TOPIC 1.3: Sound

Students will be able to:

S3P-1-17 Investigate to analyze and explain how sounds are produced, transmitted, and detected, using examples from nature and technology.

Examples: production of sound by a vibrating object, drums, guitar strings, cricket, hummingbird, dolphin, piezocrystal, speakers...

S3P-1-18 Use the decision-making process to analyze an issue related to noise in the environment.

Examples: sonic boom, traffic noise, concert halls, loudspeakers, leaf blowers...

S3P-1-19 Design, construct (or assemble), test, and demonstrate a technological device to produce, transmit, and/or control sound waves for a useful purpose.

Examples: sound barrier or protective headphones to reduce the effects of noise, electromagnetic speakers, echo chamber, microphone, musical instruments, guitar pickup, electronic tuner, sonar detector, anechoic chamber, communication devices...

S3P-1-20 Describe and explain in qualitative terms what happens when sound waves interact (interfere) with one another.

Include: production of beats

S3P-1-21 Experiment to analyze the principle of resonance and identify the conditions required for resonance to occur.

Include: open- and closed-column resonant lengths

S3P-1-22 Experiment to calculate the speed of sound in air.

S3P-1-23 Compare the speed of sound in different media, and explain how the type of media and temperature affect the speed of sound.

S3P-1-24 Explain the Doppler effect, and predict in qualitative terms the frequency change that will occur for a stationary and a moving observer.

S3P-1-25 Define the decibel scale qualitatively, and give examples of sounds at various levels.

S3P-1-26 Describe the diverse applications of sound waves in medical devices, and evaluate the contribution to our health and safety of sound-wave-based technologies.

Examples: hearing aid, ultrasound, stethoscope, cochlear implants...

S3P-1-27 Explain in qualitative terms how frequency, amplitude, and wave shape affect the pitch, intensity, and quality of tones produced by musical instruments.

Include: wind, percussion, stringed instruments

S3P-1-28 Examine the octave in a diatonic scale in terms of frequency relationships and major triads.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Understand essential life structures and processes pertaining to a wide variety of organisms, including humans (GLO D1)

SPECIFIC LEARNING OUTCOME

S3P-1-17: Investigate to analyze and explain how sounds are produced, transmitted, and detected, using examples from nature and technology.

Examples: production of sound by a vibrating object, drums, guitar strings, cricket, hummingbird, dolphin, piezocrystal, speakers…

SUGGESTIONS FOR INSTRUCTION

Entry-Level Knowledge

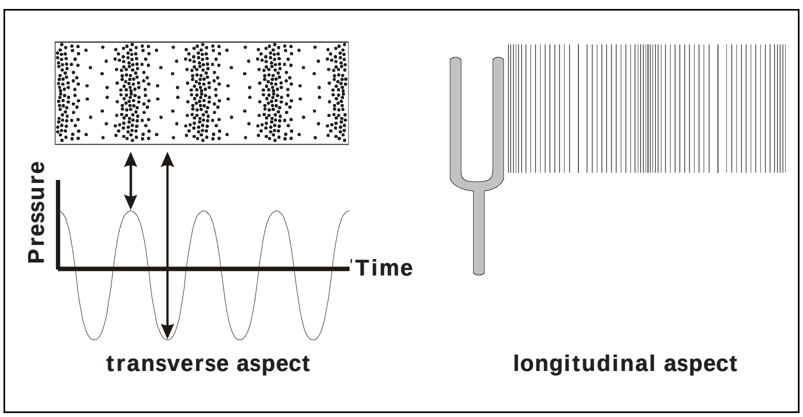
The phenomenon of sound is a part of the student's everyday sensory experience. The previous units on characteristics of waves are the basis for understanding the nature of sound. Sound is also an excellent topic to address many varied STSE applications, ranging from noise pollution to music.

Notes to the Teacher

Most sounds are waves produced by vibrations. The vibrating source moves the nearby air particles, sending a disturbance through the surrounding medium as a longitudinal wave. We use our eyes for the detection of light and our ears enable us to detect sound. The compressions of sound waves cause the eardrum to vibrate, which, in turn, sends a signal to the brain. There are many interesting experiences that students will have with sound. Ask students if they have ever heard the ocean in a seashell. Actually, the sounds they hear in a seashell are outside noises that resonate in the shell, creating the illusion of hearing the ocean.

Sound waves can be demonstrated in class with a tuning fork. The tines of the tuning fork are struck with a mallet and, as they vibrate back and forth, they disturb surrounding air molecules in a series of compressions and rarefactions. The propagation of these waves is very similar to longitudinal waves in a coil spring toy like a Slinky™. A sound wave can be represented mathematically as a transverse wave with the crests corresponding to regions of high pressure and the troughs corresponding to regions of low pressure.

Note: Even though the wave is represented mathematically as a transverse wave, sound is physically a longitudinal wave.



SKILLS AND ATTITUDES OUTCOMES

S3P-0-4b: Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solutions, and carry out investigations.

S3P-0-4c: Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.

S3P-0-4e: Demonstrate a continuing and more informed interest in science and science-related issues.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Demonstrate curiosity, skepticism, creativity, open-mindedness, accuracy, precision, honesty, and persistence, and appreciate their importance as scientific and technological habits of mind (GLO C5)

SUGGESTIONS FOR INSTRUCTION

Demonstrations

Strike a tuning fork, and then place it on a sound box, piece of wood, or the top of a musical instrument such as a violin or an acoustic guitar. Often we cannot see the tines of the tuning fork vibrate because the frequency is very high. When we place the tuning fork on another surface, the vibrations are transmitted to that surface and the sound is amplified.

Place the vibrating tuning fork in a beaker of water or near a suspended pith ball to demonstrate a transfer of energy.

Hold a steel strip or plastic ruler in place at the edge of a table. Pull the free end to one side, and then release it to demonstrate the oscillations necessary to produce waves. Although we cannot hear the air movement, there is a displacement of the air particles as the sound is transmitted to our ears.

Sound waves are mechanical waves; that is, they can only be transmitted in a medium. We can use a ringing bell in a vacuum jar to illustrate that as the medium (air) is removed, the sound disappears.

Senior Years Science Teachers' Handbook Activities

Students use Rotational Cooperative Graffiti, page 3.15, to describe sound, its production, transmission, and detection.

SUGGESTIONS FOR ASSESSMENT

Class Discussion

Students describe how compressions and rarefactions are formed.

Students describe how the vibration of an object is linked to the compressions and rarefactions of longitudinal waves.

Research Report

Students research how animals in nature make different sounds. Many animals use sounds as a defense mechanism by shaking a rattle, by scratching, by beating wings, or by vocalizing.

Students research how sound is produced in nature (e.g., a cricket, a hummingbird, or a dolphin).

Students provide some examples to illustrate the detection of sound (e.g., human ear, microphone, oscilloscope).

Class Discussion

Students identify the source of a sound, explain how the sound is transmitted, and explain how this sound is detected. Students also link the explanation to the concept of waves.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Understand essential life structures and processes pertaining to a wide variety of organisms, including humans (GLO D1)

SPECIFIC LEARNING OUTCOME

S3P-1-17: Investigate to analyze and explain how sounds are produced, transmitted, and detected, using examples from nature and technology.

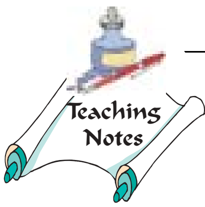
Examples: production of sound by a vibrating object, drums, guitar strings, cricket, hummingbird, dolphin, piezocrystal, speakers...

SUGGESTIONS FOR INSTRUCTION

Student Activity

Using a variety of objects, students can produce different sounds and explain how the sound is produced and transmitted. Examples could include a guitar string being plucked, a drum being hit, or air being blown through a straw.

Students can also observe the vibration of an electromagnetic speaker. By placing an object such as a piece of light plywood in front of the speaker, you can feel the vibration of the speaker. You can also place light, non-magnetic particles on a speaker cone to observe their motion.



SKILLS AND ATTITUDES OUTCOMES

S3P-0-4b: Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solutions, and carry out investigations.

S3P-0-4c: Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.

S3P-0-4e: Demonstrate a continuing and more informed interest in science and science-related issues.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Demonstrate curiosity, skepticism, creativity, open-mindedness, accuracy, precision, honesty, and persistence, and appreciate their importance as scientific and technological habits of mind (GLO C5)

SUGGESTIONS FOR INSTRUCTION

Teaching Notes

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Applets (Websites)

<http://www.mta.ca/faculty/science/physics/suren/applets.html>

<http://www.kettering.edu/~drussell/forkanim.html>
This applet shows longitudinal waves produced by a vibrating tuning fork, using particles and areas of high and low pressure.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Understand essential life structures and processes pertaining to a wide variety of organisms, including humans (GLO C3)

SPECIFIC LEARNING OUTCOMES

S3P-1-18: Use the decision-making process to analyze an issue related to noise in the environment.

Examples: sonic boom, traffic noise, concert halls, loudspeakers, leaf blowers...

S3P-1-19: Design, construct (or assemble), test, and demonstrate a technological device to produce, transmit, and/or control sound waves for a useful purpose.

Examples: sound barrier or protective headphones to reduce the effects of noise, electromagnetic speakers, echo chamber, microphone, musical instruments, guitar pickup, electronic tuner, sonar detector, anechoic chamber, communication devices...

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

Outcomes S3P.1.18 and S3P.1.19 can be introduced at any time during this topic. They are intentionally placed at the beginning in order to suggest a context for learning about sound. It is suggested that these outcomes be introduced to students at this point and that they guide the investigations into sound that follow. The topic could culminate with the design activity described in outcome S3P.1.19. It is also possible that outcome S3P.1.19 could be combined with the outcomes in the Fields topic on electromagnetism.

Student Activity

Using their own experience, students can brainstorm and generate a list of sources of noise in different environments. Then students can investigate ways in which unacceptable noise can be reduced.

Students work in groups to design, construct (or assemble), test, and demonstrate a technological device to produce, transmit, and/or control sound waves for a useful purpose. Examples could include the following.

- Use a 9-volt battery to power a piezoelectric buzzer. Students are challenged to build a device that is no larger than 15 cm x 15 cm x 15 cm to house the buzzer and reduce the noise level. Materials could include cotton batting, foam bits, cardboard, tongue depressors, plastic sandwich bags, et cetera. A variation has each team of students provided with a certain amount of “money” they use to purchase their materials. A rubric can be used to assess the project for effectiveness, economy, and style.
- Students design and build their own musical instruments. They can compare the frequency of the notes on their instruments with an oscilloscope or an electronic tuner. Some students may even be motivated to build quality instruments, such as dulcimers or violins, from readily available kits.
- Students can build a sonar detecting system using an ultrasonic motion detector. The team is required to detect and diagram a hidden landscape using its system.

SKILLS AND ATTITUDES OUTCOMES

S3P-0-3c: Identify social issues related to science and technology, taking into account human and environmental needs and ethical considerations.

S3P-0-3d: Use the decision-making process to address an STSE issue.

S3P-0-4c: Demonstrate confidence in carrying out scientific investigations and in addressing STSE issues.

S3P-0-4e: Demonstrate a continuing and more informed interest in science and science-related issues.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Demonstrate appropriate critical thinking and decision-making skills when choosing a course of action based on scientific and technological information (GLO C4)

SUGGESTIONS FOR INSTRUCTION

Senior Years Science Teachers' Handbook Activity

Students read a current events article about sound pollution in the city (e.g., should leaf blowers be banned?). They complete an Anticipation Guide before and after reading the article.

SUGGESTIONS FOR ASSESSMENT

Research Report/Presentation

Students research and report on how sound devices work to produce, transmit, detect, or reduce sound (e.g., car muffler, concert hall baffles).

SUGGESTED LEARNING RESOURCES

Applets (Websites)

Keyword Internet Search: build a musical instrument, noise pollution, musical instrument making
<http://www.oriscus.com/mi/making.asp>

General Learning Outcome Connection

Students will…

Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers (GLO B4)

Specific Learning Outcome

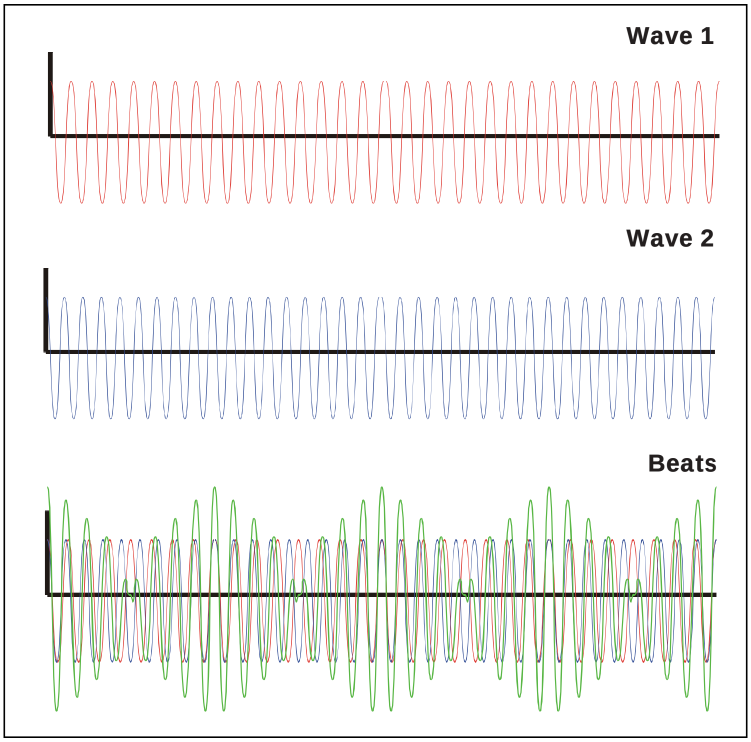
S3P-1-20: Describe and explain in qualitative terms what happens when sound waves interact (interfere) with one another.

Include: production of beats

Suggestions for Instruction

Notes to the Teacher

Sound beats are the periodic and repeating fluctuations heard in the intensity of a sound when two sound waves of slightly different frequencies interfere with one another. The sound changes from loud to soft, then loud again, and so on. The diagram below illustrates the wave interference pattern resulting from two waves with slightly different frequencies.



A loud sound is heard when the waves interfere constructively and this corresponds to a peak on the beat pattern. No sound is heard when the waves interfere destructively. The beat frequency is the rate at which the sound alternates from loud to soft and equals the difference in frequency of the two sounds. If two sound waves with frequencies of 440 Hz and 442 Hz interfere to produce beats, a beat frequency of 2 Hz will be heard.

The human ear is only capable of hearing beats with small beat frequencies (e.g., 8 Hz or less). Musicians frequently use beats to tune instruments. If two different sound sources, such as a piano string and a tuning fork, produce detectable beats, then their frequencies are not identical and they are not in tune. The tension of the string is then adjusted until the beats disappear.

Skills and Attitudes Outcome

S3P-0-2f: Record, organize, and display data, using an appropriate format.

Include: labelled diagrams, tables, graphs

General Learning Outcome Connection

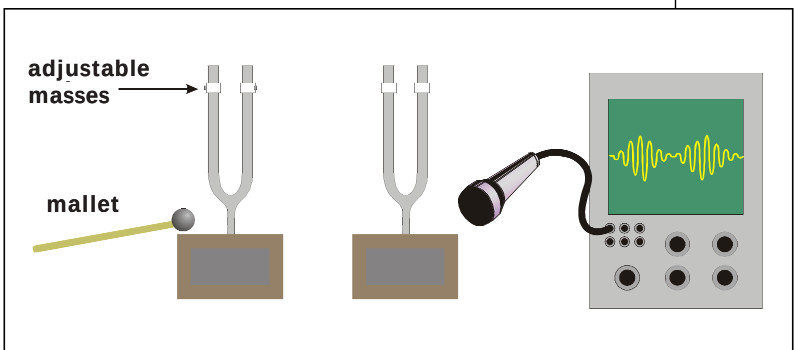
Students will...

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

Suggestions for Instruction

Demonstration

Beats can be produced in a classroom demonstration using two tuning forks. Strike the forks with a rubber mallet and observe the waves on an oscilloscope. Vary the beat frequency by adjusting the position of a mass on one of the forks.



Senior Years Science Teachers' Handbook Activities

Students use Concept Frames to illustrate the characteristics of beats.

Suggestions for Assessment

Pencil-and-Paper Tasks

Students label constructive and destructive interference on a diagram.

Students calculate the beat frequency of two tuning forks (or other vibrating sources).

Suggested Learning Resources

Applets (Websites)

<www.wiley.com/college/howthingswork>

<http://www.physicsweb.com>
A program can be downloaded to visually demonstrate the production of beats using two transverse waves.

<http://explorescience.com/activities/activity_page.cfm?ActivityID=44>
Hear beats produced for fixed frequencies. Change frequencies and hear the number of beats change.

<http://www.cs.earlham.edu/~rileyle/Applet.html>
Adjust the frequency and see the program graphically plot the beats produced.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Demonstrate appropriate scientific inquiry skills when seeking answers to questions (GLO C2)

SPECIFIC LEARNING OUTCOME

S3P-1-21: Experiment to analyze the principle of resonance and identify the conditions required for resonance to occur.

Include: open- and closed-column resonant lengths

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

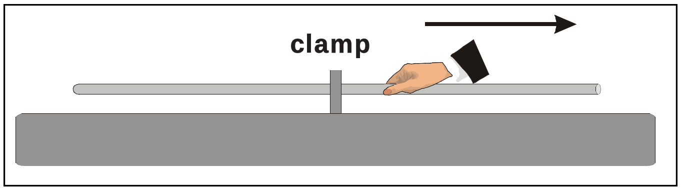
Every object tends to vibrate with a natural frequency. Resonance is the vibrational response of an object to another object that is vibrating at the same natural frequency. Resonance can be illustrated with a number of simple demonstrations.

Demonstrations

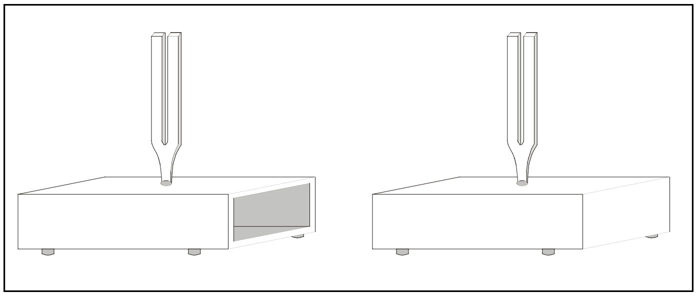
Suspend several pendula from a tight string. Two of the pendula should be of the same length, and the others of different lengths. Set one of the identical pendula in motion, and soon the other(s) will begin to vibrate in resonance.

Run a moistened fingertip around the edge of a long-stemmed glass and hear the sound produced. This is the resonant frequency. Students can fill up the glass with water and note the resulting sound differences.

Singing rod: Hold an aluminum rod exactly in the middle (at a node). Run moistened fingertips up and down the rod to produce a resonance frequency (see diagram).



Two identical tuning forks are mounted on resonance boxes separated by some distance. One of the forks is struck with a mallet. Soon after, the other fork will begin to vibrate in resonance.



A resonance tube can be used to increase the intensity of the sound from the tuning fork. Suspend a glass tube with its lower end in water and a tuning fork at its upper end. Strike a tuning fork and hold it above the end of the tube (see diagram next page).

SKILLS AND ATTITUDES OUTCOMES

S3P-0-2b: Propose problems, state hypotheses, and plan, implement, adapt, or extend procedures to carry out an investigation.

S3P-0-2d: Estimate and measure accurately, using Système International (SI) units.

S3P-0-2e: Evaluate the relevance, reliability, and adequacy of data and data-collection methods.

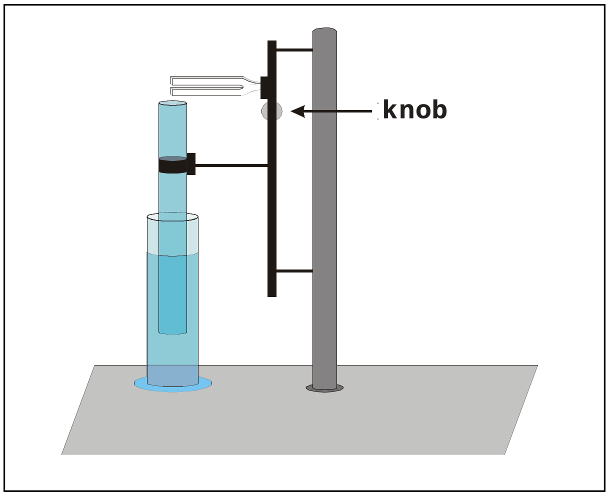
Include: discrepancies in data and sources of error

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

SUGGESTIONS FOR INSTRUCTION



The air column is closed at one end and open at the other. If a tuning fork is held over the open end, the loudness increases at specific lengths of the column. Typically, in a demonstration or experiment, the length of the column is changed by adding water (see diagram). The resonant lengths of a closed-air column are 1/4λ, 3/4λ, 5/4λ, and so on. Resonance may also be produced on open-air columns such as organ pipes. The resonant lengths of an open-air column are 1/2λ, lλ, 3/2λ, and so on.

Student Activity

Using a number of glass test tubes filled with water, students can produce different tunes. Students can also perform a laboratory activity on resonance in open and closed pipes.

SUGGESTIONS FOR ASSESSMENT

Class Discussion

A classic in physics: students can view the Tacoma Narrows Bridge collapse and explain the collapse of the bridge (video/DVD).

Students describe the conditions necessary for resonance to occur.

Students compare and contrast resonance in open- and closed-air columns.

Pencil-and-Paper Tasks

Students solve problems to calculate resonance length for different frequencies.

Laboratory Report

Students describe their observations from their experiment with open- and closed-pipe resonance.

SUGGESTED LEARNING RESOURCES

Videodisc (the Tacoma Narrows Bridge Collapse)

Conceptual Physics Alive: Sound II

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Demonstrate appropriate scientific inquiry skills when seeking answers to questions (GLO C2)

SPECIFIC LEARNING OUTCOMES

S3P-1-22: Experiment to calculate the speed of sound in air.

S3P-1-23: Compare the speed of sound in different media, and explain how the type of media and temperature affect the speed of sound.

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

The speed of a sound wave describes how fast the disturbance is passed through a medium. The speed of sound, like other waves, depends on the properties of the medium. Generally, the speed of sound is fastest in solids, then liquids, and slowest in gases. (See Appendix 1.9: Data Table for Speed of Sound for a data table on the speed of sound in various media.)

Present students with a table of values for the speed of sound in different media and temperatures. They should note that sound travels faster in a solid medium and that sound travels faster in the same medium if the temperature is higher.

Students commonly confuse the concepts of speed and frequency. Carefully differentiate between these two concepts. Help them remember that speed is "how fast" and frequency is "how often."

Student Activity

A good way to begin investigating the speed of sound is with a rough estimate using echoes. Find a large wall in the school and try to determine the time between a loud noise, such as the clap of your hands or some wooden blocks, and its echo. The time will be very fast, so first try an estimation. You could also try repeatedly clapping so that the sound and the echo are in phase. In this way, you can find the time for 10 claps. Using the appropriate distance, calculate the speed of sound (see Suggested Learning Resources).

The resonance experiment can be used to accurately calculate the speed of sound.

Another experiment to calculate the speed of sound can be performed with a microphone and an oscilloscope or CBL probe and associated program. Place the microphone at the end of a long (3 m) carpet tube. Connect the microphone to the oscilloscope and snap your fingers. The oscilloscope will record the snap and its echo as peaks on the screen. Use these peaks to determine the time it took the sound to travel twice the length of the tube.

SKILLS AND ATTITUDES OUTCOMES

S3P-0-2d: Estimate and measure accurately, using Système International (SI) units.

S3P-0-2e: Evaluate the relevance, reliability, and adequacy of data and data-collection methods.
Include: discrepancies in data and sources of error

S3P-0-2g: Interpret patterns and trends in data, and infer or calculate linear relationships among variables.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Understand the properties and structures of matter as well as various common manifestations and applications of the actions and interactions of matter (GLO D3)

SUGGESTIONS FOR INSTRUCTION

Teaching Notes

SUGGESTIONS FOR ASSESSMENT

Teacher Observations

Students experimentally determine the speed of sound.

Class Discussion

Students explain how the type of medium and the temperature of a medium affect the speed of sound.

Pencil-and-Paper Tasks

Students solve problems for calculating the speed of sound in air and for calculating spacing between resonances in open and closed pipes.

SUGGESTED LEARNING RESOURCES

Multimedia

Video Encyclopedia of Physics Demonstrations (1992) videodisc, Chapter 24, Properties of Sound

Software

Physics with CBL Experiment 24: Speed of Sound (Vernier, 1998)

Student Activity

CBL Experiment 24: Speed of Sound (Vernier, 1998)

General Learning Outcome Connection

Students will…

Demonstrate appropriate scientific inquiry skills when seeking answers to questions (GLO C2)

Specific Learning Outcome

S3P-1-24: Explain the Doppler effect, and predict in qualitative terms the frequency change that will occur for a stationary and a moving observer.

Suggestions for Instruction

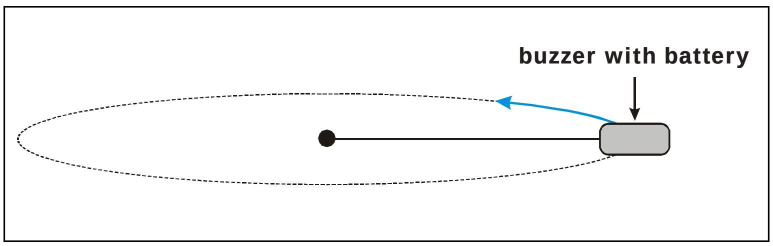
Notes to the Teacher

The Doppler effect can be observed when the source of waves is moving with respect to the observer. There is an apparent upward shift in frequency when the observer and the source are approaching each other and an apparent downward shift in frequency when the observer and the source are moving away from each other. Students will be most familiar with the Doppler effect from emergency vehicles such as police and ambulance sirens. As the vehicle approaches with its siren blasting, the pitch (frequency) of the siren will be higher. After the vehicle passes the observer, the pitch (frequency) of the siren sound will be lower.

Note that the Doppler effect is not an actual change in the frequency of the source. The source of the sound always emits the same frequency. The observer only perceives a different frequency because of the relative motion between them.

Demonstration

Embed a buzzer in a foam ball and swing it around in a circle.



Use diagrams to illustrate the frequency differences that occur when an object approaches, meets, and passes by an observer.

Senior Years Science Teachers' Handbook Activities

Students use Three-Point Concept Frames for the Doppler effect and shock waves.

SKILLS AND ATTITUDES OUTCOME

S3P-0-2b: Propose problems, state hypotheses, and plan, implement, adapt, or extend procedures to carry out an investigation.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

SUGGESTIONS FOR INSTRUCTION

Teaching Notes

SUGGESTIONS FOR ASSESSMENT

Class Discussion

Students predict the frequency changes that occur in the Doppler effect and will explain these changes.

Pencil-and-Paper Tasks

Students diagram the frequency changes that occur in the Doppler effect.

Research Report/Presentation

Students research and report on the application of the Doppler effect in radar and ultrasound imaging.

SUGGESTED LEARNING RESOURCES

Applets (Websites)

<http://www.walter-fendt.de/ph11e>
This is an animation of a car approaching and then passing an observer.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Identify the factors that affect health and explain the relationships among personal habits, lifestyle choices, and human health, both individual and social (GLO B3)

SPECIFIC LEARNING OUTCOME

S3P-1-25: Define the decibel scale qualitatively, and give examples of sounds at various levels.

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

The vibration of an object produces a sound wave by forcing the surrounding air molecules into an alternating pattern of compressions and rarefactions. Energy, which is carried by the wave, is imparted to the medium by the vibrating object. The amount of energy that is transferred to the medium depends on the amplitude of the original vibration. For example, if more energy is put into plucking a guitar string, more work is done displacing the string a greater amount and the string vibrates with a larger amplitude.

The intensity of a sound wave is the energy that is transported past a given area per unit of time. If the amplitude of a vibration increases, the rate at which energy is transported also increases. Consequently, the sound wave is more intense. As a sound wave carries its energy through a medium, the intensity of the sound wave decreases as the distance from the source increases. The decrease in intensity can be explained by the fact that the wave is spreading out over a larger surface area.

The scale used to measure the intensity of sound is the decibel scale. The decibel scale is not a linear scale. It is based on multiples of 10 since human hearing can detect a large range of intensities. The threshold of hearing is assigned a sound level of 0 decibels (0 dB) and a sound that is 10 times more intense is assigned a sound level of 10 dB. A sound that is 100 times more intense (10^2) is assigned a sound level of 20 db. A sound that is 1000 times more intense (10^3) is assigned a sound level of 30 db, and so on. (A table showing the intensity levels and examples of each is included in Appendix 1.10: Sound Intensity Levels Table.)

Student Activity

Play music (in mono) from a tape recorder through a pair of stereo speakers. Think how the speakers should be arranged to produce sounds of different intensities.

SKILLS AND ATTITUDES OUTCOMES

S3P-0-3c: Identify social issues related to science and technology, taking into account human and environmental needs and ethical considerations.

S3P-0-2c: Formulate operational definitions of major variables or concepts.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally (GLO B5)

SUGGESTIONS FOR INSTRUCTION

Teaching Notes

SUGGESTIONS FOR ASSESSMENT

Class Discussion

Students interpret a table of sound intensity levels and use it to associate common sounds/noises.

Research Report/Presentation

Students research noise pollution and make suggestions on how to reduce it.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally (GLO B1)

SPECIFIC LEARNING OUTCOME

S3P-1-26: Describe the diverse applications of sound waves in medical devices, and evaluate the contribution to our health and safety of sound-wave-based technologies.

Examples: hearing aid, ultrasound, stethoscope, cochlear implants...

SKILLS AND ATTITUDES OUTCOMES

S3P-0-2i: Select and integrate information obtained from a variety of sources.

Include: print, electronic, and/or specialist sources, resource people

SUGGESTIONS FOR INSTRUCTION

Many students use their physics to advance to medical careers. The histories of the stethoscope, hearing aids, and ultrasound are very rich and inspiring for these students. Today, many medical devices use the physics of sound as a diagnostic tool and a method of treatment. The use of sound in medical technology has its roots in the military development of sonar. Sonar is the technique of sending out sound waves and observing their echoes to characterize submerged objects. Early ultrasound investigators explored ways to apply sonar to medical diagnosis.

Student Activity

Students investigate an application of sound waves in a medical device and evaluate the contribution of this device to the medical field.

Collaborative Teamwork

Students can work in research teams to report on the following people's contributions to the development of medical devices employing the principles of sound.

- René T.H. Laennec
- Samuel H. Maslak
- Ian Donald
- Alexander Graham Bell

SKILLS AND ATTITUDES OUTCOMES

S3P-0-3a: Analyze, from a variety of perspectives, the risks and benefits to society and the environment when applying scientific knowledge or introducing technology.

S3P-0-4e: Demonstrate a continuing and more informed interest in science and science-related issues.

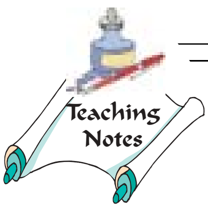
S3P-0-4d: Develop a sense of personal and shared responsibility for the impact of humans on the environment, and demonstrate concern for social and environmental consequences of proposed actions.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Recognize that scientific and technological endeavours have been and continue to be influenced by human needs and the societal context of the time (GLO B2)

SUGGESTIONS FOR INSTRUCTION



SUGGESTIONS FOR ASSESSMENT

Visual Displays

Students prepare a poster presentation and gallery walk on the historical development of medical devices that use the physics of sound as their basis of operation.

Research Report/Presentation

Students prepare a presentation on the contributions of René T.H. Laennec, Samuel H. Maslak, Ian Donald, and Alexander Graham Bell to the development of medical devices.

Group/Peer Assessment

Presentations can be evaluated using rubrics negotiated in advance.

SUGGESTED LEARNING RESOURCES

Internet Search Keywords: history of hearing aids, ultrasound, stethoscope

<http://www.pbs.org/wnet/soundandfury/index.html>
Sound and Fury homepage, excellent resource on the ear and cochlear implants (includes animations).

<http://www.ob-ultrasound.net/history.html>
A short history of the development of ultrasound in obstetrics and gynecology by Dr. Joseph Woo.

General Learning Outcome Connection

Students will...

Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers (GLO B4)

Specific Learning Outcome

S3P-1-27: Explain in qualitative terms how frequency, amplitude, and wave shape affect the pitch, intensity, and quality of tones produced by musical instruments.

Include: wind, percussion, stringed instruments

Suggestions for Instruction

Notes to the Teacher

Most musical instruments consist of a vibrating source and a structure to enhance the sound through mechanical and acoustical resonance. A stringed instrument consists of a vibrating string and a resonating sound board or hollow box. Wind instruments contain either open- or closed-air columns of vibrating air; the initial vibration is created by a reed or by the player's lips. Percussion instruments involve striking one object against the other. Students can examine and explain how a variety of musical instruments (e.g., string instruments, percussion instruments, wind instruments) produce sound.

For wind instruments, the length and shape of the resonating air column determines the quality of the sound. Blowing harder can produce a second standing wave or a second harmonic. For string instruments, students can change the length of the vibrating string and note the change in pitch. Plucking the string harder produces a larger vibration and an increase in sound intensity. Pluck the string at different positions along the length of the string to hear the change in harmonics. Resonating boxes amplify the sound. The shape of the resonating box (e.g., guitar versus violin) determines the quality of tones produced.

For percussion instruments, students can strike a drum at various places to note the different pitch produced. Similar objects of different size (e.g., tuning forks) also vibrate at different frequencies.

Student Activity

Students can perform the Singing Straw experiment. Suck a liquid up into a straw and hold it there with your tongue. Pull the straw out of the liquid and pinch the bottom. Now remove your tongue from the straw and blow across the top of the straw. At the same time, slowly release your grip on the bottom of the straw. You should hear a change in pitch as the liquid drains out the bottom of the straw.

SKILLS AND ATTITUDES OUTCOMES

S3P-0-4b: Work cooperatively with a group to identify prior knowledge, initiate and exchange ideas, propose problems and their solutions, and carry out investigations.

S3P-0-4e: Demonstrate a continuing and more informed interest in science and science-related issues.

S3P-0-2i: Select and integrate information obtained from a variety of sources.

Include: print, electronic, and/or specialist sources, resource people

GENERAL LEARNING OUTCOME CONNECTION

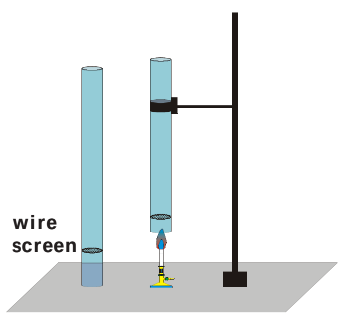
Students will...

Describe and appreciate the similarity and diversity of forms, functions, and patterns within the natural and constructed world (GLO E1)

SUGGESTIONS FOR INSTRUCTION

Hoot Tubes: Insert a wire screen in an open-ended glass tube. Heat the end with the screen. The tube hoots when it is removed from the flame. The sound stops when the tube is held horizontally.

Demonstration



Senior Years Science Teachers' Handbook Activities

Students research and report on a family of musical instruments (see *Senior Years Science Teachers' Handbook*, Chapter 14).

Students use Compare and Contrast Frames: Students can compare and contrast instruments that are similar in structure but different in sound: violin versus bass fiddle, horn versus tuba, small bell versus a larger bell.

Students can compare the frequency of the sounds produced by each instrument.

SUGGESTIONS FOR ASSESSMENT

Class Discussions

Students identify the type of musical instrument and how this instrument produces sound.

Students explain, in qualitative terms, how frequency and pitch are related, how amplitude and intensity of sound are related, and how wave shape and quality of tone are related.

Performance Assessment

Students design and build a musical instrument (see outcome S3P.1.19).

SUGGESTED LEARNING RESOURCES

Multimedia

Physics: Cinema Classics (video/DVD)

Software

Exploring Physics and Math with the CBL System (Texas Instruments, 1994)

Student Activity: CBL Lab Activity 26: Nature of Sound (Texas Instruments)

References

Internet Search Keywords: physics of music

The Science of Sound (Thomas Rossing, 1990)

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers (GLO B4)

SPECIFIC LEARNING OUTCOME

S3P-1-28: Examine the octave in a diatonic scale in terms of frequency relationships and major triads.

SUGGESTIONS FOR INSTRUCTION

There are many different musical scales. Of them all, the diatonic is the most basic. Any three notes whose vibration frequency ratios are 4, 5, and 6 will produce a major chord (triad). A diatonic scale consists of three sets of major triads. Within an octave, three major triads can be constructed as follows:

C	D	E	F	G	A	B	C^1	D^1
4		5		6				
			4		5		6	
				4		5		6

Physicists commonly use a frequency of 256 Hz for middle C. In terms of frequency, in order to reach the higher C (above middle C), we simply double the frequency; that is, middle C is 256 Hz and the next higher C is at 512 Hz. The other frequencies can be found from the 4, 5, 6 ratios. For example:

C = 256 Hz

E = 256 x 5/4

∴ E = 320 Hz

Student Activity

Using the frequency ratio of 4, 5, 6, students calculate the frequency for each note in the diatonic scale. From these calculations, we find that the note A = 426.6 Hz. Musicians typically use A = 440 Hz. Interested students might want to research the various types of musical scales that make adjustments in the frequencies so that the notes are equally spaced apart and different instruments can play together (i.e., chromatic and equal tempered scales).

Chromatic scale: consists of C, C#, D, D#, E, F, F#, G, G#, A, A#, B, and C (all intervals in the chromatic scale are *halftones or semitones*).

The **tempered scale** is a scale in which there is a constant change of frequency between notes.

Teacher or Student Demonstration

Play examples of music from different cultures (e.g., Eastern music) and compare the frequency changes between the notes.

SKILLS AND ATTITUDES OUTCOMES

S3P-0-2c: Formulate operational definitions of major variables or concepts.

S3P-0-2g: Interpret patterns and trends in data, and infer or calculate linear relationships among variables.

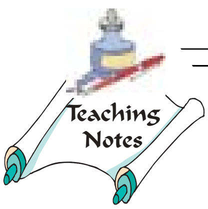
S3P-0-4e: Demonstrate a continuing and more informed interest in science and science-related issues.

GENERAL LEARNING OUTCOME CONNECTION

Students will...

Describe and appreciate the similarity and diversity of forms, functions, and patterns within the natural and constructed world (GLO E1)

SUGGESTIONS FOR INSTRUCTION



SUGGESTIONS FOR ASSESSMENT

Pencil-and-Paper Tasks

Students complete Compare and Contrast Frames for fretted and non-fretted instruments.

Given a frequency for a specific note, students determine the frequency of the tone one or two octaves above the specific note and/or one or two octaves below the specific note.

Given a frequency, students determine the frequencies of the major triad.

Research Report/Presentation

Students research and report on the musician's equal tempered scale.

SUGGESTED LEARNING RESOURCES

Physics for a Modern World (Alan Hirsch, 1986)

The Science of Sound (Thomas Rossing, 1990)

NOTES