Physics Exploration Homework Supplement **P110-10.pdf**

Double Spring Oscillator on the Air Track

Go to the Physics Exploration Center. Enter through the resource room 311/312 Thaw Hall. An air cart of mass *m* is connected to two identical springs and is at rest on a horizontal air track as shown in the Figure.

Before starting the exploration, answer the following questions. Ignore the frictional force on the track (due to the presence of air flow).

(a) A student comments: "The net horizontal force on the block is zero no matter how much the spring is displaced to the right from its equilibrium position. This is because the restoring force on the block due to the compressed spring cancels the restoring force due to the stretched spring." Do you agree with the student? Justify your answer by drawing a free body diagram for the block when it is displaced to the right by a distance x from the equilibrium position. Also, write an expression for the net horizontal force in terms of the spring constant k and displacement x for each spring.

(b) Predict and draw rough sketches of the displacement and velocity of the mass as a function of time if you displace the mass from the equilibrium position and then release it. Also, predict and sketch the elastic potential energy, kinetic energy, and the sum of the two for the spring mass system as a function of time. Choose the initial time $t = 0$ to be the time when you release the maximally displaced spring. Keep the time axis such that it is easy to check what the velocity is when the displacement is maximum or what the potential energy is when the kinetic energy was is maximum. Do you expect the motion to be simple harmonic? Why?

<u>Now turn the air on</u>. Move the air cart to the left or right so that one of the springs is compressed and the other spring is stretched. Then, let go of the cart. Perform the following activities:

(c) With the help of the computer, plot the displacement (from the equilibrium position), and velocity of the mass as a function of time. Also, plot the elastic potential energy and kinetic energy of the mass-spring system as a function of time.

(d) Look at the displacement and velocity graphs. What kind of motion do you observe? Is this what you predicted in part (b)? Can you approximate this motion as simple harmonic motion by ignoring friction and air resistance? Explain.

(e) Measure the period of oscillation T from the graph. The mass of the cart is marked on the air cart; from this mass calculate the spring constants for each spring. (Assume that the springs are identical and that the spring constant is the same for both springs.)

(f) Look at the kinetic energy and potential energy for the mass-spring system. The largest kinetic energy corresponds to zero displacement of the mass from the equilibrium position. Is that what you predicted in part (b)? Does this make sense? Justify this result.

(g) Look at the kinetic energy and potential energy for the mass-spring system. The largest elastic potential energy corresponds to largest displacement of the mass from the equilibrium position. Is that what you predicted in part (b)? Does this make sense? Justify this result.

(h) Does the sum of the elastic potential energy and kinetic energy of the mass-spring system as a function of time look similar to what you predicted in part (b)? If this curve is not perfectly horizontal, what is the reason for this? Justify your answer.

(i) Add a 50 gram mass on each side of the air cart for a total of 100 extra grams of mass. Plot the displacement, velocity, potential and kinetic energies for this case. Is the period of oscillation smaller or larger in this case as compared to the period measured in part (c)? Justify your answer. (Note: to plot the correct graph you must readjust the Total Energy Vs. Time graph to reflect the increase in mass of the cart. See the instructions posted beside the air track --- "Instructions for the last question".)