The
Video
Encyclopedia
of
Physics
Demonstrations™

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DISC TEN

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CHAPTER 23

SOUND PRODUCTION

Demo 10-01 Guitar and Scope

This demonstration allows us to see the wave shapes produced by plucking various guitar strings using an oscilloscope,[†] as shown in *Figure 1*. The effect of tightening and loosening a string is demonstrated, along with the difference between the strings. The effect of shortening the strings by stopping them can also be seen on the video.

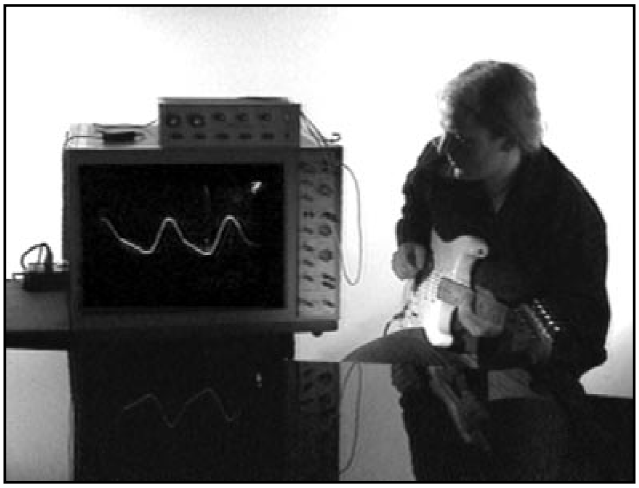

Figure 1

[†] Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Sj-2, Mode of String Oscillations.

Guitar and Scope / Script

A guitar uses tightly stretched metal strings to produce many different sounds. We'll use this electric guitar and an oscilloscope to show the wave forms produced by a guitar string, and the effect on the note produced of string length and tension.

This is the bottom E string on the guitar, played open.

Here is how the note changes as a finger is pressed against the frets higher up on the string.

This is the next string, the A string, which has a lower mass per unit length.

Here is what happens as the tension on the A string is decreased by loosening the tuning peg.

Equipment

1. Guitar.
2. Microphone.
3. Amplifier.
4. Oscilloscope.
5. Speaker.

Demo 10-02 Sonometer

A sonometer string is connected by an electromagnetic pickup to an oscilloscope, as illustrated in *Figure 1.* In the video this system is used to study the standing waves in a stretched wire.† The effect of tightening and loosening the string is illustrated, and a stop is used to determine the effect of shortening the string. Plucking the string near the end produces more harmonics, as illustrated in the video.

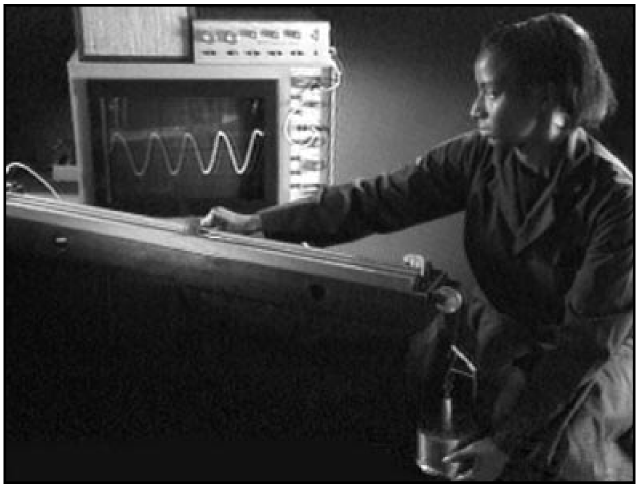

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration S-131, Sonometer.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Sj-1, Sonometer.

This sonometer uses a single stretched wire and a sounding board to demonstrate sound production from a stretched wire.

The wire is put under tension with a hanging weight. Electrical pickups transform vibrations in the wire into electrical signals which are amplified and then fed into this speaker and oscilloscope.

Here is a note produced by the wire under the full tension of the weight.

If we decrease the tension in the wire by lifting up on the weight, the frequency decreases.

If we shorten the wire to half its length by putting a bridge in the middle,

the frequency increases

and increases again when the wire is shortened once more.

Notice that the frequency produced is not “pure” just after the wire is plucked. That’s because harmonics in the wire produce additional, higher frequencies.

The harmonics are more intense when the wire is plucked at the end.

Equipment

1. Sonometer with pulley and heavy weight.
2. Two long clip leads and shorter leads of sufficient number.
3. Impedance matching device.
4. Amplifier.
5. Speaker.
6. Oscilloscope.
7. Horseshoe magnet of appropriate size.
8. Bridge for sonometer.

Demo 10-03 Tuning Forks

Three tuning forks of frequencies 256, 512, and 1024 Hz (at octave frequency intervals) are sounded and their waves displayed on an oscilloscope.† The wave produced by a tuning fork is sinusoidal, as can be heard on the video and illustrated in *Figure 1.*

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstrations S-55, Tuning Forks, and S-125.

Tuning Forks / Script

We'll strike these three tuning forks in turn and use this microphone and oscilloscope to show the frequency and purity of the tones they produce.

Here is the first tuning fork, with a frequency of 256 hertz. Notice the purity of the tone produced, and the smooth trace seen on the oscilloscope.

Here is the second fork, with a frequency of 512 hertz.

Here is the third fork, with a frequency of 1024 hertz.

Equipment

1. Microphone.
2. Amplifier.
3. Oscilloscope.
4. 256-Hz tuning fork.
5. 512-Hz tuning fork.
6. 1024-Hz tuning fork.
7. Rubber mallet.

Adjustable Tuning Fork

The waveform of large tuning fork with masses attached to the tines, as illustrated in *Figure 1,* is displayed on an oscilloscope.† The pitch of the tuning fork rises as the masses are moved downward along the tines. If the two masses are located at different points along their respective tines, the tuning fork is mistuned and the sound damps out very quickly, as can be seen on the video.

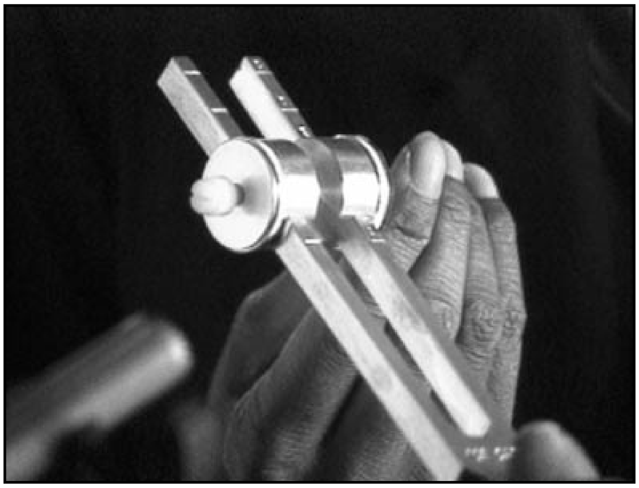

Figure 1

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† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Sh-4, Low Frequency Tuning Fork

Adjustable Tuning Fork / Script

A tuning fork puts out sound with a very stable frequency. The frequency of the fork usually depends on the mass and stiffness of the tines of the fork.

This tuning fork has an adjustable weight that can be slid to different positions on the tines.

Here is the note produced by the fork when the weights are at the bottom of the tines.

If we move the weights further up, how will the frequency of the fork change?

The frequency is now lower.

Raising the weight further decreases the frequency of the fork still more.

If the weights on the two arms are put in two different places, the sound from the fork dies away almost immediately.

Equipment

1. Adjustable tuning fork.
2. Rubber mallet.
3. Microphone.
4. Amplifier.
5. Speaker.

Demo 10-05 Rectangular Bar Oscillations

A long aluminum bar with rectangular cross section, clamped in its center as shown in *Figure 1,* is excited in three types of oscillations.[†] First, the bar is struck near the end of its larger (vertical) face, creating transverse vibrations of the bar in the horizontal plane. Second, the bar is struck near the end of its smaller (horizontal) face, creating transverse vibrations of the rod in the vertical plane. Finally, the end of the rod is struck, creating longitudinal vibrations of the rod. Various harmonics are heard in each case, with the frequencies in the second case being approximately one octave above the frequencies in the first case. The frequency of the longitudinal oscillation is higher than those of the two transverse modes, as can be heard on the video.

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration S-135, Vibrations of Bars. Lawrence W. Panek, Demonstration of the first overtone transverse vibrational mode in a stiff solid bar, *Am. J. Phys.* 48, 786 (1980).

Rectangular Bar Oscillations / Script

This rectangular aluminum bar is supported at its center.

We'll produce three different sounds by striking the bar three different ways.

When we strike the bar on this face, a low frequency sound results.

When we strike across this face, the frequency of the sound is higher.

If we strike the bar on the end, the frequency of the sound is higher still.

Notice how all three sounds can be heard each time the bar is struck, with one sound dominating in each case.

Equipment

1. Three-foot rectangular aluminum bar firmly mounted at its center through the most narrow dimension with the least amount of surface contact.
2. Rubber mallet.
3. Support system (can be held by hand).

Demo 10-06 High Frequency Metal Bars

A short aluminum rod held in the middle is struck sharply on the end, as shown in *Figure 1,* producing a high frequency longitudinal oscillation.† The fundamental mode for the rod vibration is one loop, with a nodal point in the middle and antinodes at each end, so shorter rods produce higher frequencies. Two rods an octave apart in frequency are shown in the video.

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration S-67, Point Source of Sound. Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration sf-4, Ultrasonic Waves.

High Frequency Metal Bars / Script

Demo 10-06

These cylindrical metal bars have lengths in ratios 2 to 1.

When we strike the longer bar with a hammer

a high frequency sound results.

Striking the shorter bar produces an even higher frequency sound.

The bar which is half as long produces a sound with a frequency twice as high as that produced by the longer bar.

Equipment

1. Two cylindrical aluminum bars held by center supports with least amount of surface contact; one length twice as long as the first.
2. Small wooden mallet.

Demo 10-07 Xylophone Bars

Notes at one-octave intervals are played in succession on a xylophone, and the waves displayed on an oscilloscope, as shown in *Figure 1*. Being an octave apart, the frequency is doubled for each successive note, so the period is halved, as observed in the video.

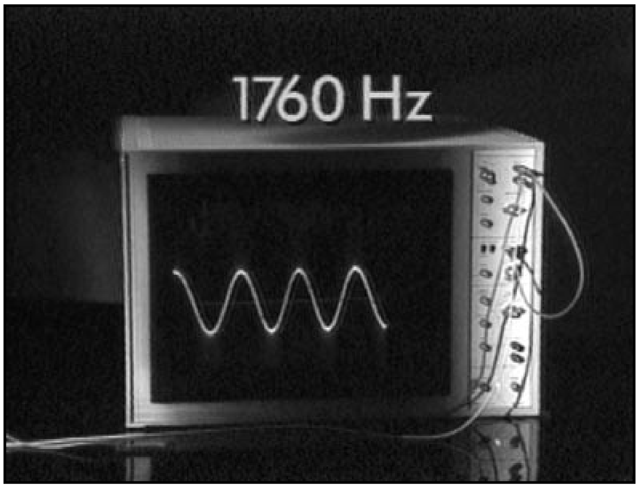

Figure 1

Xylophone Bars / Script

This xylophone has a series of metal bars of various sizes.

We'll strike three of the bars and observe the frequency and purity of the tone emitted with a microphone and oscilloscope.

Here is the first bar, with a frequency of 880 hertz.

Here is the second bar, with a frequency of 1760 hertz.

Here is the third bar, with a frequency of 3520 hertz.

Equipment

1. Metal xylophone.
2. Small wooden mallet.
3. Microphone.
4. Amplifier.
5. Oscilloscope.

Demo 10-08 Singing Rods

Longitudinal vibrations in the audible frequency range can be produced in an aluminum rod by holding the rod at a nodal point and drawing a cloth or fingers covered with powdered violin rosin tightly along the rod,[†] as shown in *Figure 1*. The ends of the rod are antinodes, and a nodal point can be forced by holding the rod at ½, ¼, ⅙, ⅛, etc. of the length of the rod from one end, creating the notes of the overtone series. The first and the second harmonic of a long rod are illustrated on the video, along with the first harmonic of a second rod.

Figure 1

[†] E. R. Pinkston and L. A. Crum, *Journal of the Acoustical Society of America* 55, 2-6 (1974)

These long aluminum rods will be used for an unusual method of sound production. The longest rod is held at its midpoint between a thumb and forefinger.

A second thumb and forefinger are placed on the rod and pulled along as if trying to stretch the rod.

A musical tone results.

This second rod is shorter than the first. If we repeat the demonstration using this rod, how will the frequency differ from that of the longer rod?

The frequency of this rod is higher.

If the support fingers are moved so that they grasp the rod one-quarter of the way down its length instead of at the middle, will the frequency change?

The frequency is higher.

Equipment

1. Two long aluminum rods with differing lengths, with markings showing their fractional lengths: 1/2, 1/4, 1/8, etc.
2. Supply of crushed rosin.

CHAPTER 24

PROPERTIES OF SOUND

Demo 10-09 Siren in Vacuum

When a sound source is activated within a glass chamber and the air is pumped out of the chamber, as illustrated in *Figure 1,* the sound disappears.[†] The reason generally given as to why the sound disappears in the case of the common demonstration is that the sound cannot travel through the vacuum created when all the air is pumped out of the jar; sound waves require a medium. While this statement is true, this demonstration actually illustrates a more subtle effect.[‡] This experiment was first devised during the middle of the seventeenth century to show that sound was a wave, not a transfer of "particles" from the source to the receiver. On the video the sound of the siren is heard to disappear as the air is pumped out of the jar and return when air is let back into the jar.

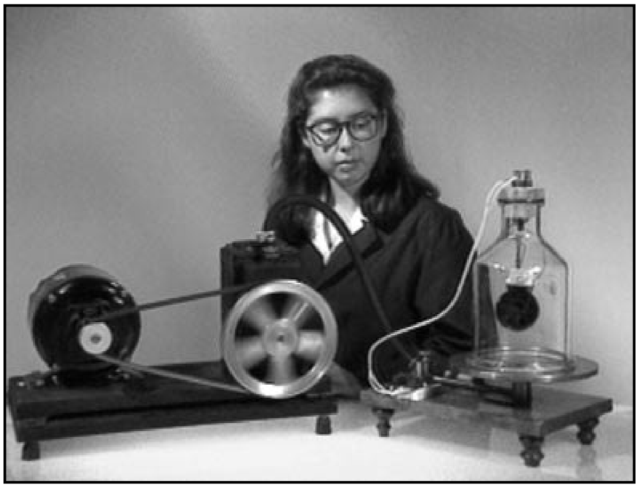

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstrations S-52, Material Medium Necessary for Transmission of Sound, and S-53, Sound is Wave Motion.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Sh-2, No Sound Through Vacuum.

[‡] R. B. Lindsay, Transmission of Sound through Air at Low Pressure, *Am. J. Phys.* 16, 371-377 (1948).

Siren in Vacuum / Script

Light from distant stars reaches our eyes because light can travel in the vacuum of interstellar space. But what about sound waves? Can they also travel in a vacuum?

We'll use this electronic siren in a bell jar to find out.

When we run the siren with the bell jar filled with air, the sound comes through.

We'll remove the air from the jar with a vacuum pump to see whether the sound still comes through.

Now that the air is gone from the jar we can no longer hear the siren.

If we return the air to the jar, the sound reappears.

Equipment

1. Glass bell jar with an electronic siren, having a LED (light emitting diode) in series with it.
2. Pump plate with batteries and switch for the siren, LED combination.
3. Vacuum pump.
4. Heavy-walled rubber hose.

Demo 10-10 Siren Disc

The siren disc shown here is a rapidly rotating disc with a large number of holes equally spaced around circles of several radii. When a jet of air is directed onto the passing holes a tone is created whose frequency is the frequency with which the holes pass the air jet.† Using the disc of *Figure 1*, the tones of a musical scale are produced, along with the sound from a random array of holes, which produces noise, a sound with no discernible periodicity.

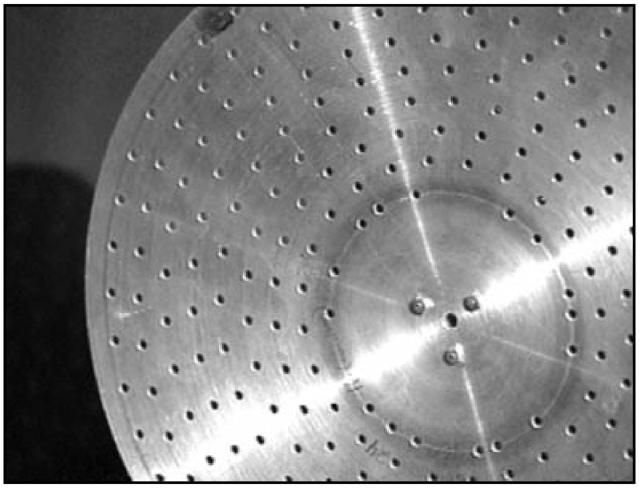

Figure 1

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† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Sc-1, Siren Disc.

We'll use this siren disc to show how sounds are produced by pressure changes in the air.

The siren disc has numerous small holes regularly spaced along circles of varying diameter. The number of holes in each circle is greatest for the outer circle and decreases toward the center. We'll spin the disc at a constant speed, then bring an air jet up behind each circle of holes in turn.

This is the sound produced by air passing through the outer sets of holes.

The innermost circle of holes is randomly spaced. When the air jet blows through these holes, only noise is produced.

This animation shows the pressure variations, or sound waves, created by the puffs of air passing through the holes.

Equipment

1. An aluminum disc with concentric rings of regularly spaced, identically drilled small holes, with the number of holes per ring ever increasing from the near center to the outermost ring; also equipped with a center mounting shaft.
2. Electric motor and support.
3. Supply of compressed air through a hose and nozzle with a small orifice.

Demo 10-11 Gear and Card

A rapidly rotating gear can be contacted by a cardboard or plastic sheet to produce a steady state tone using a device called a Savart Wheel.† Using the apparatus of *Figure 1*, four gears with number of teeth in the ratio of 4:5:6:8, spinning on a motor shaft, are contacted by a card, producing a major chord.

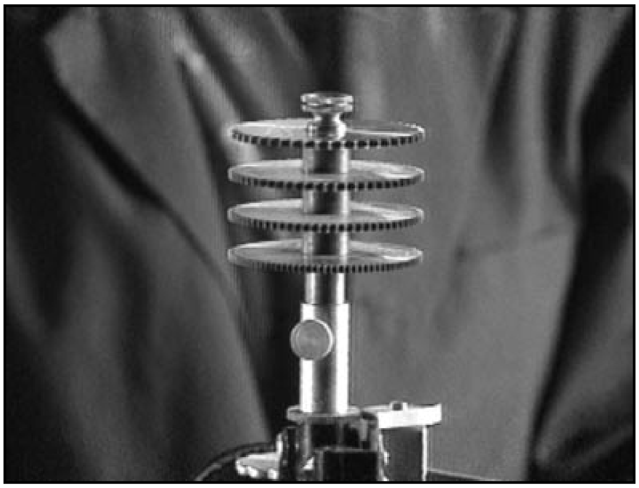

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration S-121, Savart Wheel.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Sc-2, Musical Saw.

Gear and Card / Script

Demo 10-11

We'll use this set of toothed gears and a plastic card to show how sound is produced by periodic motions of different frequencies.

Each of the gears has a different number of teeth.

When the gears are set spinning at a constant speed and a plastic card is rubbed against the teeth of the gears, sounds of different frequencies are produced.

Equipment

1. Set of four toothed gears, each with a differing number of teeth, supported through their center by a common axle.
2. Rotator motor.
3. Two stiff, but still flexible, pieces of plastic sheeting.

Demo 10-12 Cutaway Speaker

A loudspeaker has been cut in two, as shown in *Figure 1*, so that the motion of the cone can be easily observed at low frequencies. An amimation shows how the speaker creates sound by successive compressions of the surrounding air. Sounds made by the loudspeaker can be heard on the video.

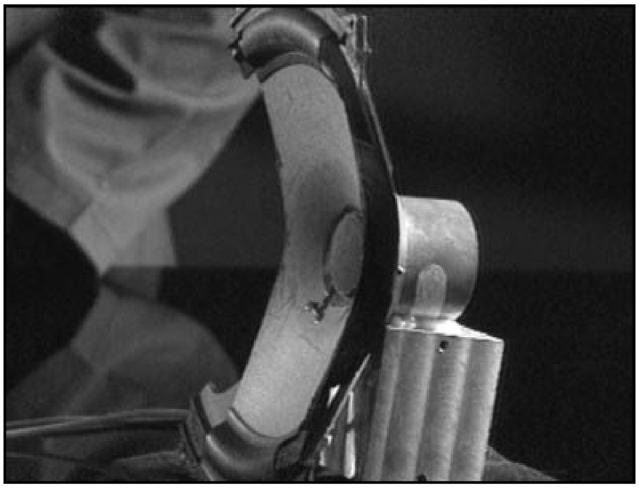

Figure 1

Have you ever wondered how a speaker produces sound?

We've cut the outer parts of this speaker off so that we can see the diaphragm of the speaker from the side.

We'll power the speaker with a 10 hertz signal from this audio oscillator.

Notice the motion of the diaphragm. The diaphragm pushes the air as it moves

creating a pressure wave at the same frequency as the motion of the diaphragm.

We'll now increase the driving frequency. When the frequency is high enough, the pressure waves created by the speaker are heard as sound.

Equipment

1. Speaker with two lateral sections cut away, leaving the center slice intact.
2. Audio oscillator.
3. Two leads.

Demo 10-13 Sound Velocity at Different Temperatures

The speed of sound in air varies as the square root of the absolute temperature. In this video, two identical organ pipes are activated by the same air source, originally producing the same frequency of tone. When the air going to one of the organ pipes is heated, as shown in *Figure 1*, the speed of sound is faster in that pipe and its resonant frequency rises, leading to beats between the two pipes.[†]

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration S-83, Effect of Air Temperature on Speed of Sound.

Sound Velocity at Different Temperatures / Script

Does the velocity of sound vary with temperature? We'll use these two identical organ pipes to find out.

When air is blown through the pipes, they emit identical frequencies when the air through both pipes is at the same temperature.

When we heat the air going through one of the pipes, the combined sound from the two pipes begins to beat.

The frequency of the pipe blown with heated air has changed, indicating a change in the speed of sound inside the pipe.

Equipment

1. Two identical organ pipes.
2. Pyrex glass "T" assembly with one arm of the "T" much longer than the other for heating the compressed air within; also equipped by rubber tubing of appropriate size.
3. Supply of compressed air.
4. Meker burner.
5. Supply of natural gas.
6. Source of flame.

Demo 10-14 Sound in Helium

An organ pipe is activated with compressed air, creating a musical tone. When the pipe is activated with helium, as shown in *Figure 1*, it fills up with helium. The speed of sound in helium is greater than that in air; therefore the resonant frequency of the pipe rises as it fills up with helium.[†] Singing with a lungfull of helium rather than air raises the frequency of the vocal formants (not the frequency with which the vocal folds are vibrating), leading to the characteristic squeaky Donald Duck voice.[‡]

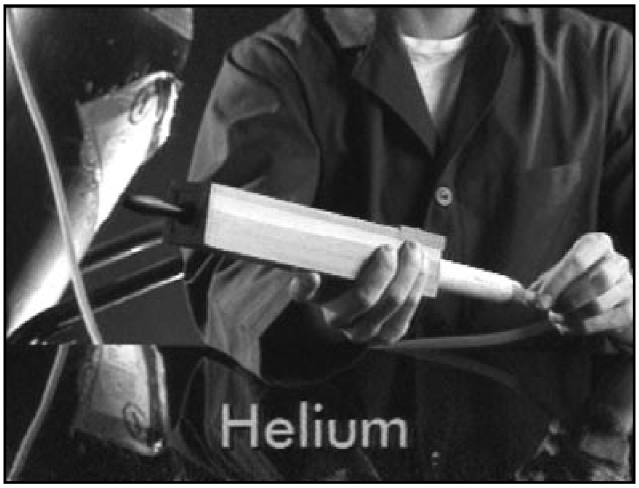

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration S-85, Effect of Medium on Speed of Sound.

[‡] Sutton, *Demonstration Experiments in Physics,* Demonstration S-86.

Sound in Helium / Script

We'll blow this horn first with air, then with helium.

So the shift in frequency shows that sound travels at a different speed in helium than in air.

This is the human voice with air.

This is the human voice with helium.

Equipment

1. Organ pipe.
2. Supply of compressed air.
3. Supply of helium.

Demo 10-15 Fourier Synthesizer

A commercially available Fourier synthesizer[†] is used to add together various harmonics of 440 Hz and to create a square wave and a triangular wave. The sound of the wave can be heard as the harmonics are added, and the difference between the square wave and the triangular wave is clearly audible. The synthesized square wave is illustrated in *Figure 1*.

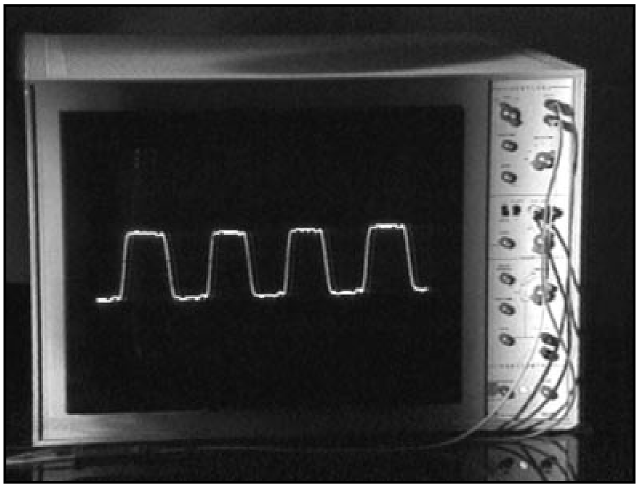

Figure 1

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† Pasco Scientific Company.

This Fourier synthesizer produces electrical signals of precise frequencies. It produces a fundamental frequency of 440 hertz. It can also produce harmonics of the fundamental at 880 hertz, 1320 hertz, 1760 hertz, and higher frequencies. We can select harmonics to add to the fundamental, with amplitudes and phases we choose.

The sum of all the signals we select are displayed on this oscilloscope and speaker.

Here is the fundamental, at 440 hertz.

We'll now add the second harmonic at 880 hertz. Notice how the sound changes.

Now we'll take away the second harmonic and add the third, at 1320 hertz.

Here is the fundamental with the ninth harmonic at 3960 hertz.

Now we'll add together a specific combination of fundamental and harmonics to make a square wave.

Here is a different combination which makes a triangular wave.

Equipment

1. Fourier synthesizer.
2. Six long leads.
3. Oscilloscope.

Demo 10-16 Vocal Formants

Vocal formants are responsible for the differences between the various steady state vowel sounds.[†] This demonstration illustrates the difference in the spectrum of the vocal sounds oo, as in “moo,” and ee, as in “knee.” Following an introduction to the computer based ⅓ octave real time spectrum analyzer, the spectra of the above vowel sounds are displayed for a male voice singing the same pitch for each. The difference between the formant structure of the two vowels is clearly visible. The frequency at which the vowel is sung is then varied, illustrating that the frequency of the formant remains the same for any pitch sung. The spectrum obtained for the vowel ee is shown in *Figure 1*.

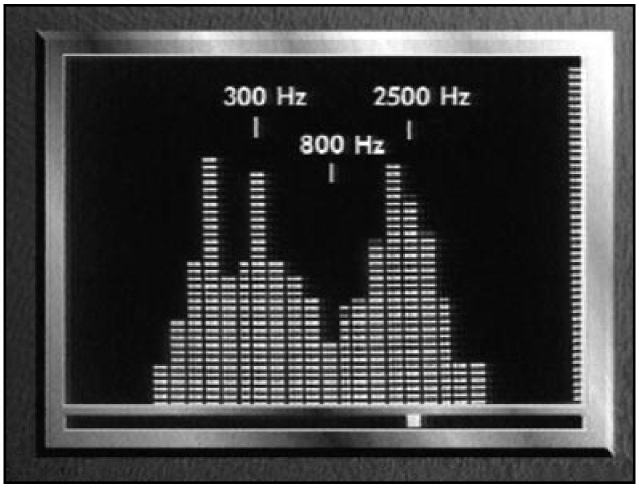

Figure 1

[†] Thomas D. Rossing, *The Science of Sound* (Addison-Wesley, Reading, Massachusetts, 1982) Chapter 17, pages 316-328.

This demonstration uses an Apple-computer-based real-time spectrum analyzer consisting of a series of filters covering the entire ten-octave audio spectrum in one-third octave intervals.

To indicate the calibration, the cursor will now be moved from 100 hertz up to 10 kilohertz, with an audio oscillator set to each frequency. The top channel shows the total intensity of the signal.

Using this analyzer, we can observe the groups of harmonics, called formants, associated with certain sung vocal sounds.

Here is a male voice singing the vowel "oo" at a frequency of about 150 hertz.

The frequency of the first formant is about 300 hertz, and the frequency of the second formant is about 800 hertz, so they overlap.

Here is a male voice singing the vowel "ee" at a frequency of about 150 hertz.

The frequency of the first formant is about 300 hertz, as in the vowel "oo," but the frequency of the second formant has risen to about 2500 hertz.

The difference between the sounds "oo" and "ee" is the frequency of the second formant.

The second formant does not change significantly as the frequency of the voice changes for the same vowel sound.

Equipment

1. Apple computer-based real time spectrum analyzer.
2. Audio oscillator.

Demo 10-17 Acoustic Coupling

A properly constructed exponential horn provides the best acoustic coupling between the loudspeaker transducer and the outside world, allowing the most efficient radiation of the sound from the loudspeaker into the air. This demonstration illustrates the effect of an exponential horn enclosure, shown in *Figure 1*, on the radiation efficiency of a small loudspeaker. A 2000-Hz tone is first sounded by the loudspeaker alone, and then through the horn. The sound is clearly more intense when the horn is used.

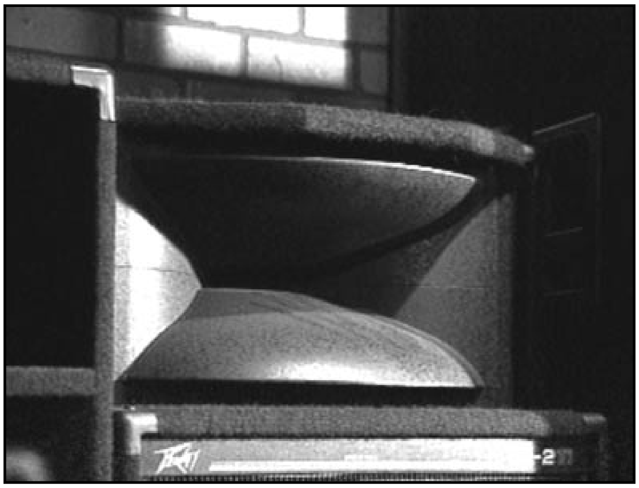

Figure 1

Acoustic Coupling / Script

Here is a tweeter horn like those used in loudspeakers.

The horn can be removed from the speaker itself so that we may show the effect the horn has on sound output from the speaker.

Here is a 2000-hertz signal from the bare speaker.

This is the sound with the horn.

Here is a 2000-hertz signal from the bare speaker.

This is the sound with the horn.

Equipment

1. Audio oscillator.
2. Two clip leads.
3. Tweeter horn that has been separated into its speaker and horn for later quick reassembly by hand.

Demo 10-18 Tuning Fork Beats

Two tuning forks with slightly different frequencies, shown in *Figure 1*, are sounded simultaneously with approximately the same intensities, producing beats.[†] If the frequencies of the two tuning forks are f_1 and $f_2 < f_1$, the observer will hear a steady state tone of the average frequency of the two bars,

$$F = \frac{(f_1 + f_2)}{2}$$

where the amplitude of the tone changes at a rate equal to the difference between the two component frequencies,

$$f_{\text{beats}} = f_1 - f_2$$

The periodic variation in the amplitude is "beats." After the tuning forks are struck the beats can be clearly heard on the video. Two different beat frequencies are demonstrated.

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration S-106, Beats.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Si-4, Beat Bars.

Tuning Fork Beats / Script

These two tuning forks have frequencies of oscillation that are very close together.

The frequency of one of the forks can be adjusted by sliding these weights up and down the tines, or arms, of the fork.

Here is the sound produced when the two forks are set at nearly identical frequencies.

Now we'll raise the frequency of this fork slightly and repeat the demonstration.

Notice the variations in sound intensity, or beats.

When the difference in frequency is increased, the beats occur more rapidly.

Equipment

1. Two 512-Hz tuning forks, one of which has been trimmed off with new masses added (with locking thumb screws) that are just able to slide over the tines, thereby returning the frequency of the adjustable fork to essentially that of the first.
2. Resonating boxes for each.
3. Foam rubber pads for each resonator to minimize energy loss.
4. Rubber mallet.

Demo 10-19 Beats with Speaker and Oscilloscope

In this demonstration audio oscillators are used to create beats, which are displayed on an oscilloscope.[†] When the two frequencies are close together the beats can be readily heard. As the difference between the two frequencies grows larger, the beats become inaudible, because they occur at too high a frequency. If the frequencies are harmonically related, they produce stable beat patterns on the oscilloscope, as shown in *Figure 1*.

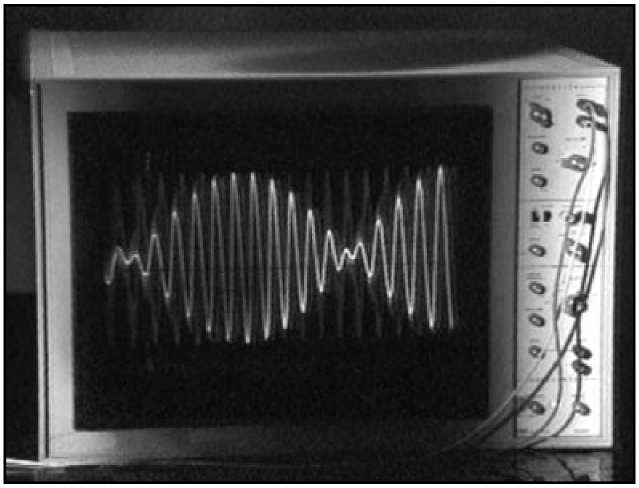

Figure 1

[†] Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Si-4, Beat Bars.

Beats with Speaker and Oscilloscope / Script

We'll demonstrate beats in sound waves using these two audio oscillators.

The signals from the oscillators will be added together and amplified, and then fed into this speaker and oscilloscope.

The oscillators start with equal frequencies.

Now we'll decrease the frequency of one oscillator.

Now we'll further decrease the frequency of the oscillator.

Equipment

1. Two audio oscillators.
2. Impedance matching device.
3. Amplifier.
4. Load on/off switch.
5. Speaker.
6. Oscilloscope.
7. Associated leads.

Demo 10-20 Two-Speaker Interference

If two identical loudspeakers approximately one meter apart are excited by the same high frequency tone (a few kilohertz), the waves will interfere, producing an interference pattern similar to the interference between two optical slits.[†] This demonstration, illustrated in *Figure 1*, is therefore also known as Young's experiment for sound. On the video the interference pattern is observed for two different frequencies, illustrating that the pattern of nodal and antinodal lines spreads out as the wavelength is increased and becomes closer together as the wavelength is decreased.

It may be helpful to use the demonstration "Moire Pattern," Disc 8, Demonstration #23, as an analog.

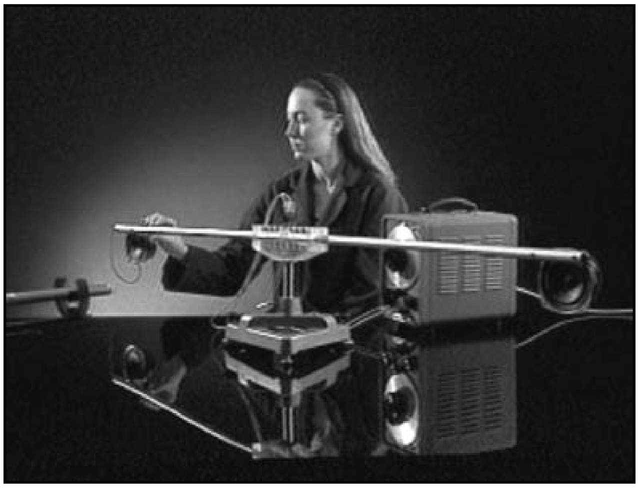

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration S-102.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Sl-3, Interference of Sound Waves.

Two-Speaker Interference / Script

Two speakers at the ends of this boom arm will be used to demonstrate interference of sound waves.

Both speakers are driven in phase by an audio oscillator.

A microphone placed in front of the boom arm will pick up the combined sound signal from the two speakers for you to hear.

Here's how that sound varies as we rotate the boom arm.

Notice the intensity pattern of the sound: there are points of high intensity and low intensity at regular intervals.

If we double the frequency of the sound, how will that affect the intensity pattern?

The points of high and low sound intensity are now closer together.

Equipment

1. Two speakers mounted on a bar and wired in phase with one another.
2. Support assembly.
3. Audio oscillator.
4. Two leads.

Demo 10-21 Doppler Effect

If the source of sound and the observer are in relative motion, the sound wave is shifted in frequency.† When the motion is separating the source and the observer, the observed frequency decreases, whereas when the motion is bringing the source and the observer closer together, the observed frequency increases. In this demonstration small speakers are rotated on the end of a boom arm, as shown in *Figure 1*, where the observer is a microphone located at the video camera. A rise in frequency can clearly be observed when the speaker is coming toward the camera, and a drop in frequency observed when the speaker moves away from the camera.

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration S-150, Doppler Effect.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstrations Si-1, Doppler Shift, Si-2, Doppler Shift with Reed, and Si-3, Doppler Shift from Turntable.

Doppler Effect / Script

If you listen to the sound the horn on a train makes as it passes, you'll notice that the frequency is higher as it approaches and lower as it moves away.

We'll now demonstrate this "Doppler Effect" using two small speakers mounted on a swing arm. Here is the sound the speakers emit when stationary.

Listen to the changes in frequency as the speakers are spun around, alternately approaching and receding from the microphone.

This animation shows the sound waves emitted by the speakers when they are stationary, and the sound waves emitted when the speakers are moving.

Equipment

1. Rotating Doppler device (made with a small speaker mounted on a framework that has its electric connections made with slip rings in its rotating handle).
2. Two very long leads.
3. Audio oscillator.