

Tips for controls:

- Tabs at the top of the page toggle between 1D and 2D systems.
- You can put the system into motion either by grabbing and releasing a mass or by adjusting the mode controls.
- In 1D, you can set amplitudes and phases of the modes independently with the slider controls. Also in 1D, if you “pluck” the system, by grabbing and releasing a mass, the sliders show you the amplitudes and phases of all the modes for that motion. In 2D, however, the control and display of modes is more limited. In 2D, you can turn a given mode on or off by clicking on the appropriate button in the Mode Spectrum Display Panel, but you cannot adjust the phase or the magnitude of the amplitude of an individual mode. Also, in 2D, when you pluck the system there is no readout of the phases of the modes: the Display Panel shows relative amplitudes only.
- You can pause the sim, with the **Stop** button, and then use **Step** to move forward in time incrementally. You can also adjust the speed of the sim, with the sim speed slider.
- In 1D, to understand the effect of changing the phase of a mode, it is useful to pause the simulation (by pressing the **Stop** button) and then adjust the phase and amplitude sliders while the sim is paused.
- If you are doing a lecture demonstration, set your screen resolution to 1024x768 so the simulation will fill the screen and be seen easily.

Important modeling notes / simplifications:

The frequencies of the normal modes shown in this sim are those for small amplitude motions in a system under constant tension. For pedagogical simplicity, we use the same frequency for a given normal mode, regardless of how large the amplitude of the mode is. In a real system, large amplitude motion would result in larger tension and non-linear effects; i.e. mode-mixing.

Insights into student use / thinking:

A normal mode is a motion of the system that involves *all* the masses. Because the number of normal modes is always equal to the number of masses, some students may mistakenly think that a given normal mode is associated with the motion of a given mass.

Suggestions for sim use:

- Have the student, either singly or in groups, estimate the relative amplitudes of the modes (the power spectrum) for a given motion of the masses. In 1D, you can turn off the displays of the amplitude and phases of the modes with the little red “minus” buttons. With the room projector off, the teacher sets the mode spectrum with the sliders and then turns off the mode spectrum display. When the projector is turned on, the students see only the motion of the masses. The students then estimate the power spectrum and commit answers to paper, before the spectrum is revealed.
- For general tips on using PhET sims with your students see: [Guidelines for Inquiry Contributions](#), [Using PhET Sims](#), [Teaching Physics using PhET Simulations](#), and [Teacher Ideas & Activities](#)