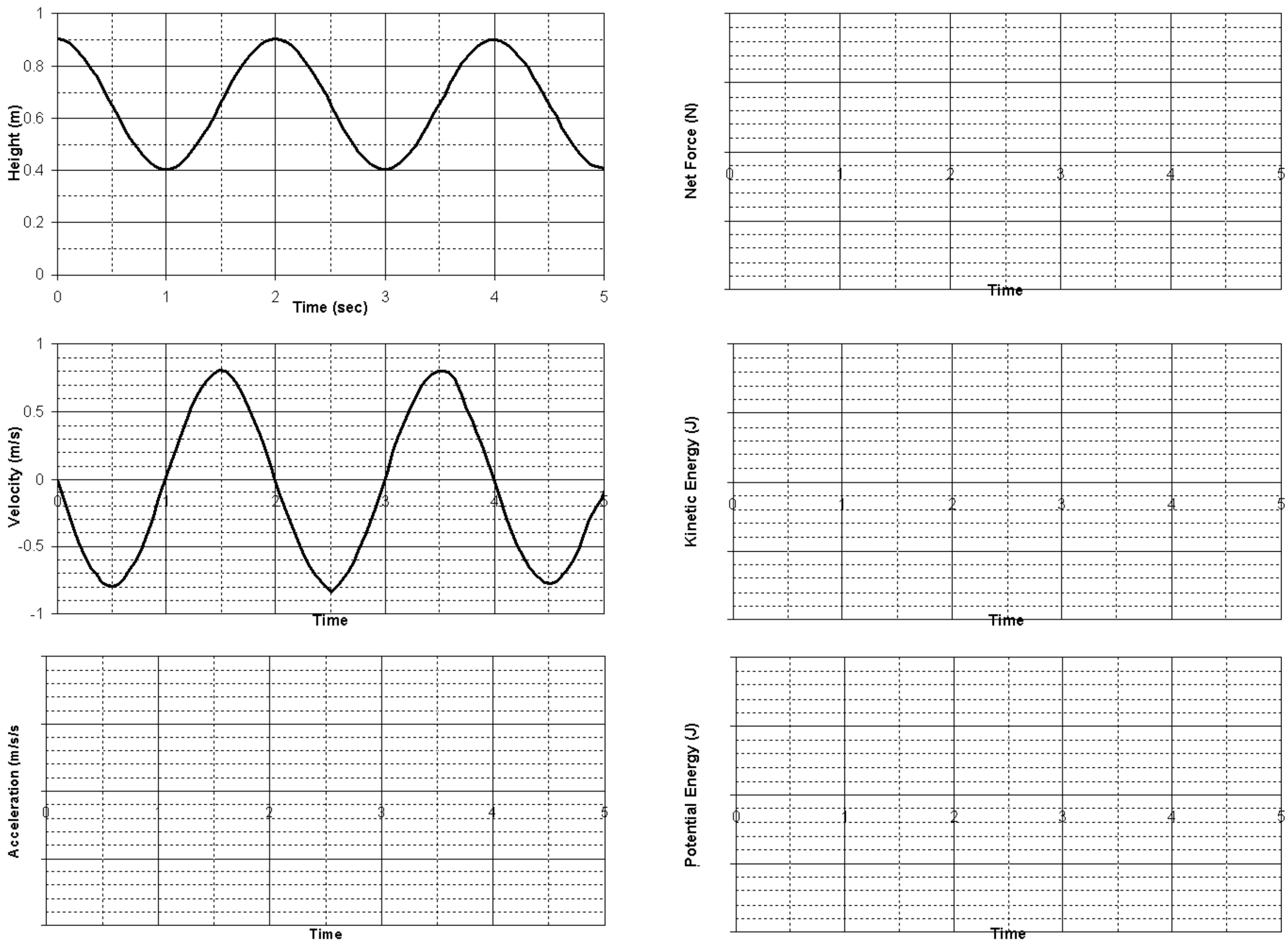
Due On: _______________ Name: __________________________

AP Physics 1: Review Packet 07

Problem 1: The graphs show the motion of an object on the end of a spring. The object is 6.8 kg.



(a) Determine the following. Explain how you found each quantity. Do not merely show equations and calculations—explain where the equations and plug-ins came from with words.

(i) The period of the motion.

(ii) The frequency of the motion.

(iii) The maximum acceleration experienced by the object.

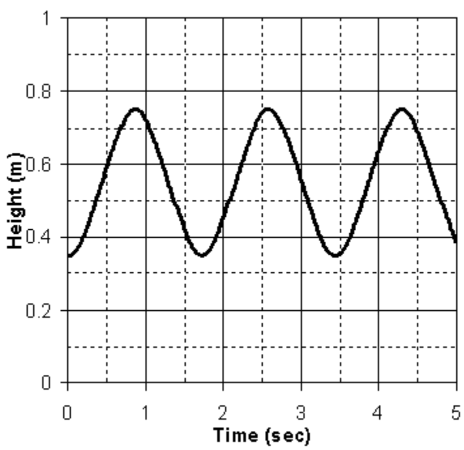
(iv) The maximum net force experienced by the object.

(v) The maximum kinetic energy experienced by the object.

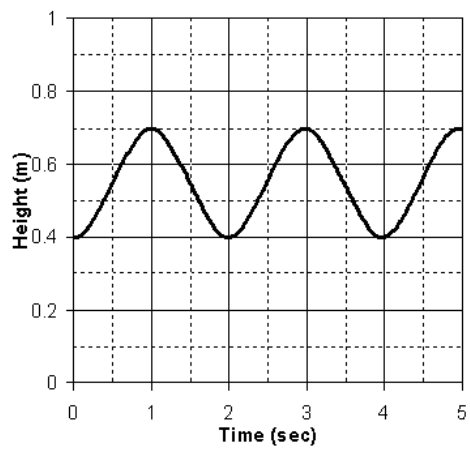
(vi) The spring constant of the spring.

(b) Complete all of the above graphs. Label maxima and minima on each graph with numerical values. Make sure your graphs have the appropriate phase relationship with the first two graphs (when is the graph maximum and minimum).

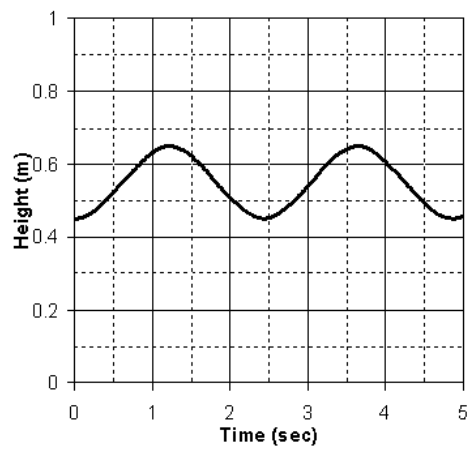
Problem 2: A student is testing to see if a mass oscillating on the end of a rubber band exhibits a simple harmonic motion. The student uses a motion sensor and force sensor to find the rubber band's force and mass's height as functions of time. The three trials are shown below.



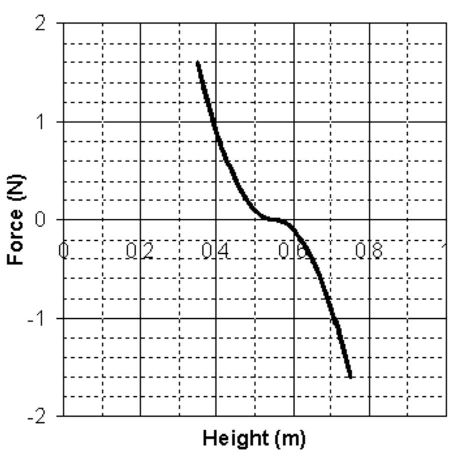
Trial 1 Height vs. Time



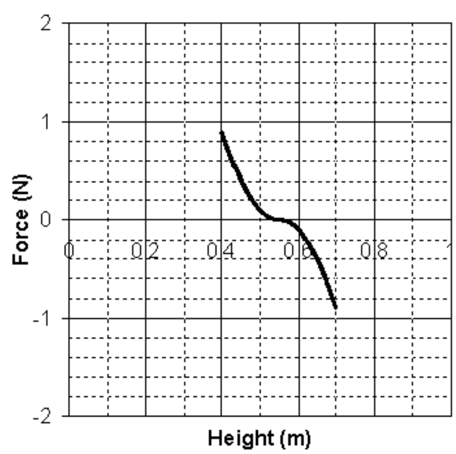
Trial 2 Height vs. Time



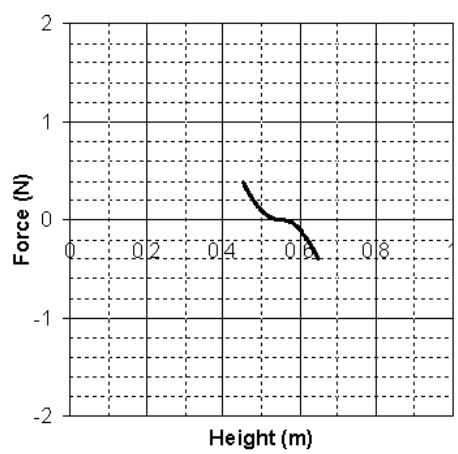
Trial 3 Height vs. Time



Trial 1 Force vs. Height



Trial 2 Force vs. Height



Trial 3 Force vs. Height

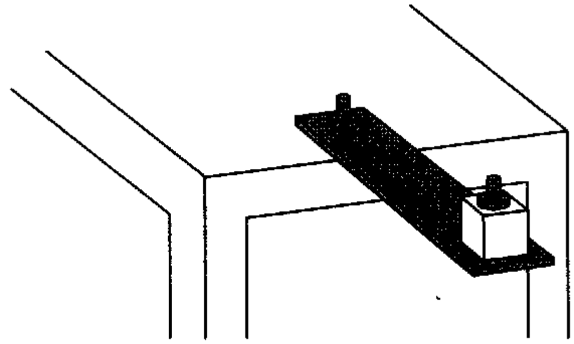
The student also has access to a physics textbook with the following excerpt:

> Not all oscillations (periodic motions) qualify as "simple harmonic motion." Simple Harmonic Motion is a special class of oscillatory motions. To qualify as simple harmonic motion, and oscillation must meet all of the following requirements:
>
> - The graph of any motion quantity (like position or velocity) as a function of time must take the shape of a sine graph.
> - The net force acting on the object must vary linearly with the object's position.
> - The net force must act in a direction that is opposite displacement from equilibrium (where "equilibrium" is the location where net force is zero).
> - The period of the motion must be independent of the amplitude.

(a) In a coherent, paragraph-length response, conclude whether this motion is simple harmonic motion. State evidence that supports your conclusion and why it supports your conclusion. Acknowledge evidence that contradicts your conclusion.

(b) Now consider a ball that is perfectly elastic that is dropped from rest at some height. The ball bounces such that, on each bounce, the ball rises up to the same height from which it was dropped. Explain whether this is simple harmonic motion. You may draw graphs or diagrams to aid your response, as appropriate.

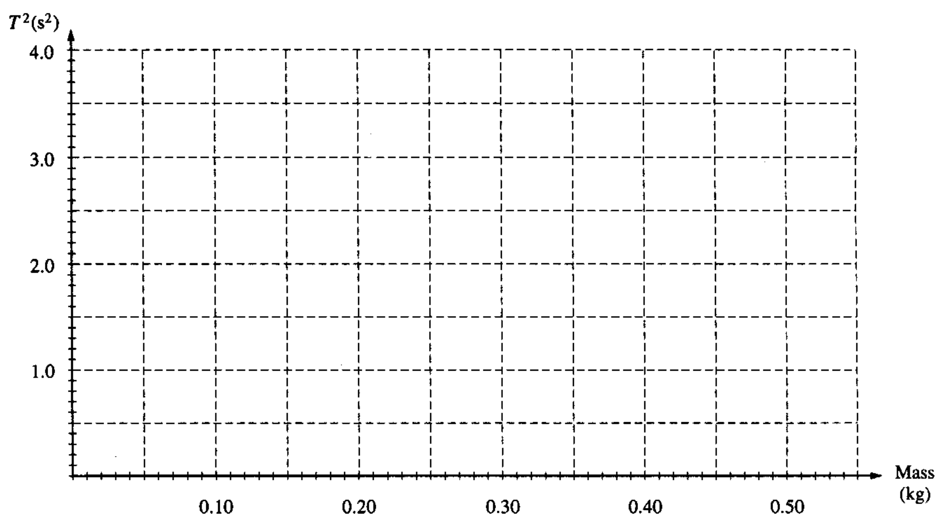
Problem 3: A thin, flexible metal plate attached at one end to a platform, as shown above, can be used to measure mass. When the free end of the plate is pulled won and released, it vibrates in simple harmonic motion with a period that depends on the mass attached to the plate. To calibrate the force constant, objects of known mass are attached to the plate and the plate is vibrated, obtaining the data shown below.



Mass (kg)	Avg. Time for Ten Vibrations (s)	Period T (s)	T^2 (s^2)
0.1	8.86		
0.2	10.6		
0.3	13.5		
0.4	14.7		
0.5	17.7		

(a) Fill in the blanks in the data table.

(b) On the graph below, plot T^2 versus mass. Draw on the graph the line that is your estimate of the best straight-line fit to the data points.



(c) An object whose mass is not known is vibrated on the plate, and the average time for ten vibrations is measured to be 16.1 s. From your graph, determine the mass of the object. Write your answer with a reasonable number of significant digits.

(d) Determine the force constant of the metal plate.

Simple Harmonic Motion Review

IMPORTANT QUANTITIES

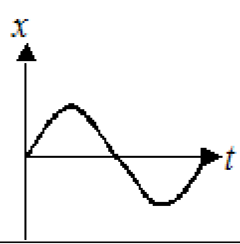
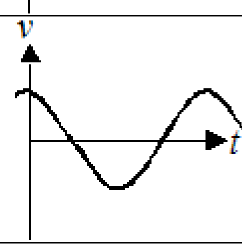
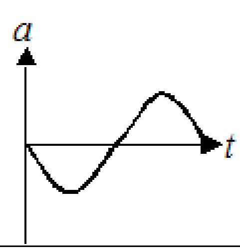
Name	Symbol	Units	Basic Equation
Amplitude	A	m	None

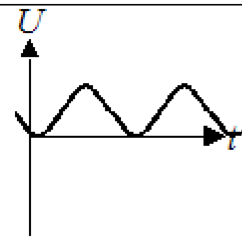
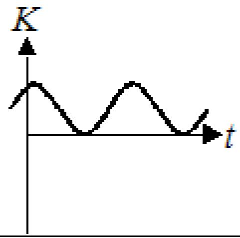
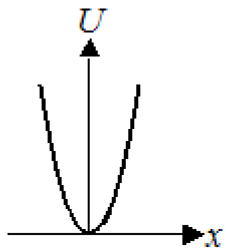
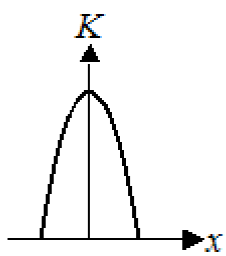
Name	Symbol	Units	Basic Equation
Spring Constant	k	N/m	$F_s = kx$

IMPORTANT EQUATIONS

Name	Equation	Given?	Notes
Period of a Spring-Mass Oscillator	$T = 2\pi\sqrt{\frac{m}{k}}$	Yes	A larger mass will make the period longer, but a stiffer spring will make the period shorter.
Period of a Pendulum	$T = 2\pi\sqrt{\frac{\ell}{g}}$	Yes	The mass at the end of the pendulum does not affect period. A longer string results in a longer periood.
Angular Frequency of a Spring-Mass Oscillator	$\omega = \sqrt{\frac{k}{m}}$	No	Don't memorize this. Instead remember the above equation for period and know that $\omega = \frac{2\pi}{T}$.
Maximum Displacement of a Spring-Mass Oscillator	$x_{\max} = A$	No	Maximum displacement occurs at the endpoints of oscillation.
Maximum Velocity of a Spring-mass Oscillator	$v_{\max} = A\omega$	No	Maximum velocity occurs at the equilibrium point.
Maximum Acceleration of a Spring-mass Oscillator	$a_{\max} = A\omega^2$	No	Maximum acceleration occurs at the endpoints.
Total Energy for a Spring-Block Oscillator	$E_{tot} = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$	No	Total energy is constant throughout the entire oscillation, but "trades off" between kinetic and potential.

IMPORTANT GRAPHS

Name	Graph (Shape)	Notes
Position vs. Time		Displacement varies sinusoidally with time. The highest peak is $x = A$, and the lowest trough is $x = -A$.
Velocity vs. Time		Velocity varies sinusoidally with time. The highest peak is $v = A\omega$, and the lowest trough is $v = -A\omega$.
Acceleration vs. Time		Acceleration varies sinusoidally with time. The highest peak is $a = A\omega^2$, and the lowest trough is $a = -A\omega^2$.

Potential Energy vs. Time		The maximum potential energy is $U_{max} = \frac{1}{2}kA^2$, and only occurs at the points $x = A$ and $x = -A$.
Kinetic Energy vs. Time		The maximum kinetic energy is $K_{max} = \frac{1}{2}kA^2$, and only occurs at the point $x = 0$.
Potential Energy vs. Displacement		PAY ATTENTION TO THE AXES! THIS HAS DISPLACEMENT ON THE HORIZONTAL!
Kinetic Energy vs. Displacement		

IMPORTANT CONCEPTS

- Simple harmonic motion is the constant exchange of potential and kinetic energy from one form to another.
- Maximum speed and maximum kinetic energy both occur at the equilibrium point. They are zero at the endpoints.
- Maximum force, acceleration, and potential energy occur at the endpoints. They are all zero at the equilibrium position.
- When the position graph has a positive slope, the velocity is positive. When the position graph has a negative slope, the velocity is negative.
- When the position graph looks like part of an upward-opening parabola, the acceleration is positive. When the position graph looks like part of a downward-opening parabola, the acceleration is negative.
- When the velocity graph has a positive slope, the acceleration is positive. When the velocity graph has a negative slope, the acceleration is negative.
- The force of a spring is $F_s = kx$. On the AP exam chart, it says $\mathbf{F}_s = -k\mathbf{x}$. The concept-carrying negative indicates that force is directed opposite the displacement of the spring.