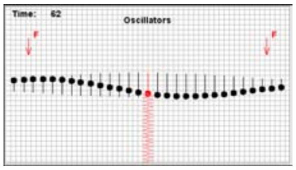
Worksheet for Exploration 16.7: A Chain of Oscillators



Twenty-nine damped harmonic oscillators are driven by an external force, sin(t). Each oscillator can be thought of as a mass connected to the floor with a spring. The masses are not connected to each other in any way. One spring has been shown for demonstration purposes. Restart.

The center oscillator, shown in red, is in resonance with the external force. It has a natural frequency of oscillation of $\omega = 1$ rad/s. Oscillators to the left have a spring with a lower spring constant, while those on the right have a larger spring constant. This animation shows how this collection of oscillators responds to the driving force.

The animation starts with all oscillators at rest. The oscillators then begin to move up and down in phase with the driving force during the first few cycles. This motion is, however, transient; and differing amplitudes and phases soon manifest themselves. Since oscillators to the right of the center have a higher resonance frequency, they begin to lead the driving force; while those to the left of center begin to lag. Although the above oscillators are not connected, this phase shift gives the appearance of a traveling wave. After a few hundred oscillations the transient behavior has dissipated; and a resonance curve appears since the amplitude and phase of each oscillator approach their steady state behavior.

a. Find an example of a resonance curve (amplitude vs. frequency) in your textbook. How does the motion of the masses relate to the resonance curve you found in your book? Hint: Look at both amplitude and phase.

b. What effect does the damping coefficient have on the motion of the masses?

c. Assume that the mass of each ball is 1 kg and that the spring constant for the center spring is 1 N/m. By how much does the spring constant change between neighboring springs?