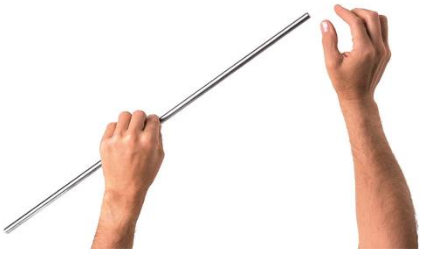
Sound and Waves Discovery Bundle

P7-2030

Contents

Super Springy



Singing Rods

Boomwhackers

Sound Pipe

Doppler Ball

Individual Standing Wave Demo

Music Box Mechanism

Spring Wave

Item	Topics	Instructions
Super Springy (33-0130)	Wave Types, Wave Properties	Demonstrate transverse waves by shaking the spring from side to side. Show longitudinal waves by shaking it lengthwise. Demonstrate reflection, interference, and the dependence of a wave's speed on its medium.
Singing Rods (P7-7250)	Sources of Sound, Standing Waves	Instructional Guide Included
Boomwhackers (P7-7400)	Sources of Sound, Resonance, Frequency, and Pitch	Instructional Guide Included
Sound Pipe (P7-7200)	Standing Waves, Harmonics, Resonance	Instructional Guide Included
Doppler Ball (P7-7120)	Doppler Effect	Instructional Guide Included
Standing Wave Demo (individual of P6-7700)	Standing Waves	Instructional Guide Included
Music Box Mechanism (P7-7330)	Transmission of Sound Sources of Sound	Instructional Guide Included
Spring Wave (P7-7220)	Wave Types, Wave Properties, Wave Interactions	Instructional Guide Included

Related Products

Mechanical Wave Complete Bundle (P7-1100) The Arbor Scientific Mechanical Wave Complete Bundle makes harmonic and motion demonstrations affordable for ALL Physics classrooms.

Mini Ripple Tank (PA-8638) The Mini Ripple Tank provides a simple and effective method to investigate wave properties. The tank has settings that allow you to adjust the wave frequency and the frequency of the strobe light showing a broad range of wave patterns.

Acrylic Pendulum Wave (P4-1755) Captivate your students using the Acrylic Pendulum Wave, which consists of a series of pendula with increasing time periods.

Singing Rods (Set of 2)

P7-7250

INSTRUCTIONAL GUIDE

Contents

- 75 cm Singing Rod
- 50 cm Singing Rod
- Bag of Rosin

Recommended for activities:

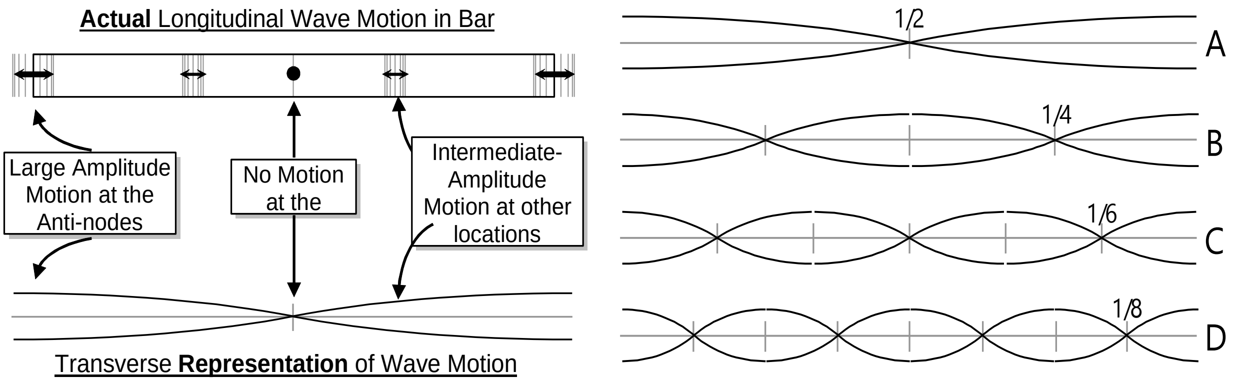
- Sound Level Sensor (P7-7700)

Background

The Singing Rods “sing” because of resonance, the building up of standing longitudinal waves. These waves are created by the repeated sliding of your hand down the length of the rod, which causes vibrations within the metal. This action is helped by the addition of rosin, which causes your thumb and forefinger to stick to the rod more and vibrate as they traverse the length of the rod. The pitch of the sound can be varied by changing where one holds the Singing Rod or by changing the length of the rod itself.

Standing Waves

Although the waves in the singing rod are longitudinal, they are more easily represented by showing a transverse standing wave. The diagram to the right shows how the motion is represented. When an object such as the Singing Rod resonates, standing waves result.



A standing wave in the rod has nodes, or regions where the rod does not vibrate at all, and antinodes, or regions where the rod is vibrating at its maximum. A rod will always have antinodes at its ends. The lower diagram shows the four standing wave patterns that will occur in the singing rods. Each pattern has antinodes at the ends of the rod and equally spaced nodes in between.

As the rod vibrates longitudinally, holding the rod at the place you don’t want it to vibrate forces it into one of these wave patterns. The damping from your fingers will cause a node to occur there.

Instructions

Each Singing Rod is marked at its center. The longer of the two is also marked near both ends at a fourth of the length of the rod. The trick to making the Singing Rods sing is in how the rod is held and in the generous use of rosin. Begin by holding the center of one rod firmly between the thumb and forefinger of one hand (using the edges of your fingers to minimize the area of contact). Place some rosin on your other thumb and forefinger and pinch the rod while pulling your fingers towards its end. Each successive stroke on the rod will add to the amplitude of the vibrations within the rod until you can begin to hear them. By continuing this action, the sound will become louder and louder. With a little practice you will be able to generate a sound that will certainly get your students' attention as well as cause teachers in classrooms down the hall to wonder what mischief you're up to.

If you do not want your hand to get as dirty, try putting rosin on a heavy cloth and rubbing the cloth on the rod. As you use your Singing Rods more, and as more rosin coats the surface, it will be easier to generate a sound.

Activities

1. A basic lesson that can be seen immediately is causing the longer of the two Singing Rods to "sing" by holding the marked center point of the rod and noting its pitch (wave pattern A). Then take the same rod and hold it by one of the marks near the end. When the rod begins to sing, a noticeable change in pitch can be heard (wave pattern B). This will reinforce the idea of the inverse relationship between frequency and wavelength. Examine the diagrams above and notice that the wavelength of wave pattern B is half that of wave pattern A. That means that the frequency is doubled. You may be able to notice that the higher tone is exactly one octave above the lower.

   Note: The tone you hear is not the only wave occurring in the rod. When you force a node in the center of the rod, higher resonant frequencies with nodes in the center also exist. The longest wave is the loudest, though, and that is the one you hear. (E.g. When you produce wave pattern A, wave pattern C also exists, although you cannot hear it.)

2. Next, while the rod is "singing" in wave pattern B, grasp it at the mark near the opposite end. Since the mark represents the other node in that wave pattern, grasping it there will not stop the vibration. Touching the rod anywhere else will stop the sound.

3. Other wave patterns can be produced in the rod (wave patterns C, D, and beyond), but their pitches are too high for most people to hear. For that reason, only the nodes for the longest two waves have been marked on the longer rod. The shorter rod has only been marked in the center, but some people can hear wave pattern B (with a very high pitch) in it also. Estimate or measure ¼ of the rod length and try to force a node there.

4. Measure the frequency produced by each rod. Use that, along with the wavelength (determined from the diagrams above) to find the speed of sound in aluminum. Compare that to the speed of sound in air.

5. Use a **sound level meter** to measure the loudness of the sound produced down the length of the bar. Show how the sound intensity increases at the antinodes and decreases at the nodes.

6. Demonstrate the Doppler effect by tying a string around the rod at its middle node. Make the rod sing and swing the rod as a pendulum. You will hear the sound change pitch as it approaches and recedes. You can also spin the rod on its string. Since the sound is mostly coming from the ends of the rod, as the rod spins you hear a combination of the approaching and receding ends, resulting in a beat frequency.

7. You can also produce transverse waves in the singing rod. Hold the rod at the middle node and strike it with a mallet on the side near the end of the rod. You will hear a lower pitch that dies away. The higher pitch of the longitudinal waves persists longer. The production of transverse waves in the singing rods is more complex. They do not follow the same pattern as the longitudinal waves.

Related Products

Chladni Plates Kit (P7-1500-04) The first step to Visualize Acoustics! At special frequencies, standing waves appear on the plate, driving the sand away from the points of large vibration to points of no vibrations.

Transverse Wave String (P7-1500-03) This Wave string is ideal for demonstrating standing waves. Typical experiments such as the resonant frequencies of taut vibrating string can be performed with additional parts.

Set of 8 Boomwhackers (P7-7400) Demonstrate open- and closed-piped resonance with these colorful tubes. When whacked against the floor or your knee, each tube produces a clear tone. Students can even play songs!

Extra Rosin (P7-7250-01) For use with Singing Rods (P7-7250)

Acknowledgement

Thanks to Mark Fischer, Assistant Professor at College of Mount St. Joseph, for making the diagrams and for activity suggestions.

This page intentionally left blank.

Set of 8 Boomwhackers

P7-7400

INSTRUCTIONAL GUIDE

Contents

- 8-note, C-major scale Boomwhackers
- 4 end caps
- Instructional Guide

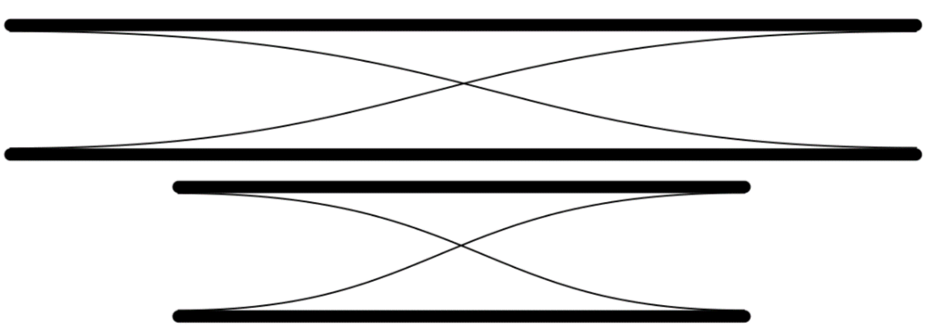
Background

Boomwhackers create distinct tones when whacked against a surface. The tone is determined by the length of the tube. The tubes are cut to the correct lengths to form the eight notes in a C major diatonic scale (C-D-E-F-G-A-B-C).

The tubes create tones in much the same way as other tube-shaped instruments. They filter a particular tone from noise that is introduced into the tube. A clarinet is played by vibrating a reed at one end. The reed does not vibrate at any particular frequency, but produces a range of frequencies (a buzzing noise). The shape of the clarinet and which holes are covered determine which frequency is amplified. Boomwhackers work in much the same way. Whacking the tube produces a noisy sound that contains many frequencies. The tube, because of its length, resonates and amplifies one of the frequencies. Notice, in the figures below, that the resonant wavelength is one that has antinodes at both ends of the tube.

Experiments

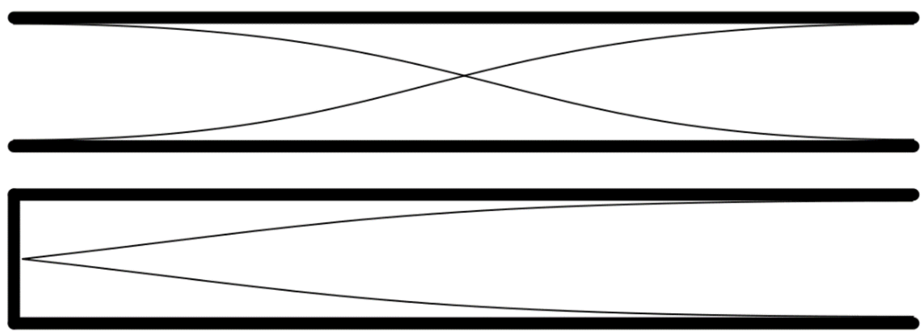
1. **Pitch/Wavelength:** Whack two different tubes. Which tube produces the lower tone? How do the lengths of the tubes compare? Longer tubes produce lower tones because they amplify a longer wavelength (lower frequency).



2. **Resonance:** Hum loudly over the end of a tube near and at its natural frequency. The tube will vibrate when you reach its natural frequency, in addition to amplifying the sound.

3. **Resonance 2:** Strike a 256 Hz tuning fork and hold it just inside the end of the longest C tube. The tube will resonate and amplify the 256-Hz tone. Strike the tuning fork again and hold just inside the SHORTEST C tube. The short tube also resonates, because the tuning fork's vibration includes another frequency, 512 Hz. This overtone is much quieter than the fundamental tone, so it is usually not noticed.

4. **Open/Closed Pipe Resonance:** Whack one tube and notice the tone it produces. Cap one end with one of the black caps and whack the tube again. How does the new tone differ from that produced by the open tube? The capped (closed) pipe produces a tone that is exactly one octave lower than the uncapped (open) pipe. The cap forces a node to be at the end of the tube, and the lowest resonant wavelength is twice as long as the wavelength of the uncapped tube. An octave is produced by doubling the frequency (or halving the wavelength) of a sound.



5. **Noise Filtering:** Take the Boomwhackers to a noisy environment, such as a crowded hallway or cafeteria. Put a tube to your ear and listen to the sounds. The tube filters and amplifies the same tone that it produces when it is whacked. If you hold the tube tightly against your head, it becomes a closed tube and will amplify the note an octave lower.

6. **End Correction:** Ideal open pipes amplify a sound whose wavelength matches the length of the pipe. The frequencies of each note are listed below. Calculate the wavelength of each note (wavelength = speed of sound in air / frequency) and compare them to the tube lengths. (For open pipes, the length of the tube is HALF of the wavelength of the fundamental tone. See the diagrams above.) The tubes are a bit shorter than the calculated wavelengths. This is because the vibrating air in the tube does not disperse immediately at the end of the tube. This causes the tube to effectively be slightly longer when it is played.

C: 256 Hz	**F:** 341.3 Hz	**B:** 480 Hz
D: 288 Hz	**G:** 384 Hz	**C:** 512 Hz
E: 320 Hz	**A:** 426.7 Hz	

Related Products

Sound and Wave Discovery Bundle (P7-2030) Hands-on discovery brings lessons on Sound & Waves to life, with this complete sound and wave explorations kit!

Standing Wave Kit (10pk) (P6-7700) Perfect for middle school and high school students, this kit includes all the materials you need to make 10 standing wave demonstrations. Instructions include qualitative and quantitative experiment ideas.

Mechanical Wave Complete Bundle (P7-1100) The Arbor Scientific Mechanical Wave Complete Bundle makes harmonic and motion demonstrations affordable for ALL Physics classrooms.

Sound Pipe

P7-7200

INSTRUCTIONAL GUIDE

Contents

- Sound Pipe
- Instructional Guide

Background

What makes the Sound Pipe produce sounds? The answer is a combination of resonance and Bernoulli's principle.

When you twirl the Sound Pipe, the outer end moves faster than the end in your hand. Bernoulli's principle states that the faster a fluid (like air) moves across a surface, the lower the pressure on the surface will be. With higher pressure occurring at the end of the tube held in your hand, the pressure differential results in air rushing up the tube. The faster you twirl the Sound Pipe, the greater the pressure differential, increasing the speed of air moving up the tube.

Introduction

Turbulence is created when air travels through the tube. This turbulence is compounded by the ridges in the sides of the tube. These turbulences produce areas of high and low pressure which when traveling along the tube form the vibrations known as waves. Sound waves traveling out the open ends of the tube partially reflect into the tube. (Because we can hear the sound outside the tube, we know the reflection is not complete.) If the wavelength of the reflected wave matches the wavelength of the incoming wave, these waves reinforce one another, producing sound waves of greater amplitude (sound waves loud enough to hear) and that is what is called resonance.

Waves of many different wavelengths are produced, but only waves whose wavelengths fit the length of the tube (or a whole number of half wavelengths) will be reinforced by the reflected waves. The lowest frequency for which the waves resonate is called the fundamental.

As the speed of the air moving up the tube increases, a different set of wavelengths is produced by the faster-moving air. Higher frequencies, related to the fundamental, will also resonate and are called overtones of the fundamental. Since the length of the tube dictates these frequencies, only these select sound waves will be heard. The diagrams below show the different wavelengths that resonate in an open-ended tube.

Activities

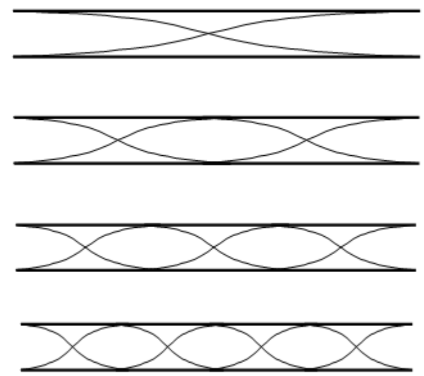
1. Hold the Sound Pipe at one end and twirl it around. Slowly at first. Gradually increase the rate at which you twirl the tube. Try to produce 5 separate standing wave frequencies.
2. Place the stationary end of the tube over a table on which small torn-up pieces of paper have been placed. Twirling the outer end of the Sound Pipe will vacuum the paper off the table, spraying it out the other end.

Fundamental Frequency
$L=1/2\,\lambda$ $\lambda = 2L$ $f=f_1$

Second Harmonic
$L=\lambda$ $\lambda = L$ $f=2f_1$

Third Harmonic
$L=3/2\,\lambda$ $\lambda = 2/3\,L$ $f=3f_1$

Fourth Harmonic
$L=2\,\lambda$ $\lambda = 1/2\,L$ $f=4f_1$



Related Products

Resonance Bowl (P7-7510) See water dance to the vibrations from your hands with the Resonance Bowl! A fun and effective way to demonstrate the behavior of waves and their interactions.

Set of 8 Boomwhackers (P7-7400) Demonstrate open- and closed-piped resonance with these colorful tubes. When whacked against the floor or your knee, each tube produces a clear tone. Students can even play songs!

Singing Rods (Set of 2) (P7-7250) A must for explorations of sound and waves, these rods are an easy way to demonstrate longitudinal waves as opposed to transverse waves. They're ideal for teaching about nodes and anti-nodes in standing waves.

Doppler Ball

P7-7120

INSTRUCTIONAL GUIDE

Contents

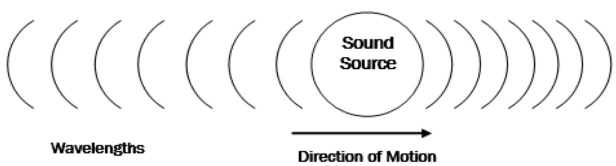
- Doppler Ball
- 9V Battery
- Instructional Guide

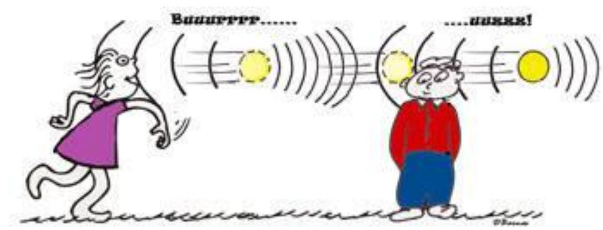
Recommended for activities:

- Roll of String (PX-2134)

Background

The Doppler effect occurs when an observer hears a sound from a moving source. If the sound source is moving toward the observer, the perceived frequency will be higher than the actual sound frequency. If the source is moving away from the observer, the perceived frequency will be lower.





Slide the cover off the battery holder and insert the included 9 V battery into the compartment. Use the switch on the battery holder to activate the buzzer. Insert the battery holder into the slit in the foam ball first, followed by the buzzer.

Activities

1. Start the buzzer and play catch. If the ball is thrown fast, students should be able to hear that the pitch is higher as the ball approaches than as it moves away.
2. Tie a string tightly around the ball. Swing it in a circle above your head. Students can hear the shift in pitch as it alternately approaches and moves away.

Related Products

Sound and Wave Discover Bundle (P7-2030) Hands-on discovery brings lessons on Sound & Waves to life, with this complete sound and wave explorations kit!

Sound Pipe (P7-7200) Twirling the pipe at different speeds produces up to five resonant tones.

Set of 8 Boomwhackers (P7-7400) Demonstrate open- and closed-piped resonance with these colorful tubes. When whacked against the floor or your knee, each tube produces a clear tone.

This page intentionally left blank.

ARBOR SCIENTIFIC

Standing Wave Kit

P6-7700 (Individual)

INSTRUCTIONAL GUIDE

Contents

- Vibrator Unit with string, battery holder and plastic disk
- AA battery

Recommended for activities:

- LED Stroboscope (92-9050)

To activate the motor, insert the battery into the battery holder. To deactivate, remove the battery.

Background

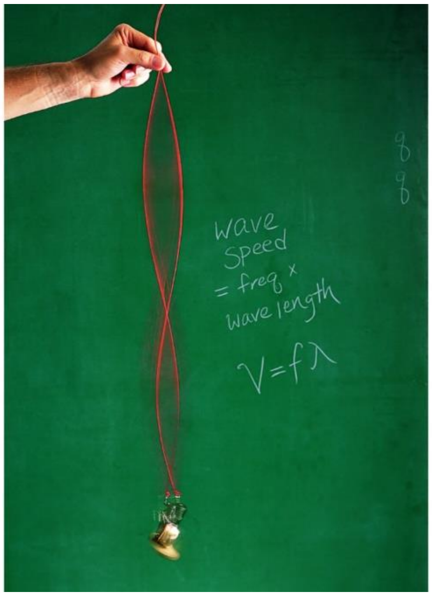
When two longitudinal waves coming from different directions, cross and pass through each other their crests and trough can combine together increasing or decreasing the amplitude of the wave displacements. The observed overlapping appearance is called an interference pattern. For instance, when formed along a one-dimensional rope or spring, this can produce a pattern called a standing wave. Tie a rope to a wall and shake it and the wave reflected from the wall will come back and interfere with the following waves moving toward the wall. At the right frequencies a standing wave forms with parts standing still along the rope called nodes. Antinodes in contrast, form in regions of maximum displacement where the waves from opposite direction cross and add together constructively

Activities

Demonstrating Standing Waves:

1. Activate the vibrator unit.

2. Hang the vibrator from the string. Adjust the length of string until a standing wave is obtained. To change the number of anti-nodes in the standing wave pattern, simply vary the length of the string.



Determining Wave Speed - Method 1

1. Establish a standing wave on the string.

2. Measure the distance between adjacent nodes. Multiply this distance by two to obtain the wavelength of the disturbance.

3. Use a strobe light to measure the frequency of wave.

4. Calculate wave speed from $v = f \cdot \lambda$

Determining Wave Speed - Method 2

1. Use a balance to find the mass of the vibrator unit and the mass of a string sample.
2. Calculate the weight of the vibrator in Newtons. This equals the tension in the string (T).
3. Find the linear density of the string (μ= mass/length).
4. Calculate the wave speed from $v=\sqrt{(T/\mu)}$.

Related Products

Spring Wave (P7-7220) Use this highly visible Spring Wave to observe phase reversal at the fixed end of wave pulses and to test fundamental and multiple vibrations.

Resonance Bowl (P7-7510) See water dance to the vibrations from your hands with the Resonance Bowl! A fun and effective way to demonstrate the behavior of waves and their interactions.

Mechanical Wave Complete Bundle (P7-1100) The Arbor Scientific Mechanical Wave Complete Bundle makes harmonic and motion demonstrations affordable for ALL Physics classrooms.

Acknowledgement

Thank you, Chris Chiaverina, for help in developing this product.

Music Box Mechanism

P7-7330

INSTRUCTIONAL GUIDE

Contents

- Music Box Mechanism
- Instructional Guide

Background

Sound travels as a longitudinal wave through matter. Sound waves are a result of mechanical energy from a vibrating mass changing the pressure of the medium the sound is traveling through. By placing a vibrating object against a larger resonant object such as a drum head, chalk board, or thin board, the sound is amplified. The larger surface area of the resonant object creates more sound waves than the vibrating object alone.

Instructions

Demonstrations:

1. Hold the mechanism in your hand (or, better yet, hang it from a string) and wind it. Ask students to listen and describe the loudness of the sound.
2. Amplify the sound with one of the methods listed below.
3. Ask students to predict which amplification method will produce the loudest sound.

To amplify the sound, hold the music box mechanism against:

- Chalkboard
- Desk
- Window
- Piece of paper
- Piece of paper rolled into a cone
- Piece of cover stock rolled into a cone
- Drum
- Guitar body
- Piano cabinet
- Student's temple
- Student's elbow, as they press an index finger against the bone behind their ear

Related Products

Sympathetic Tuning Fork Set (P7-6000) Set includes two C Note 256 Hz tuning forks, one fixed and one adjustable, each mounted on a wooden resonance box and a mallet.

Loudspeaker Kit (P7-7800) This DIY speaker kit is all you need to construct 10 loudspeakers so that students can get real, hands-on experience of how the device works.

Piezo Buzzer in Vacuum Chamber (97-6600) A modern replacement for the traditional Bell Jar and Ringer. An acrylic chamber houses a battery-operated, high output piezo sounder. When the end plates are attached and the unit connected to a vacuum pump no sound can be heard but the sound returns when the air is allowed back in.

ARBOR SCIENTIFIC

Spring Wave

P7-7220

INSTRUCTIONAL GUIDE

Contents

- Spring Wave
- Instructional Guide

Background

The spring wave is a long, helical spring that can be used to demonstrate waves and other phenomena. A mechanical wave is a disturbance that moves through a medium. The spring wave can demonstrate longitudinal and transverse waves. The particles move parallel to the direction of the wave in longitudinal waves. The spring coils move perpendicular to the direction of the wave in transverse waves. With the spring wave, you can also demonstrate standing waves. Standing waves appear to be stationary because of interference. With the spring wave and a rope, you can also show what happens when a wave enters a new medium. The spring wave can also be used to demonstrate Hook's Law and harmonic motion, and even Hubble's constant.

The spring wave is a helical spring with a diameter of 2 cm and a length of 20 cm, which can be stretched to 12 feet. Its silvery-white color makes the demonstration of its wave properties highly visible, while its lightweight construction makes it safe when it snaps back into shape after being stretched.

Activities

Most of the activities are best done on a tile floor. It keeps the motion in two dimensions and gives a convenient reference. Also, if the spring is accidentally let loose, it is less likely to hit someone in the face.

- **Longitudinal and transverse waves:** You can put a piece of tape on the spring to better show how the individual parts of the spring are moving. Stretch the spring lightly across the room. For transverse waves, strike and shake the spring side to side. For longitudinal waves, gather up several coils of spring and then let go.

- **The speed of a mechanical wave depends on the medium through which it travels:** Stretch the spring lightly across the room. Measure the time that it takes for one pulse to make one complete trip – back and forth – down the spring. Have the students predict methods to make the wave move faster, i.e. hit the spring harder, etc. The only way to make the wave travel faster is to stretch the spring more, changing the medium. This can also be done with two springs side-by-side as a race. Have one team of students change something to try to make their wave beat the other team's wave.

- **Behavior at wave boundaries:** Tie a rope to one end of the spring. Make a single transverse pulse by striking the spring sideways. If the other end of the spring is held, the reflected pulse will come back on the other side of the spring (inverted). If the rope is held instead, the pulse that is reflected at the boundary of the spring and rope will come back on the same side of the spring (erect or upright). You will also get a pulse that is reflected at the end of the rope.

- **Interference:** Have two students at opposite ends of the stretched spring hit the spring to the side. Watch what happens at the place where the two pulses meet. Also, watch what happens to the original pulses after they pass through each other. Try having the students hit the spring on the same side and opposite sides. Also, have them hit the spring with different amounts of force in both directions.

- **Standing waves:** Shake the spring slowly back and forth, adjusting the speed until you get one antinode in the middle of the spring. Try to get 2, 3, 4, etc. antinodes. How many can you get? The students can touch the spring at the node with a finger without disturbing the wave, but touch it anywhere else and the motion will be dampened. Also, try this with the rope attached to the other end. You will get an antinode at that end. Show the difference between guitar strings and clarinets this way.

- **Harmonic motion:** Using the same setup as above, pull a light mass down a few centimeters and let go. It should bob up and down harmonically. You may have to try a few different masses and a few lengths of spring to get it to sustain motion.

- **Expansion of the universe:** How can everything be moving away from us, even if we're not in the middle of the universe? How can astronomers estimate distances from speed? Put five or so sticky notes along the length of the spring wave. It does not matter exactly where they are. Pick one of them to be the Earth. The others are galaxies. With the spring wave held lightly between two people, measure the distances between the notes. Put a table of the distances on the board. Have the two people holding the spring take a step backward. Measure the distances again. Have them take another step back. Measure the distances again. With the table that you now have, show that the galaxies that are farthest from the Earth are moving away from the Earth the fastest. Try it again with the Earth in a different location. It still works! The Earth does not have to be in the center.

- **Earthquakes and elastic rebound theory:** Attach the spring wave to a box or other weighty object. Put the object on the floor (carpet works best). Pull the spring wave slowly to the side (You can grab the spring wave in the middle.) If there is enough friction between the object and the floor, the object will stick for a while, then suddenly move. Keep going. It will jump, again, but maybe not as much or more than before. This shows that as the tectonic plates slide past each other, they stick. When enough stress builds up, the plates suddenly move: an earthquake. Some earthquakes are big, some are small. You will need to find the right size, weight, and material for your box. Otherwise, it will slide too easily, or jump too much.

Related Products

Helical Spring (33-0140) 2cm diameter, 180cm long (collapsed) helical spring. "Snaky" is ideal for demonstrating fundamentals of wave theory, including transverse and longitudinal waves and wave behavior at the interface of two media.

Super Springy (33-0130) This extra-long version of the familiar and always popular spring toy provides an excellent demonstration of wave theory.

Standing Wave Kit (10pk) (P6-7700) Perfect for middle school and high school students, this kit includes all the materials you need to make 10 standing wave demonstrations. Instructions include qualitative and quantitative experiment ideas.