Free Fleas in Breezy Trees: Resonance

Commentary

Dr. Seuss liked to rhyme, but I like to observe natural phenomena like swaying trees in the wind and note that there is some order in Nature. Have you ever noticed that swaying traffic lights, vibrating telephone wires, and even trees of similar size can act as windspeed indicators? The harder it blows, the faster they move! Have you ever pushed yourself or a child on a swing? Did you notice that you must push at just the right time in order to make the arc increasingly large? Perhaps you have seen a video of the famous Tacoma Narrows Bridge collapse, which resulted from wind-induced motion.

The back and forth motion of a tree or swing or the up and down of a car with bad shock absorbers or any mass on a spring is called ***simple harmonic motion*** (SHM), or oscillation. Yes, the word is related to the musical term harmony. The SIZE of the motion is called the ***amplitude***. The objects undergoing SHM are called ***oscillators***. You can initiate SHM and increase the amplitude by "forcing" the oscillator at just the right RATE, which is the same as the ***natural frequency*** of oscillation. The frequency of an object, in cycles per second, or Hertz, is equal to one divided by the period of oscillation (time it takes for one complete cycle). This important phenomenon by which motion is maintained and energy is put into a vibrating system is called ***resonance***. In this exercise, we will construct a simple apparatus for demonstrating mechanical resonance (you can hear the acoustical equivalent by singing in the shower).

Inquiry

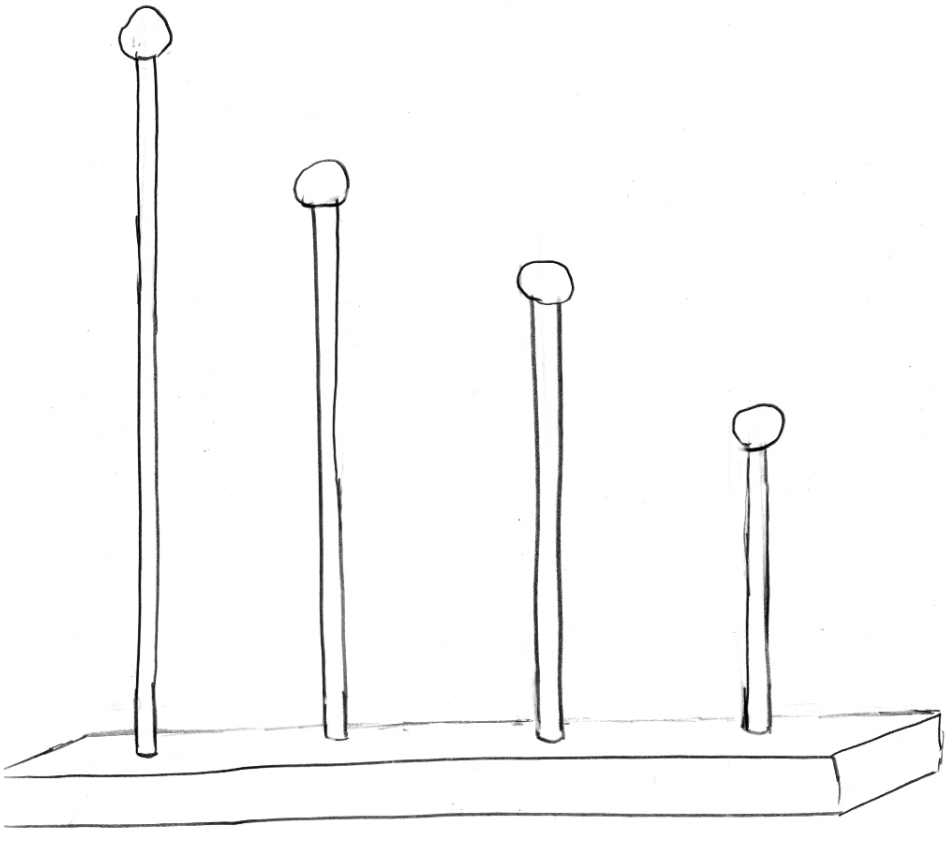
Materials required: Styrofoam board, cut to about 2"W x 12" long, small diameter (1/8" preferred) dowels or other thin sticks which bend easily, and modeling clay.

1. Obtain a piece of 1” or 2” thick Styrofoam board or some other object into which you can push sticks.

- Cut your sticks into four pieces of varying lengths. It is not advisable to make them shorter than 8” or longer than 20”. You will see why.

- Insert the sticks into the board in a row and top them with balls of clay about ½”-1” in diameter – the exact size is not important, but the ball must outweigh the stick.

- Place the assembly on a tabletop with the sticks vertical and slide it **back and forth** (NOT side to side so the sticks hit each other!). Try to vary the frequency of the sliding motion so that ONLY the longest stick moves back and forth. You have found the **resonant frequency** for that stick!



2. Can you make the other sticks sway to and fro, one at a time? Do you have to increase or decrease the frequency? Do you have to push hard or is it actually easier when at resonance?

3. Rank the sticks in order of frequency required to excite them. Are there frequencies for which there is no significant oscillation at all for any of them? Explain your answer and your observations.

4. *(Do at Home:)* Make observations of several objects undergoing SHM and record your observations in your portfolio. Indicate what the driving force was. Guess at the period of oscillation. Look for relationships between size and period. If it is the wind that is forcing the oscillation, see if you can see a correlation between motion and wind speed. For slender objects like wires, the frequency of the driving force is proportional to wind speed due to turbulence as the wind blows past the object. The Greeks used to build "Wind Harps" which harnessed this phenomenon to make music. You can do something similar by clasping a large blade of grass between the heels of your two cupped hands and blowing hard over the grass. It should emit a shrill noise as it vibrates. Try it!