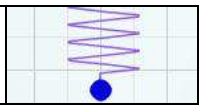
1. When the spring touches the arrow, click the green button on the stopwatch. Count the movements, or **oscillations**. Click the green button again after the tenth oscillation.

   A. What is the time for 10 oscillations of the spring? _____

   B. Divide this time by 10 to find the **period** of the spring: _____

2. Click the red button to reset the stopwatch. Use the same procedure on the pendulum.

   What is the period of the pendulum? _____

Activity A: **Period of a spring**	Get the Gizmo ready: • Click the red button to reset the stopwatch.	

Introduction: The **spring constant** is a measure of the stiffness of a spring. The greater the spring constant, the harder it is to stretch or compress the spring. The *Simple Harmonic Motion* Gizmo allows you to manipulate the mass on the end of the spring (*m*), the spring constant (*k*), and the gravitational acceleration (*g*).

Question: Which factors affect the period of a spring?

1. Predict: Which factors do you think will increase or decrease the period of a spring? Which do you think will have no effect on the period of a spring?

   _____

   _____

2. Gather data: In a **controlled experiment**, only one factor changes at a time. Controlled experiments are a fair way to compare the effects of each variable on a system.

   For each of the combinations given in the table below, measure the time for 10 oscillations of the spring and calculate the period. If necessary, reduce the **Sim. speed** to improve your accuracy.

***m* (kg)**	***k* (N/m)**	***g* (m/s^2)**	**Time for 10 oscillations (s)**	**Period (s)**
0.5 kg	100 N/m	9.8 m/s^2		
2.0 kg	100 N/m	9.8 m/s^2		

***m* (kg)**	***k* (N/m)**	***g* (m/s^2)**	**Time for 10 oscillations (s)**	**Period (s)**
1.0 kg	50 N/m	9.8 m/s^2		
1.0 kg	200 N/m	9.8 m/s^2		

***m* (kg)**	***k* (N/m)**	***g* (m/s^2)**	**Time for 10 oscillations (s)**	**Period (s)**
1.0 kg	100 N/m	5.0 m/s^2		
1.0 kg	100 N/m	20.0 m/s^2		

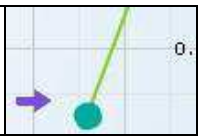
3. Analyze: Examine the results of each experiment.

   A. Which factors affected the period of the spring? _____

   B. Which factor had no effect on the period? _____

   C. What is the effect of quadrupling the mass? _____

   D. What is the effect of quadrupling the spring constant? _____

Activity B: **Period of a pendulum**	Get the Gizmo ready: • Reset the stopwatch. • Set ***L*** to 1.0 m and ***g*** to 9.8 m/s^2.	

Introduction: The *Simple Harmonic Motion* Gizmo allows you to manipulate three variables for the pendulum: its mass (*m*), its length (*L*), and the gravitational acceleration (*g*).

Question: Which factors affect the period of a pendulum?

1. Predict: Which factors do you think will increase or decrease the period of a pendulum? Which do you think will have no effect at all?

   _____

   _____

2. Gather data: For each of the combinations given in the table below, measure the time for 10 oscillations of the pendulum and calculate the period. If necessary, change the **Sim. speed** to improve the accuracy of your measurements.

m **(kg)**	***L*** **(m)**	***g*** **(m/s^2)**	**Time for 10 oscillations (s)**	**Period (s)**
0.5 kg	1.0 m	9.8 m/s^2		
2.0 kg	1.0 m	9.8 m/s^2		

m **(kg)**	***L*** **(m)**	***g*** **(m/s^2)**	**Time for 10 oscillations (s)**	**Period (s)**
1.0 kg	0.5 m	9.8 m/s^2		
1.0 kg	2.0 m	9.8 m/s^2		

m **(kg)**	***L*** **(m)**	***g*** **(m/s^2)**	**Time for 10 oscillations (s)**	**Period (s)**
1.0 kg	1.0 m	5.0 m/s^2		
1.0 kg	1.0 m	20.0 m/s^2		

3. Analyze: Examine the results of each experiment.

   A. Which factors affected the period of the pendulum? _____

   B. Which factor had no effect on the period? _____

   C. What is the effect of quadrupling the length? _____

   D. What is the effect of quadrupling the gravitational acceleration? _____

   _____

Activity C: **Calculating periods**	Get the Gizmo ready: • Reset the stopwatch. • Set ***g*** to 9.8 m/s^2.	

Introduction: In activity A, you found that the period of a spring depends only on its mass and the spring constant. In activity B, you found that the period of a pendulum depends on its length and gravitational acceleration. Now, you will determine formulas for the period of each object.

Question: How are the periods of pendulums and springs calculated?

1. Summarize: Look at your results from prior activities.

   A. How did quadrupling *m* affect the period of the spring? _____

   B. How did quadrupling *k* affect the period of the spring? _____

   C. How did quadrupling *L* affect the period of the pendulum? _____

   D. How did quadrupling *g* affect the period of the pendulum? _____

2. Gather data: Use the Gizmo to find the period of the spring for three sets of ***m*** and ***k*** values. Then find the period of the pendulum for three sets of ***L*** and ***g*** values.

Spring

m **(kg)**	***k*** **(N/m)**	**Time for 10 oscillations (s)**	**Period (s)**	$\frac{m}{k}$	$\sqrt{\frac{m}{k}}$	$\frac{\text{Period}}{\sqrt{\frac{m}{k}}}$

Pendulum

L **(m)**	***g*** **(m/s^2)**	**Time for 10 oscillations (s)**	**Period (s)**	$\frac{L}{g}$	$\sqrt{\frac{L}{g}}$	$\frac{\text{Period}}{\sqrt{\frac{L}{g}}}$

3. Calculate: Calculate the ratios listed in the last three columns of each table.

(Activity C continued on next page)

Activity C (continued from previous page)

4. Analyze: Examine your data tables.

   A. No matter what values of *m* and *k* you used for the spring, what is the ratio of the period to $\sqrt{\frac{m}{k}}$? _____

   B. No matter what values of *L* and *g* you used for the pendulum, what is the ratio of the period to $\sqrt{\frac{L}{g}}$? _____

5. Challenge: Put together what you learned in this activity to come up with formulas for the period (*T*) of a spring based on its mass (*m*) and spring constant (*k*) and for the period of a pendulum based on its length (*L*) and gravitational acceleration (*g*).

   T_{Spring} =

   $T_{Pendulum}$ =

   Have your teacher check your formulas when they are complete.

6. Apply: How long would a pendulum on Earth (where $g = 9.8\ m/s^2$) have to be to have the same period as a spring with a mass of 10.0 kg and a spring constant of 25 N/m?

   _____

7. Think and discuss: Which is more likely to keep accurate time on the Moon, a spring-driven watch or a pendulum clock? Explain your answer.

   _____

   _____

   _____

   _____