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SIMPLE PENDULUM

PROBLEMS

1. When is the motion of a simple pendulum simple harmonic?
2. What is the effect of the following physical quantities on the period of oscillation of a simple pendulum: mass of the pendulum bob, length, acceleration due to gravity, and angular displacement.

MATERIALS Pendulum Lab (PhET simulation)

ONLINE RESOURCES Pendulum Lab PhET simulation: https://phet.colorado.edu/sims/html/pendulum-lab/latest/pendulum-lab_en.html

PROCEDURE

Frequency and Spring Constant

1. Open the Pendulum Lab PhET simulation. Select LAB.
2. Set the following parameters:

Length	1 m
Friction	none
Environment	Earth
Simulation speed	slow
Velocity indicator	enabled
Acceleration vector	enabled
Simulation	PAUSED
Angular displacement	10 degrees

3. Run the simulation by clicking on the pause/play button. Observe the motion of the pendulum and the length of the velocity vector at different positions of the pendulum bob.

QUESTION:

- What happens to the speed of the pendulum bob as it (a) swings away from the equilibrium position and (b) toward the equilibrium position?

- At what position(s) is the speed of the pendulum bob at its maximum value? At what position(s) is the pendulum bob instantaneously at rest?

- What is the direction of the acceleration when the pendulum bob is (a) at the right side of the equilibrium position and (b) at the left side of the equilibrium position?

- At what position(s) is the acceleration of the pendulum bob at its maximum value? minimum value?

- Based on these observations, is the motion of a simple pendulum simple harmonic? Explain.

Period and Mass

1. Set the following parameters:

Length	1 m
MASS	0.3 kg
Friction	none
Environment	Earth
Simulation speed	normal
Velocity indicator	disabled
Acceleration vector	disabled
Simulation	PAUSED
Angular displacement	15 degrees
Period Timer	enabled

2. Run the simulation by clicking on the pause/play button. While the pendulum bob is oscillating, activate the Period Timer and note the period of oscillation.

3. Using the same parameters in (1), make several trials, each time, increasing the mass by 0.3 kg until m = 1.5 kg. Record your data in the table below.

Mass m, of the Pendulum bob (kg)	Period, T, of Oscillation (s)
0.3	
0.6	
0.9	
1.2	
1.5	

4. Using a spreadsheet, plot the graph of the period of oscillation (T) against the mass of the pendulum bob (m). Describe the graph formed.

QUESTION:

What does the T vs. m graph suggest about the relationship between the period of oscillation of a simple pendulum and its mass?

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Period and the length of the Pendulum

1. Set the following parameters:

LENGTH	0.2 m
Mass	0.5 kg
Friction	none
Environment	Earth
Simulation speed	normal
Velocity indicator	disabled
Acceleration vector	disabled
Simulation	PAUSED
Angular displacement	15 degrees
Period Timer	enabled

2. Run the simulation by clicking on the pause/play button. While the pendulum bob is oscillating, activate the PERIOD TIMER and note the period of oscillation.

3. Using the parameters in (1), make several trials, each time, increasing the length by 0.2 m until the length equals L= 1m. Record your data in the table below.

Length, L of the pendulum (m)	Period, T, of Oscillation (s)	Period Squared (T^2) (s^2)
0.2		
0.4		
0.6		
0.8		
1.0		

4. Using a spreadsheet, plot the graph of the period (T) against the length (L) of the pendulum. Describe the graph formed.

5. Plot the graph of T^2 against L. What kind of graph was formed?

QUESTIONS:

- What does the graph of T^2 vs. L suggest about the relationship between T and L?

Period and Acceleration due to Gravity

1. Set the following parameters:

Length	1 m
Mass	1 kg

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GRAVITY	5 m/s^2
Friction	none
Environment	Earth
Simulation speed	normal
Velocity indicator	disabled
Acceleration vector	disabled
Simulation	PAUSED
Angular displacement	15 degrees
Period Timer	enabled

2. Run the simulation by clicking on the pause/play button. While the pendulum bob is oscillating, activate the PERIOD TIMER and note the period of oscillation.

3. Using the parameters in (1), make several trials, each time, increasing the acceleration due to gravity by 5 m/s^2 m until g = 5 m/s^2 . Record your data in the table below.

Acceleration due to gravity, g, (m/s^2)	Period, T, of Oscillation (s)	(T^2) (s^2)	1/g (s^2/m)
5			
10			
15			
20			
25			

4. Plot the graph of T^2 against 1/g. Describe the graph formed.

QUESTIONS:

- What does the graph of T^2 vs. 1/g suggest about the relationship between the period of oscillation of the pendulum and the acceleration due to gravity?

Period and Angular Displacement

1. Set the following parameters:

Length	1 m
Mass	1 kg
Environment	Earth
Friction	none
Environment	Earth
Simulation speed	normal
Velocity indicator	disabled
Acceleration vector	disabled
Simulation	PAUSED
ANGULAR DISPLACEMENT	3 degrees
Period Timer	enabled

2. Determine the period of oscillation using the photogate timer.

3. Repeat procedure (1) for different values of the angular displacement (Refer to the table below)

4. Record your data.
5.

Angular Displacement (degrees)	Period (s)	Angular Displacement (degrees)	Period (s)
3		25	
6		40	
9		55	
12		70	
15		85	
18		90	

QUESTIONS:

- For $\theta < 15°$, does the period of oscillation depends on the angular displacement?

- For $\theta > 15^o$ does the period of the pendulum depend on the angular displacement? What happens to the period of the pendulum as the angular displacement increases?

- When do you say that the motion of a simple pendulum is simple harmonic?

CONCLUSION(S)

GOING FURTHER

In the simulation, the acceleration due to gravity on Planet X is not known. Develop a method to determine the acceleration due to gravity on Planet X.