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Longitudinal Wave Demonstrator #1811

Warning:

- Not a toy; use only in a laboratory or educational setting.
- California Proposition 65
 Warning: This product can
 expose you to chemicals including lead, which are
 known to the State of California to cause cancer,
 birth defects, or other reproductive harm. For more
 information go to www.P65Warnings.ca.gov.

Introduction

Waves are an essential part of physics. They are a major means of transferring energy across a distance. They can exist as **electromagnetic waves**, in which the energy is moved via electric and magnetic fields with or without a medium to travel through, or as **mechanical waves**, where energy moves through matter in oscillating patterns.

This set of instructions will teach you how to use your Longitudinal Wave Demonstrator to explore the workings of mechanical waves by

creating some for yourself as you transfer energy from one end of a spring to the other. Concepts related to waves such as **resonance**, **propagation**, **reflection**, and **interference** can also be shown with your new device.

Its 110cm long spring is suspended from two metal rods fastened between two metal frames. Three additional metal rods hold up a white cotton backdrop to make your spring and waves more visible. On each frame is an oscillator rod with movable weights that you can use to manipulate the size and frequency of the waves you make.

The next couple of pages will explain your device to you in more detail by laying out each component piece and then explaining how to put them all together. Various demonstrations that you can then perform will be found on the pages that follow.



Components

- 1. Bag of small screws and washers
- 2. Spring with metal rings for hanging
- 3. Metal frames with oscillators

- 4. White backdrop
- 5. Rods with two holes for screws (x5)
- 6. Rods with one threaded post and one hole for screws (x5)



Parts List

Setting Up Your Device

This fantastic demonstration can show off some great waves, but it needs to be carefully assembled first. Follow the instructions below exactly to make sure your device is set up without any problems.

1. Screw your rods together. Using Figure 1 to the right and the parts list on the previous page for reference, take the four rods with the threaded posts (#6) and screw their posts into the larger hole on the other rods (#5). You will be left with five long rods with identical holes for small screws (#1) at either end. Figure 2 shows the connection between rods #5 and #6.



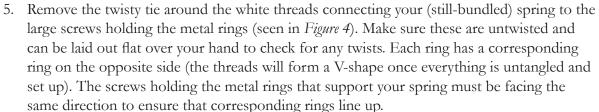
Figure 1

- 2. Slip one rod into each loop of your cloth backdrop.
- 3. Open your bag of screws and washers, and make sure your metal bases are oriented correctly (the oscillating rods on each base will be on the outward facing side of each frame). Take the rods sticking through the holes of your backdrop and, using Figure 3 as your guide, screw them into holes #3 and #4 by placing a washer over the side of the hole on the frame opposite of your rod and then tightly fastening a screw in that hole with the help of a small Phillips screwdriver.



Figure 2

4. Grab a third rod, and screw it into holes #5 on each base, using the rod to hold the backdrop in position. Look at the assembled product on the first page of this document to see how the backdrop is supposed to look.





6. Once these strings are untangled, carefully remove the washer from the end of the screws holding the metal rings in order (Note: Errors here can result in difficult tangles. Proceed through this and the next step very carefully). Place the washer to the side and then slide the metal rings onto one of your remaining two metal rods that you have yet to screw into your frame. Do the same with the other set of metal rings onto your last metal rod. Do one more quick check to confirm that your rings are on the rods in the proper order.



Figure 3

Figure 4

- 7. Without letting your rings slide off and lose their order, screw your metal rods into holes #1 and #2 of your base. The rings should hang parallel and adjacent to each other as they suspend the spring below them.
- 8. If your rings appear like they do on the completed product on page one (albeit a little squished together), you may finally undo the twisty tie around your spring and stretch it out.
- 9. Adjust the rings so that they are equally distanced from each other and they hold the spring equally stretched out across the length of the wave demonstrator. Your spring will be attached to the oscillators on your frame as needed in the demonstrations on the following page.

How to Use

Check out the experiments below to explore longitudinal waves, the relationship between wavelength and frequency, the propagation of pulses, reflection, and standing waves.

Transmission of Longitudinal Waves

- 1. Grab one of the free-hanging sides of the spring, and slip its end into the space between the oscillator rod and the adjustment screw on the small, metal slide below the weight. This metal slide should generally rest a little below the halfway point of your oscillator rod, but you can experiment with its placement. You may need to loosen the adjustment screw in order for the spring's end to slip in. Tighten as necessary all the adjustment screws on the oscillator to securely attach the spring to the oscillator and the rod to the frame.
- 2. At the end of the spring that is still free-hanging, take five or six metal suspension rings and slide them into each other towards the center of the device. This will bunch up the spring on this end and dampen incoming waves.
- 3. Grab the top of the oscillator rod that is attached to your spring, bend it back about four inches away from the spring, and release it (Note: Bending the oscillator back farther than four inches can make more pronounced waves, but use caution and your best judgment to not permanently crease and damage your oscillator rod).
- 4. Observe the longitudinal waves travel from the oscillator down the length of the spring.

Wavelength and Frequency

- 1. Set up the device as described above in steps 1 and 2.
- 2. Loosen the adjustment screw on the oscillator's weight.
- 3. Adjust the weight's position, and tighten its screw to hold it in place.
- 4. Use the oscillator again as described above in step 3.
- 5. Repeat the above steps with different positions for the weight, including removing it completely. Observe the frequency of your waves increase as their wavelengths decrease.

Propagation of Pulses

- 1. Set up the device as described in the Transmission experiment in steps 1 and 2.
- 2. Pull the oscillator back as described above, release it, and stop it quickly by grabbing the weight, creating pulses.

Reflection of Longitudinal Waves

- 1. Attach both ends of the spring to the oscillators as described in the Transmission experiment.
- 2. Create pulses as described in the Propagation of Pulses experiment using one of the oscillators.
- 3. Observe the waves as they are reflected at the opposite end. Holding the unmoved oscillator in place can make this easier to view.
- 4. Adjust the weights on your oscillators so that one is placed at the top of its oscillator and the other is towards the bottom of its oscillator. This will allow you to create pulses with different wavelengths.
- 5. Create pulses with both oscillators at the same time. Observe that the waves reflect back in the opposite direction with their own unique wavelengths.

Standing Waves

- 1. Set up the device with the spring attached to both oscillators, as described above in step 1 of the Reflection experiment.
- 2. Use one of the oscillators to start making waves. The waves will reflect back and interfere with the incoming waves still being created by the oscillator.
- 3. Adjust the placement of the weight, and repeat step 2.
- 4. Repeat step 3 until you notice the waves seemingly staying in place across the length of the spring. This is what is known as a standing wave.