Early E. C.:	/ 1
Total HW Points Unit 6:	/ 20
Total Lab Points Unit 6:	/ 46
Unit 6 Apps.:	/ 5
Late, Incomplete, No Work, No Units Fee?	Y / N

Unit 6 – Simple Harmonic Motion

Essential Fundamentals of Simple Harmonic Motion

1. The period of a pendulum depends on its length, and the local force of gravity.

Add More!!

AP Equations

In-Class Equations

Link to Algebra

In Unit 6, the following equations will be used. Isolate the indicated variables.

Period Definition

$T = \frac{1}{f}$

$f =$

Harmonic System Equation

$x = A\cos(2\pi ft)$

$A =$

$f =$

$t =$

Mass-Spring System Equation (Frequency)

$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$m =$

$k =$

Spring Potential Energy

$U_s = \frac{1}{2}kx^2$

$k =$

$x =$

Spring Force Definition

$\left|\vec{F}_s\right| = k\left|\vec{x}\right|$

$k =$

$x =$

Maximum Mass-Spring Velocity

$v_{max} = \pm A\sqrt{\frac{k}{m}}$

$k =$

$m =$

Instantaneous Mass-Spring Velocity

$v = \pm\sqrt{\frac{k}{m}\left(A^2 - x^2\right)}$

$k =$

$m =$

$A =$

$x =$

Pendulum Equation

$T_p = 2\pi\sqrt{\frac{l}{g}}$

$l =$

Mass-Spring System Equation (Period)

$T = 2\pi\sqrt{\frac{m}{k}}$

$m =$

$k =$

Possible 6.1 Pts.:	4
Late, Incomplete, No work, No Units Fee:	- 1 - 2 - 3
Final Score:	**/ 4**

6.1 Problems – Harmonic Motion
Section 13.1 of your textbook.

1. If it takes a particle in simple harmonic motion 0.50 s to travel from the equilibrium position to the first maximum displacement (amplitude), what are the period and frequency of the oscillating particle?

2. A. A 0.75-kg object oscillating on a spring completes a cycle every 0.50 s. What is the frequency of this oscillation?

   B. How many oscillations would happen in 7.5 seconds?

3. A student reading his physics book on a lake dock notices that the distance between two incoming wave crests is about 0.75 m, and then he measures the time of arrival between the crests to be 1.6 s. What is the approximate speed of the waves?

Possible 6.2 Pts.:	5
Late, Incomplete, No work, No Units Fee: - 1 - 2 - 3	
Final Score:	/ 5

6.2 Problems – Introduction to Springs and Energy

Section 5.2 of your textbook.

Wizard Challenge Alert!

1. What is the spring constant for a spring that takes 2.5 N of force to compress 2.4 cm?

2. Why is the value of the force that a spring exerts a negative value?

3. How much force does it take to compress a spring with a spring constant of 145 N/m 138 mm?

4. Explain verbally and pictorially how a rock could have both potential and kinetic energy.

5. Two springs A and B are stretched the same distance in a spring-stretching system. The spring constant of A is three times that of B. How much force is exerted on spring A, compared to the total force on the system?

Possible 6.3 Pts.:	5
Late, Incomplete, No work, No Units Fee:	- 1 - 2 - 3
Final Score:	/ 5

6.3 Problems – Mass-Spring Systems

Section 13.2 of your textbook.

1. An object of mass 1.0 kg is attached to a spring with spring constant 15 N/m. If the object has a maximum speed of 0.50 m/s, what is the amplitude of oscillation?

2. If m = 0.250 kg, k = 100 N/m, and A = 0.10 m, what is the mass's maximum speed?

3. A 0.50-kg mass oscillates in simple harmonic motion on a spring with a spring constant of 200. N/m. What are

   A. the period

   B. the frequency of the oscillation?

4. How much mass should be at the end of a spring (k = 100.0 N/m) to have a period of 2.0 s?

Possible 6.4 Pts.:	6
Late, Incomplete, No work, No Units Fee:	- 1 - 2 - 3
Final Score:	/ 6

6.4 Problems – Simple Pendulum Systems
Section 13.2 of your textbook.
Wizard Challenge Alert!

1. Would the period of a pendulum in an upward-accelerating elevator be increased or decreased compared with its period in an elevator moving with constant motion? Explain.

2. Why does the mass of the pendulum bob not matter when comparing periods of two pendulums with equal lengths?

3. A breeze sets a suspended lamp into oscillation. If the period is 1.0 s, what is the distance from the ceiling for the lamp at the lowest point? Assume that the lamp is a point mass and acts as a simple pendulum.

4. A. Consider a pendulum with an arm of 2.5 m. What is its period?

   B. What is its frequency?

5. Consider two pendulums, A and B. Pendulum A is half the length of B. What is the ratio of the periods of A and B?

AP Physics 1	6.1 Lab - Mass-Spring System
Reminder: Update Table of Contents	**Correction Credit: Half**

Lab Overview:

When harmonic motion is graphed, certain characteristics can be measured, such as wavelength, amplitude, period, and frequency.

In this lab, you will use a mass-spring system to calculate relations between amplitude and energy, and produce a time vs. amplitude graph.

Mass-Spring Lab (6.1) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1: Constant	Data Table	/ 2
	Spring Constant	/ 2
Mission 2: Period	Data Table	/ 2
	Period of System	/ 2
Mission 3: Calculations	Frequency	/ 2
	Energy	/ 2
	Maximum Velocity	/ 2
Mission 4: Graph	Large	/ 1
	Well Labeled	/ 2
	Two Cycles	/ 1
Question 1:	Compute Period	/ 2
	Period Comparison	/ 2
Question 2:	Sources of Error	/ 2
Work Not Shown Fee:		-1 -2 -3
Late Lab Fee		-5
Total:		**/ 26**

Equipment:

50 gram Mass Hanger
Set of Masses
Spring
Stopwatch
Standardized Testing Ruler
Construction Set Equipment

Mission 1 (5 Points)

Determine an average spring constant of your spring (at least three different masses). You have a spring, masses, construction equipment, measuring tools, and gravity. Produce a data table that an outside observer could use to check your value. Use enough mass to displace the spring at least 1.0 cm.

Mission 2 (4 Points)

Using the largest mass from Mission 1, measure the period of your mass-spring system. Take at least three measurements with a stopwatch and put them into a data table.

Mission 3 – Calculations (6 Points)

Using data collected in previous missions, calculate and report: the frequency, energy at greatest amplitude, and the maximum velocity of your mass-spring system. Show all your work for full credit.

Mission 4 – Graphing a Wave (4 Points)

Using data collected and computed in previous missions, produce a large, well-labeled graph of amplitude vs. time for your mass-spring system. Graph two complete cycles.

Questions: Rephrase and answer in complete sentences for full credit.

1. Use the following equation of period that uses mass and spring constant information to calculate a theoretical period for your system. Compare your measured value to the computed one. Why are they different? Show your work for full credit (4 Points).

$$T = 2\pi\sqrt{\frac{m}{k}}$$

2. What could be done to reduce sources of error in this lab (2 Points)?

AP Physics 1	6.2 Lab - The Pendulum
Reminder: Update Table of Contents	Correction Credit: Half

Lab Overview:

You will measure relations between length, mass, and period of a pendulum, and predict how a pendulum behaves on Jupiter.

Pendulum Lab (6.2) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1: Bob Mass	Data Table	/ 2
	Average Periods	/ 2
Mission 2: Length	Data Table (Same One)	/ 1
	Average Period	/ 1
Mission 3: Calculation	Theoretical Period	/ 2
Question 1:	Period Comparison	/ 2
Question 2:	Period Comparison	/ 2
Question 3:	Period Comparison	/ 2
Question 4:	Period on Jupiter	/ 2
Question 5:	Sources of Error	/ 2
Work Not Shown Fee:		-1 -2 -3
Late Lab Fee		-5
Total:		**/ 20**

Equipment:

Mass Hanger and Masses
Meter Stick
Stopwatch
Standardized Testing Ruler
Construction Set Equipment
Medium Quality String

Mission 1: Changing Bob Mass (4 Points)

Using the construction equipment, make a pendulum system for which you can alter the length of string (being sure to record the length each time). Hang the mass hanger on the end of the string as a bob, and measure the average period of the pendulum. Then, hang a mass on the hanger, and measure its average period. Make a data table that has all measurements, and the two average periods for the two masses.

Mission 2: Changing Pendulum Length (2 Points)

Using the same mass that you used for Mission 1, change the length of your pendulum. Measure the average period of the pendulum, and record this value in the same data table.

Mission 3 – Calculation (3 Points)

Using data collected in a previous mission, calculate and report the theoretical period of your pendulum (choose either of the lengths – only one calculation needed). Show all work for full credit.

Questions: Rephrase and answer in complete sentences for full credit.

1. Compare values from Mission 1 (different masses). Do these results agree with your expectations?
2. Compare values from Mission 2 (different lengths). Do these results agree with your expectations?
3. In Mission 3, how does your pendulum's measured period compare to the calculated one? What could account for differences?
4. How would you expect a pendulum to perform on Jupiter, where the gravitational attraction is much greater? Explain your answer thoroughly.
5. What could be done to reduce sources of error in this lab?

AP Physics 1	Unit 6 - Harmonic Motion				
Application Problems, AP Test Preparation Questions					
Presentation Points:	/ 5	Late Fee:	-2	Completion (Booklet Check)	/ 5

Your grade on this problem set will depend on the presentation you provide for your problem, and whether they are complete when you submit your Booklet at the end of the Unit.

1. The frequency of a simple harmonic oscillator is doubled from 0.25 Hz to 0.50 Hz. What is the change of its period?

2. A 0.75-kg mass oscillates in simple harmonic motion on a spring with a constant of 175 N/m. What are the period and frequency of the oscillation?

3. A spring manufacturing company is making springs that will be installed in a 1400 kg vehicle. The front two wheels will have 60.0% of the load. So that the springs only deflect a minimum of 5.0 cm when the car is assembled, what will the two spring constants (front and back) have to be?

4. A 25 kg mass on a spring (spring constant = 762 N/m) is designed to act as a battering ram. For full effectiveness, the velocity of the ram must be at least 14 m/s. How far back would the operators have to pull the mass to achieve this speed?

Unit 6 Practice AP Multiple Choice Questions

The following problems (multiple choice and free response) are designed to train you to take the AP Physics 1 test in the spring, and will be scored at the end of the Unit – based on completion and accuracy.

1. Which of the following are characteristics of simple harmonic motion? Choose two answers.
   a. The acceleration is constant.
   b. The restoring force is proportional to the displacement.
   c. The frequency is independent of the amplitude.
   d. The period is dependent on the amplitude.

2. A block attached to an ideal spring undergoes simple harmonic motion. The acceleration of the block has its maximum magnitude at the point where
   a. the speed is the maximum.
   b. the speed is the minimum.
   c. the restoring force is the minimum.
   d. the kinetic energy is the maximum.

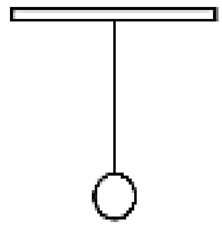
3. A student measures the maximum speed of a block undergoing simple harmonic oscillations of amplitude A on the end of an ideal spring. If the block is replaced by one with twice the mass but the amplitude of its oscillations remains the same, then the maximum speed of the block will
   a. decrease by a factor of 4.
   b. decrease by a factor of 2.
   c. decrease by a factor of $\sqrt{2}$
   d. increase by a factor of 2.

4. A spring-block harmonic oscillator is set up so that the oscillations are vertical. The period of the motion is T. If the spring and block are taken to the surface of the moon, where the gravitational acceleration is 1/6 of its value here, then the vertical oscillations will have a period of
   a. T/6 b. T/3 c. $T/\sqrt{6}$ d. T

5. A simple pendulum swings about the vertical equilibrium position with a maximum angular displacement of 5° and period T. If the same pendulum is given a maximum angular displacement of 10°, then which of the following gives the period of the oscillations?
   a. T/2 b. $T/\sqrt{2}$ c. T d. 2T

Unit 6 Example AP Question – Free Response

Note: Point values listed do not apply.



2. (15 points)

The simple pendulum above consists of a bob hanging from a light string. You wish to experimentally determine the frequency of the swinging pendulum.

(a) By checking the line next to each appropriate item on the list below, select the equipment that you would need to do the experiment.

____ Meterstick ____ Protractor ____ Additional string

____ Stopwatch ____ Photogate ____ Additional masses

(b) Describe the experimental procedure that you would use. In your description, state the measurements you would make, how you would use the equipment to make them, and how you would determine the frequency from those measurements.

(c) You next wish to discover which parameters of a pendulum affect its frequency. State one parameter that could be varied, describe how you would conduct the experiment, and indicate how you would analyze the data to show whether there is a dependence.

(d) After swinging for a long time, the pendulum eventually comes to rest. Assume that the room is perfectly thermally insulated. How will the temperature of the room change while the pendulum comes to rest?

____ It would slightly increase. ____ It would slightly decrease.

____ No effect. It would remain the same.

Justify your answer.

(e) Another pendulum using a thin, light, metal rod instead of a string is used in a clock to keep time. If the temperature of the room was to increase significantly, what effect, if any, would this have on the period of the pendulum?

____ It would increase. ____ It would decrease. ____ No effect. It would remain the same.

Justify your answer.

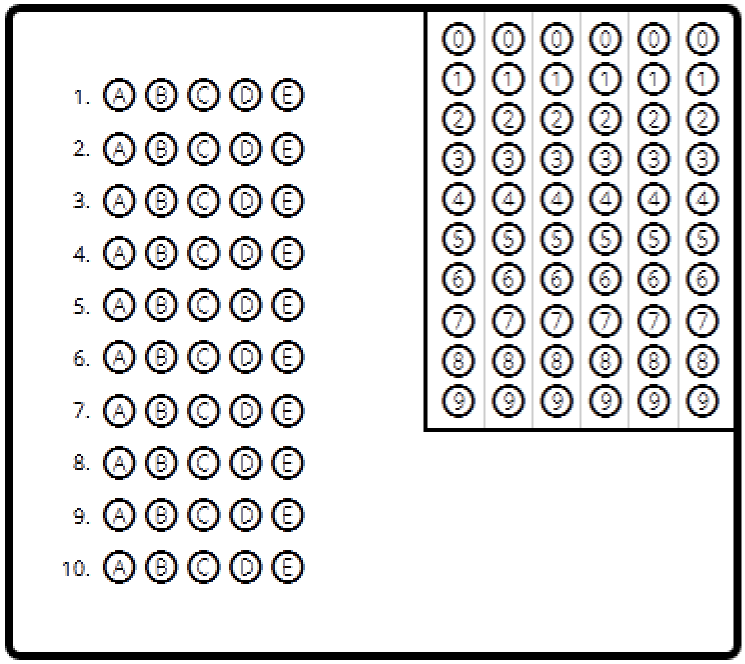
AP Physics 1	Unit 6 Review - Harmonic Motion					
Points:	**/ 20**	**Late or Incomplete Fee:**	**-2 -4 -6**	**Correction Credit:**		**Final Score:**

Solve these problems here, THEN enter your responses in the bubble sheet provided. On the due date, I will scan your responses in class, mark which problems you missed, and enter your score in Powerschool.

If you submit your responses on time, you will have one attempt to correct errors you made (for half credit back).

If you are late, you will only get one attempt, and will only receive half credit for the problems you got right.

Each question is worth two points.



1. A particle in SHM has a frequency of 40.0 Hz. What is the period of this oscillation?

A. 0.0125 s B. 0.025 s C. 20.0 s D. 40.0 s E. 8.0 s

2. How far would a spring be compressed (Constant = 32.3 N/m) if a 1.5 kg mass were placed on it?

A. 46 cm B. 15 cm C. 2.1 m D. 6.4 cm E. 4.6 m

3. An object of mass 0.50 kg is attached to a spring with spring constant 10.0 N/m. If the object is pulled down 0.50 m from the equilibrium position and released, what is its maximum speed?

A. 1.0 m/s B. 1.5 m/s C. 1.8 m/s D. 2.2 m/s E. 4.5 m/s

4. If the frequency of a mass-spring system is 1.50 Hz and the mass on the spring is 5.00 kg, what is the spring constant?

A. 7.5 N/m B. 215 N/m C. 444 N/m D. 580 N/m E. 305 N/m

5. How much energy is possessed by a mass-spring system with a mass of 15 kg, and a spring constant of 13.8 N/m, if it is drawn back 13 cm?

A. 97 J B. 1200 J C. 90. J D. 2700 J E. 0.12 J

6. Which has a greater period, a 1.5 m pendulum with a 4 kg bob, or a 2.5 m pendulum with a 2 kg bob?

A. The 1.5 m pendulum B. The 2.5 m pendulum C. They're equal. D. Not enough information.

7. The simple pendulum in a tall clock is 0.75 m long. What is the period of the pendulum?

A. 1.73 s B. 1.43 s C. 1.29 s D. 0.94 s E. 0.75 s

8. The simple pendulum in a tall clock is 0.75 m long. What is the frequency of this pendulum?

A. 0.42 Hz B. 0.51 Hz C. 0.57 Hz D. 1.73 Hz E. 2.08 Hz

9. How long would a pendulum have to be on a planet where the local gravitational constant was 5.6 m/s^2 to have a period of 2.8 s?

A. 0.57 m B. 0.84 m C. 1.1 m D. 1.5 cm E.10.2 m

10. Two pendulums of the same period (4.0 s) are set in motion, one after the other. Pendulum A is started first, and pendulum B is started 1 second later. What is the phase shift between the two pendulums?

A. Pendulum A leads B by 180° B. Pendulum B leads A by 60°
C. Pendulum A leads B by 90° D. Pendulum A leads B by 270°
E. Pendulum A lags behind B by 90°