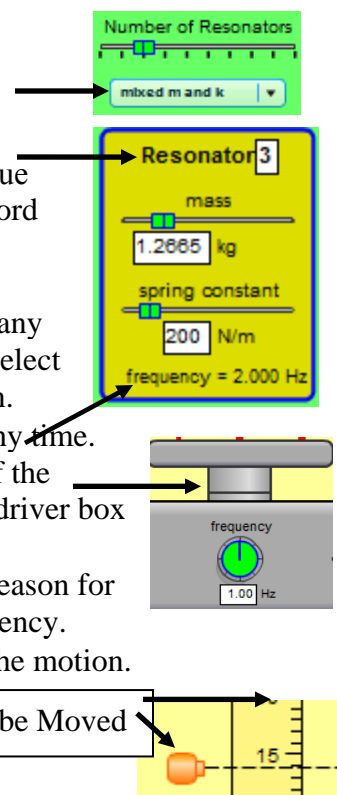


Tips for controls:

- The word “resonator” means a particular mass-spring system.
- If there is more than one resonator, a pull-down menu of preset combinations appears in the control panel on the right.
- The Resonator panel displays information about a particular “selected” resonator. To select a resonator, either click on the blue mass or enter the resonator number in the text box next to the word “Resonator”.
- You can change the mass and spring constant of the selected resonator with the sliders in the Resonator panel. If you change any of the masses or springs, the pull-down menu box changes to “Select Preset”. The “mixed m and k” choice is the default combination.
- There are two different frequencies displayed on the screen at any time. The frequency in the Resonator panel is the natural frequency of the selected resonator. The frequency on rotary control on the gray driver box is the driving frequency.
- The frequency dial can be turned through more than 360°. The reason for this is to allow the user more precision in setting the exact frequency.
- You can **Pause** the sim and then use **Step** to incrementally see the motion.
- The Ruler, which is grabbable, comes with horizontal reference lines which are also grabbable.
- To see the effects of varying the frequency and amplitude of the driver, it may be more instructive to use several resonators.
- To view in full screen, “F11” works on most Windows browsers. Check out FAQ’s for more ideas: <http://phet.colorado.edu/en/troubleshooting>
- 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 frequency shown is real-time, if the Sim Speed slider is set to “normal”.
- The natural frequency of a resonator shown in the Resonator panel is given by the formula $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$.
- This sim assumes a frictional force of the form $F_{drag} = -b * v$, where v is the velocity, and b is the “damping constant” displayed in the control panel. All resonators use the same damping constant that is selected.

Student difficulties:

- Some students wonder why the masses can pass through the driver platform, rather than collide with it. The reason for this is that this sim is designed to demonstrate driven, damped simple harmonic motion. Collisions with the platform would break the model.

- Some students have difficulty understanding the term “Damping” in this complex sim. It might be useful to have them explore Waves on a String or Masses & Springs (but damping is called “friction” in this sim because the audience is lower lever).
- If the damping constant is very low, and the amplitude is high, it takes a long time for the transient behavior to settle out and the steady-state behavior to become evident. This correct behavior is designed to teach higher-level learning goals.
- For the first three presets (same k , same m , mixed m & k), the parameters are such that the resonant frequencies are 1.0 Hz, 1.5 Hz, 2.0 Hz, 2.5 Hz etc. Some students are puzzled that the frequencies don't change when the preset is changed.
- Students turned the frequency dial so fast that they didn't really see the resonance move down the line of resonators. The lesson might include a prompt to use the frequency dial slowly.

Suggestions for sim use:

- This sim would be very useful for demonstration.
- For other examples of damping, use [Waves on a String](#) (damping slider) or [Masses and Springs](#) (friction slider)
- For tips on using PhET sims with your students see: [Guidelines for Inquiry Contributions](#) and [Using PhET Sims](#)
- The simulations have been used successfully with homework, lectures, in-class activities, or lab activities. Use them for introduction to concepts, learning new concepts, reinforcement of concepts, as visual aids for interactive demonstrations, or with in-class clicker questions. To read more, see [Teaching Physics using PhET Simulations](#)
- For activities and lesson plans written by the PhET team and other teachers, see: [Teacher Ideas & Activities](#)