IB PHYSICS

Name: _____

Period: _____ Date: _____

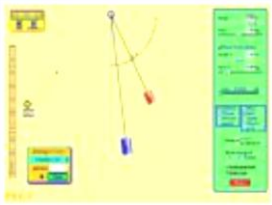
DEVIL PHYSICS

BADDEST CLASS ON CAMPUS

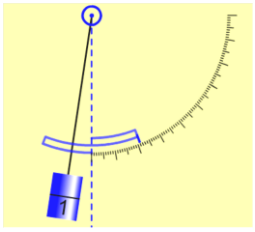
PhET Pendulum Lab

Introduction:

Old grandfather clocks have large pendulums that swing back and forth to keep time. A Foucault pendulum is a huge pendulum that swings in two axes as the earth rotates to also keep time. The time a pendulum takes to swing back and forth (*one cycle*) is referred to as one ***period***. The period of a pendulum is measured in seconds and is given by the formula shown below. The inverse of period is ***frequency***, the number of complete cycles each second. The ***equilibrium*** *position* is the point below the pivot, at a neutral position. The ***amplitude*** of the pendulum's swing is the displacement from the equilibrium. The top of each swing is referred to as ***maximum displacement*** or ***maximum amplitude***.



Pendulum Lab



Important Formulas:

$$T = 2\pi\sqrt{\frac{l}{g}} \qquad f = 1/T$$

Part I: Pendulum Basics

1. Go to http://phet.colorado.edu/en/simulation/pendulum-lab Run Now!
2. Spend some time learning about pendulums. The simulated pendulum is frictionless, so it will attain the same amplitude in every swing. That is, it will lose no *energy* to friction (heat).
3. Using a 1.00 kg pendulum, for each trial, adjust the length of the pendulum and determine the period. (In this lab, you may use the photogate timer to determine the period, but in the next lab, the spring lab you will not have this luxury.)
4. Complete the table below.

Mass (kg)	Length (m)	Period (s)	Gravity
1.00 kg			Earth, 9.8 m/s^2
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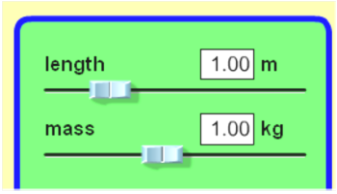
1.00 kg			Earth, 9.8 m/s^2
1.00 kg			Earth, 9.8 m/s^2

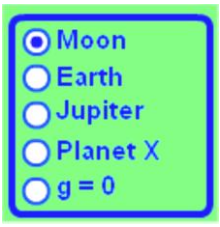


5. Repeat the investigation but for each trial, adjust only the mass of the pendulum, leaving all other variables constant.

Mass (kg)	Length (m)	Period (s)	Gravity
			Earth, 9.8 m/s^2
			Earth, 9.8 m/s^2
			Earth, 9.8 m/s^2
			Earth, 9.8 m/s^2

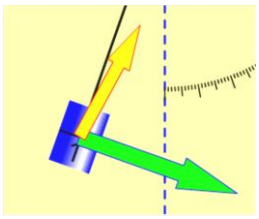
6. Repeat the experiment again but, for each trial, adjust the gravity (location) leaving all other variables constant.

Mass (kg)	Length (m)	Period (s)	Gravity



Velocity and Acceleration Vectors

7. Turn on the velocity and acceleration vectors.
8. Observe the magnitudes and directions of the vectors as the pendulum moves.
9. The green vector represents _____ and the yellow vector _____.



Lab Questions and Calculations: *(for multiple-choice answers, underline and embolden the answer)*

1. What force (or acceleration) causes the pendulum to speed up on the way down and slow down on the way up? _____
2. As pendulum length increases, the period of harmonic motion
   increases / decreases / remains the same.
3. As pendulum mass increases, the period of harmonic motion
   increases / decreases / remains the same.
4. As gravity (Jupiter) on the pendulum increases, the period of harmonic motion
   increases / decreases / remains the same.
5. A pendulum attains maximum velocity *at the equilibrium position / at maximum amplitude.*
6. A pendulum attains minimum velocity *at the equilibrium position / at maximum amplitude.*

7. A pendulum attains maximum acceleration *at the equilibrium position / at maximum amplitude*.
8. A pendulum attains minimum acceleration *at the equilibrium position / at maximum amplitude*.
9. A pendulum attains maximum PE (potential energy) *at the equilibrium position / at maximum amplitude*.
10. A pendulum attains **minimum** KE (kinetic energy) *at the equilibrium position / at maximum amplitude*.
11. Consider a playground swingset. Is it possible for a kid to swing over the bar? Why / Why not?

_____

_____

_____

_____

12. In real devices that use pendulums (clocks, Foucault pendulums in museums) a force must be added to counteract friction. When should that force be applied? *Constantly / at the same period as the pendulum / it doesn't matter*.
13. A pendulum that completes a cycle in 4 seconds has a period of _____ seconds.
14. That same pendulum has a frequency of _____ cycles per second (Hz)
15. If a pendulum completes 25 cycles in a minute, its period is _____ seconds.
16. …and its frequency is _____ Hz.

Use the period formula on the front page for the following. Answer in decimal form.

17. What is the period (on earth) of a .25 kg pendulum with a length of .45 m? (use the formula) ___

_____

_____

18. What is the period (on earth) of a 7.5 kg pendulum with a length of .45 m? (use the formula) ___

_____

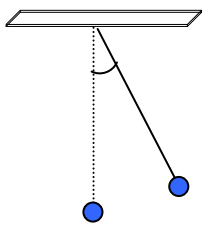
_____

19. In order to swing with a period of exactly 2.0 s, a grandfather clock's 1.5 kg pendulum must have a length of _____ m.

Part II: Conservation of Energy

Task

Determine whether or not mechanical energy is conserved as a pendulum swings. The length and mass of the pendulum will be held constant.



Tools and initial setup:

- Choose a fixed mass and length to keep throughout the experiment.
- Choose no friction initially.
- Choose Earth.
- Show energy of one.
- Choose Other Tools to get a stopwatch and a tape measure.
- Use the tape measure to obtain the diameter of the pendulum bob. (right click on the simulation and choose Zoom In).
- To determine the maximum speed of the bob, choose 1/16 time and use the stopwatch to measure the time it takes for the diameter of the pendulum bob to pass completely through the lowest point.
- Run six trials at six different amplitudes ranging from very small to very large.

Report

1. Provide free-body diagrams for the pendulum while it swings at positions of max speed and max amplitude. (Use the Shapes function of MS Word)

2. Submit a table that includes mass of the pendulum bob (keep this mass constant for all trials), length of pendulum string (keep this length constant for all trials), and diameter of the pendulum bob. Insert the table below or as an attachment.

3. Submit a data table that includes 6 different amplitudes and the corresponding times to pass through the lowest point of the swing. Insert the table below or as an attachment.

4. Submit a calculations table that includes the vertical distance the bob falls, maximum speed of the bob, gravitational potential energy, kinetic energy, and change in total energy for the pendulum bob as it falls. Insert the table below or as an attachment.

5. Use Excel to create a plot of (maximum speed)^2 vs. vertical distance the bob falls. State the model that best fits the data, and provide a correlation coefficient. Insert the graph below or as an attachment.

Analysis

1. When is the pendulum in equilibrium? When is it not in equilibrium? _____

2. What work is being done while the pendulum falls? _____

3. Compare the initial total energy to the final total energy. Find a percentage difference. _____

4. How well does the pendulum conserve mechanical energy at large amplitudes? At small amplitudes? _____

5. What physical quantity does the slope of the created plot represent? _____

6. How can you determine the tension in the string for the bob at the lowest point in the swing? _____

7. Repeat a trial w/ friction of your choosing. Does the pendulum to continue to conserve energy?

ROOM FOR IMPROVEMENT

APPLICABILITY:

This lab is best suited for (check all that apply): ☐ Pre-DP Physics ☐ IB Physics 2 ☐ IB Physics 3 ☐ None of These
In terms of the material covered thus far, this lab was given: ☐ too early in the course ☐ at the right time in the course ☐ too late in the course
In terms of degree of difficulty, this lab was: ☐ too easy ☐ just about right ☐ too hard
In terms of helping you understand the material, this lab was: ☐ not helpful ☐ somewhat helpful ☐ very helpful

Comments:

IMPROVEMENT: This lab can be improved by:

This lab may be submitted as a hardcopy or uploaded to FOCUS. If submitting electronically, ensure the filename is in the format "LastnameFirstinitialPerXLabName".