1. An object attached to a spring (k = 30N/m) has a velocity of 2.5m/s when it is 0.55m from equilibrium, and it has a period of 2.45s.

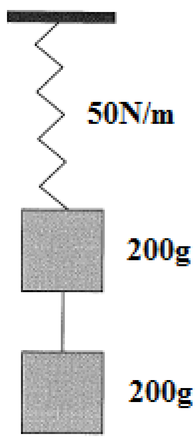
(a) What is the mass of the object?

(b) What is the total energy of the system?

(c) What is the amplitude?

(d) What is the maximum speed?

(e) At what displacement is the speed maximum?



2. Two equal masses of 200g connected by a light string are currently at rest. One of the masses is connected by a spring with constant of 50N/m to a fixed point directly above it. At t = 0, the string is cut, and the mass connected to the spring begins to oscillate.

(a) Determine the period of oscillation.

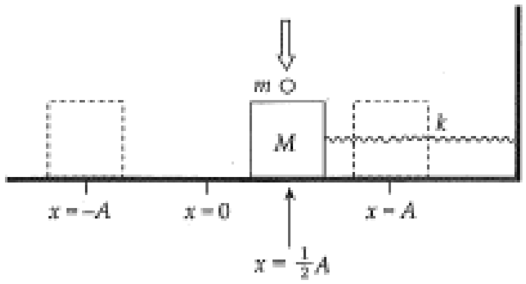
(b) Determine the amplitude of the oscillations.

(c) Determine the maximum speed of the mass.

(d) Which of these three will change if the lower mass is doubled? Explain.

(e) How much is the spring stretched when the mass is moving at half its maximum speed?

3. A block of mass *M* oscillates with amplitude *A* on a frictionless horizontal table and is connected to an ideal spring of force constant *k*. The period of its oscillations is *T*. At the moment when the block is at position x = $\frac{1}{2}$A and moving to the right, a ball of clay of mass *m* is dropped from above and lands on the block.



(a) What is the velocity of the block just before the clay hits?

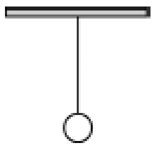
(b) What is the velocity of the block just after the clay hits?

(c) What is the new period of oscillation of the block?

(d) What is the new amplitude of oscillation in terms of *A, k, M,* and *m*?

(e) Would the answer to part (c) be different if the clay had landed on the block when it was at a different position? Explain.

(f) Would the answer to part (d) be different if the clay had landed on the block when it was at a different position? Explain.



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

(a) Select the equipment you would use by circling each appropriate item from the list below.
Meterstick
Stopwatch
Protractor
Photogate
Additional string
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 these 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 or not there is a dependence.

5. You are conducting an experiment to measure the acceleration due to gravity g_u at an unknown location. In the measurement apparatus, a simple pendulum swings past a photogate located at the pendulum's lowest point, which records the time t_{10} for the pendulum to undergo 10 full oscillations. The pendulum consists of a sphere of mass m at the end of a string and has a length l. There are four versions of this apparatus, each with a different length. All four are at the unknown location, and the data shown below are sent to you during the experiment.

ℓ (cm)	t_{10} (s)	T (s)	T^2 (s^2)
12	7.62		
18	8.89		
21	10.09		
32	12.08		

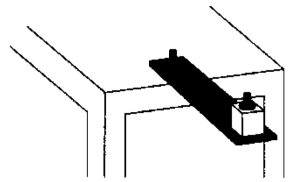
a. For each pendulum, calculate the period T and the square of the period. Use a reasonable number of significant figures. Enter these results in the table above.

b. Plot the square of the period versus the length of the pendulum. Draw a best-fit straight line for this data.

c. Assuming that each pendulum undergoes small amplitude oscillations, from your fit determine the experimental value g_{exp} of the acceleration due to gravity at this unknown location. Justify your answer.

d. If the measurement apparatus allows a determination of g_{exp} that is accurate to within 4%, is your experimental value in agreement with the value 9.80 m/s^2? Justify your answer.

e. Someone informs you that the experimental apparatus is in fact near Earth's surface, but that the experiment has been conducted inside an elevator with a constant acceleration a. Assuming that your experimental value g is exact, determine the magnitude and direction of the elevator's acceleration.



6. 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 down 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.

a. Fill in the blanks in the data table.

Mass (kg)	Average Time for Ten Vibrations (s)	Period T (s)	T^2 (s^2)
0.10	8.86		
0.20	10.6		
0.30	13.5		
0.40	14.7		
0.50	17.7		

b. 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. Explain how one could determine the force constant of the metal plate.

e. Can this device be used to measure mass aboard the space shuttle Columbia as it orbits the Earth? Explain briefly.

f. If Columbia is orbiting at 0.3×10^6 m above the Earth's surface, what is the acceleration of Columbia due to the Earth's gravity? (Radius of Earth = 6.4×10^6 m, mass of Earth = 6.0×10^{24} kg)

g. Since the answer to part (f) is not zero, briefly explain why objects aboard the orbiting Columbia seem weightless.