

Coupled Mechanical Oscillations

This lab is on coupled oscillations. It is the last formal laboratory experiment for this course, and you should try to have fun with it. Think of different things you can measure and compare with predictions, but also see if you can understand the motion, whether it is simple (i.e. eigenmodes) or more complex, by comparing it with a predicted curve of position as a function of time.

Refer to the class notes on coupled oscillations for details of the formalism.

You will have your own two-mass and three-spring setups, and you are encouraged to work in pairs in the same way as for previous labs. You will be able to take data using the motion sensor, following just one of the two masses. In this, your last laboratory for the term, I encourage you to be creative.

There will be a limited number of new prototype setups available for taking data. Instead of motion sensors, there will be accelerometers for measuring each cart's motion. The connection to your computer is through a local wireless network, which interfaces to a board connected to your laptop through the USB port. Some of you may want to try this. Being able to follow both carts simultaneously will make it possible to test various aspects of the coupled oscillation solution. For example, you could show that $x_1(t) \pm x_2(t)$ are eigenmodes, regardless of how you start out the system.

Here are some suggestions for data taking and analysis strategies.

- Measure the normal mode frequencies and compare their ratio to expectations. It can be tricky to get the masses into exact eigenmodes, but do the best you can. You can take several trials, getting the period from the zero crossings, and use the average and standard deviation (or just the range) for the value and uncertainty. For identical masses and springs, you know what you should get. How do you calculate the ratio if the coupling spring has a different value?
- Predict absolute values of the eigenmode frequencies. This will be similar to earlier labs. You'll need the mass of the carts, and values for the spring constants.
- Eigenmodes for different masses. How do you expect things to change if the two masses have different values? Try this, and see if you can set the system in motion in one or both of the two eigenmodes. Does this agree with what you expect from the equations of motion?
- General motion of the system. After you determine the eigenfrequencies, try setting one of the masses in motion from rest but away from its equilibrium position. See if its subsequent motion agrees with the predicted motion from the notes. It's probably easiest to try this first with equal masses and three identical springs, but you can of course see what happens in a more general case.