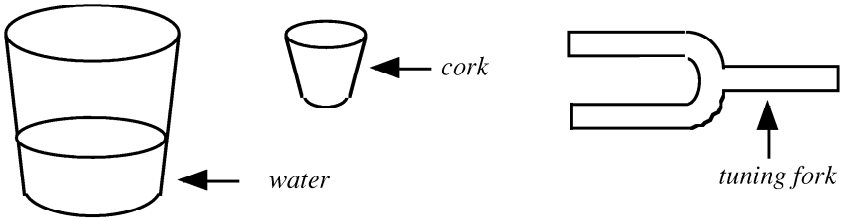
PHYSICS
Intermediate 1
Sound and Music

ACTIVITY 1

Title: Sound vibrations.

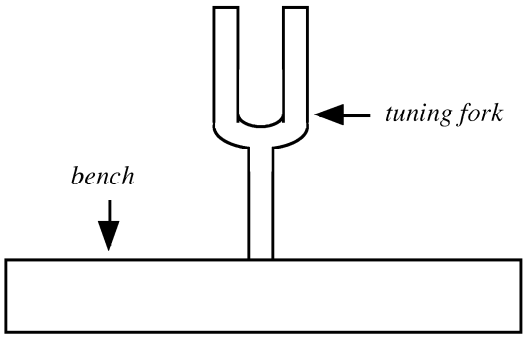
Aim: To show how sound energy is produced.

Apparatus: Tuning forks, cork and beaker.



Instructions

- Strike the tuning fork on the cork and transfer the tuning fork to just touch the water surface.
- What happens to the tuning fork after it is struck?
- Now strike the fork again and hold the tuning fork against the bench.



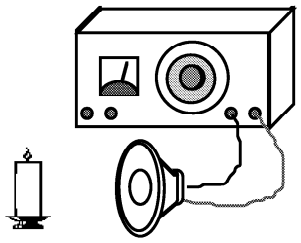
- Try various lengths of tuning fork and make a note of the frequency.
- What do you notice about the frequency of the note as the tuning fork gets longer?

ACTIVITY 2

Title: Energy transfer.

Aim: To show how sound energy is transferred.

Apparatus: Signal generator, loudspeaker and candle.



Instructions

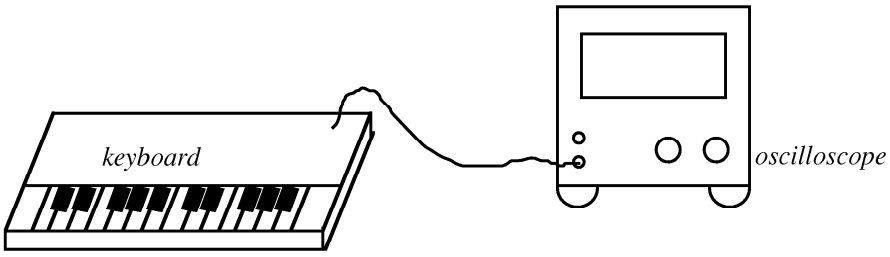
- Adjust the signal generator to about 10 Hz and maximum voltage.
- Direct the sound from the speaker towards the candle flame.
- What happens to the flame as sound passes by?
- What is moving the candle flame?

ACTIVITY 3

Title: Oscilloscope patterns.

Aim: To show that sounds vary in frequency.

Apparatus: Oscilloscope, connecting wires and keyboard.



Instructions

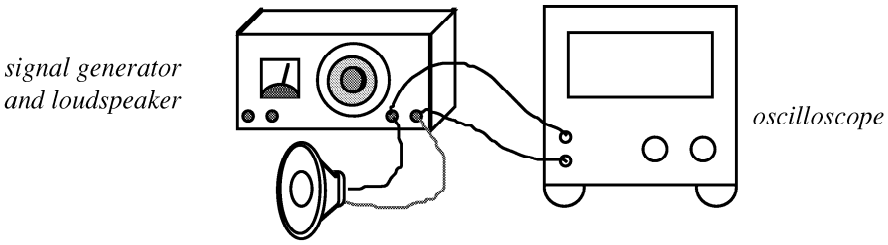
- Use the keyboard to "play" different notes and display the signal on the screen of the oscilloscope. If you have difficulty seeing the patterns, ask your teacher to adjust the controls of the oscilloscope.
- Describe the difference in pattern for low (left hand side of the keyboard) and high (right hand side of the keyboard) frequencies.
- Turn up the volume control and describe how the oscilloscope pattern has changed when a key is pressed.

ACTIVITY 4

Title: Producing different sound waves.

Aim: To investigate how sound waves vary in pitch and loudness.

Apparatus: Signal generator, oscilloscope, connecting wires and loudspeaker.



Instructions

- Set the frequency on the signal generator to 100 Hz. Adjust the voltage to produce a note at the loudspeaker. Keep the voltage constant.
- Increase the frequency of the note produced at the speaker and observe the oscilloscope pattern. If you have difficulty seeing the patterns, ask your teacher to adjust the controls of the oscilloscope.
- How does the frequency affect the number of waves on the screen of the oscilloscope?
- Very carefully draw the patterns for low and high frequencies.
- Now set the voltage to 1 volt and the frequency to, say, 1 kHz. Keep this frequency constant.
- Increase the voltage (loudness) of the note produced at the speaker and observe the oscilloscope pattern. If you have difficulty seeing the patterns, ask your teacher to adjust the controls of the oscilloscope.
- How does the loudness affect the height of waves (amplitude) on the screen of the oscilloscope?
- Very carefully draw the patterns for a quiet sound and a loud sound.

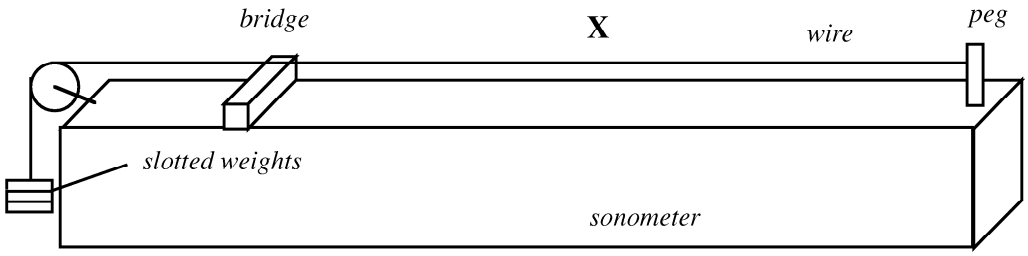
ACTIVITY 5

Title: Increasing the frequency.

Aim: To show how the frequency of a vibrating string can be changed.

Apparatus: Sonometer and slotted weights.

Instructions

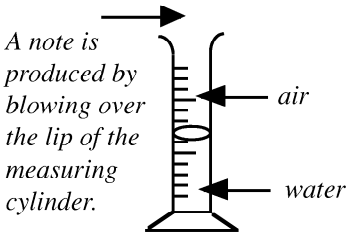


- Pluck the wire at X when there are a small number of weights pulling the wire.
- Repeat for a larger number of weights.
- How is the frequency of the note affected by the tightness of the wire?
- Describe how a musician tunes a guitar.
- Move the bridge but keep the tightness of the wire constant (number of weights).
- How does the length of wire affect the frequency (pitch) of the note produced?
- Does the volume of air in a tube affect the note produced?

  This can be investigated using a measuring cylinder.

  Change the volume of water in the cylinder making a note each time.

  Compare the pitch of the note with the volume of air in the cylinder.

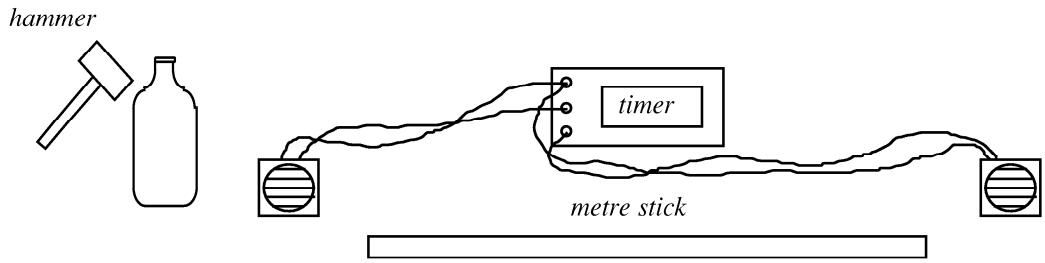


ACTIVITY 6

Outcome 3 ✔

Title: The speed of sound.

Apparatus: 2 microphones, connecting wires, electronic timer, metre stick, a hammer and a bottle.



Instructions

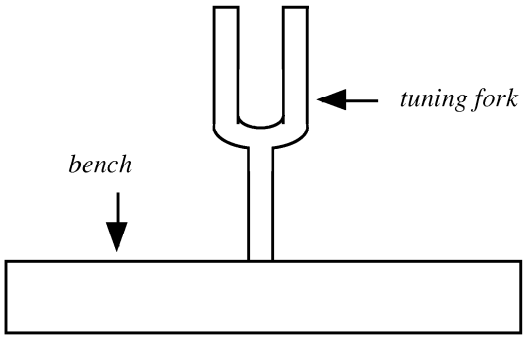
- Place the microphones 1 metre apart.
- Switch on the timer and reset it to zero.
- Strike the bottle with the hammer and record the time on the timer.
- Repeat the experiment until 5 results have been collected.
- Determine the speed of sound in air

ACTIVITY 7

Title: Solids, liquids and gases.

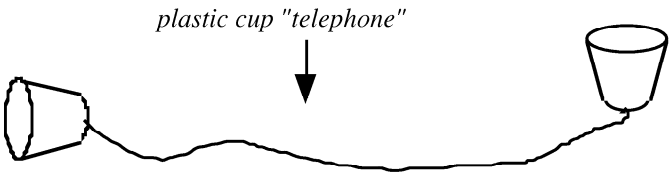
Aim: To investigate the transmission of sound through solids.

Apparatus: Tuning fork, cork, and a plastic cup "telephone."



Instructions

- Strike the fork on the cork and hold the tuning fork on the bench as shown above.
- Get someone to listen to the vibrating forks by resting their ear on the bench.



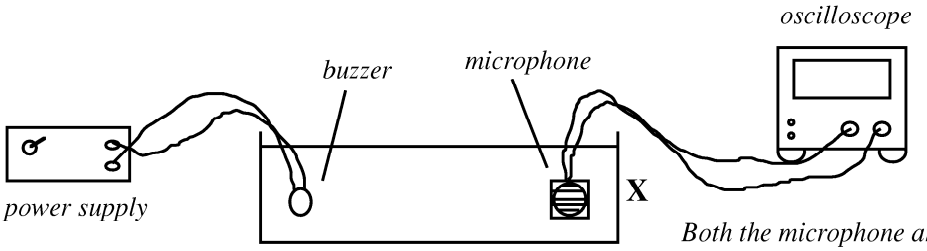
- Use the "telephone" to communicate with someone else.
- Make a list of solids which can carry sound vibrations.

ACTIVITY 8

Title: Solids, liquids and gases.

Aim: To investigate the transmission of sound through liquids.

Apparatus: Buzzer, power supply, microphone, trough, oscilloscope, plastic bags and connecting wires.



Instructions

- Place the buzzer and microphone under the water as shown.
- Start the buzzer.
- Does the microphone detect any sound energy?
  You may have to adjust the oscilloscope.
- Now hold the microphone at X, next to the glass. Is sound detected at X?
- Write a conclusion about the ability of sound to travel through solids and liquids.

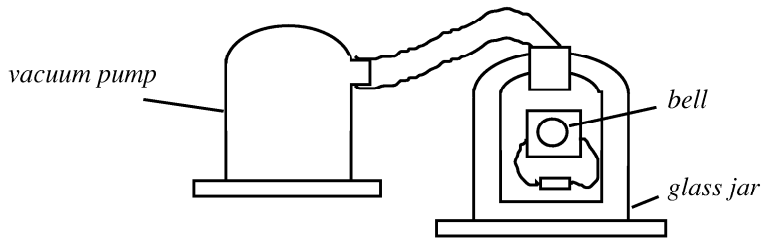
ACTIVITY 9

TEACHER DEMONSTRATION

Title: Silence in a vacuum.

Aim: To show that sound energy cannot be transmitted through a vacuum.

Apparatus: A bell in a jar and a vacuum pump.



Instructions

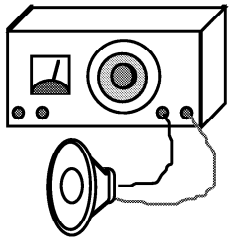
- The bell is set ringing and then air is pumped out of the jar.
- Does the bell continue to ring?
- Can the sound be heard?
- Explain what happens when air is let back into the jar.
- Write a conclusion about the transmission of sound through a vacuum.

ACTIVITY 10

Title: Range of hearing.

Aim: To show that humans have a range of hearing.

Apparatus: Signal generator and loudspeaker.



Instructions

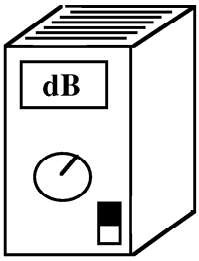
- Increase the frequency gradually from 10 000 Hz.
- Write down the highest frequency you can detect.
- Decrease the frequency from 10 000 Hz.
- Write down the lowest frequency you can detect.
- Compare your range of hearing with others in your class.

ACTIVITY 11

Title: Noise level.

Aim: To show how the level of sound can be measured and recorded.

Apparatus: Sound level meter and various sources of sound.



Instructions

- Record the sound level in different areas of the school and classroom.

location	sound level (dB)

- Draw a bar chart of the recorded sound level against location.
- Find out the permitted sound levels in various places of work. (HSE guidelines).
- Give some examples of sources of noise pollution.

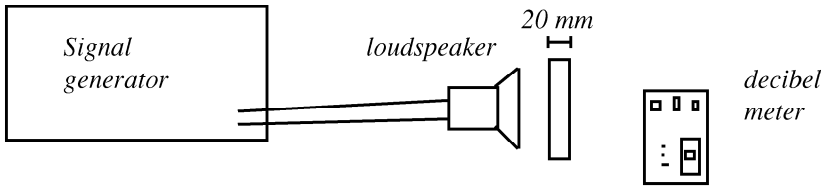
ACTIVITY 12

Outcome 3 ✔

Title: Reduction of sound by different materials.

Apparatus

Signal generator, loudspeaker, decibel meter
20 mm thick pieces of different materials, ruler



Instructions

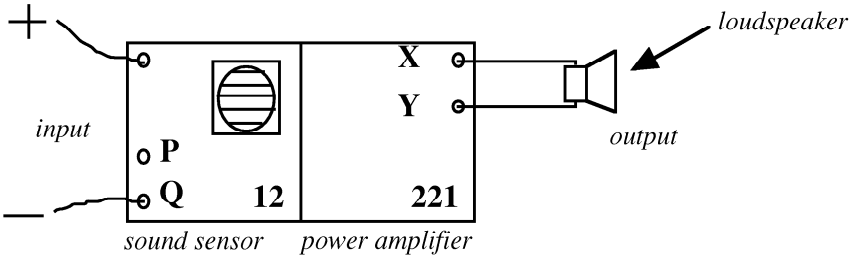
- Set up the apparatus as shown.
- Turn up volume on the signal generator until the decibel meter reads about 100 dB.
  Record the reading on the decibel meter.
- Take one of the pieces of material and insert it between the loudspeaker and the decibel meter.
  Note the new reading on the decibel meter.
- Remember that the signal generator must not be altered.
  Be sure to keep a fair test.
- Repeat the measurements using the other pieces of materials.
- Display your results on a bar chart.

ACTIVITY 13

Title: Increasing the amplitude.

Aim: To show that amplifiers increase the amplitude of a signal.

Apparatus: Alpha kit boards 12 and 221, loudspeaker, 5 V power supply and oscilloscope.



Instructions

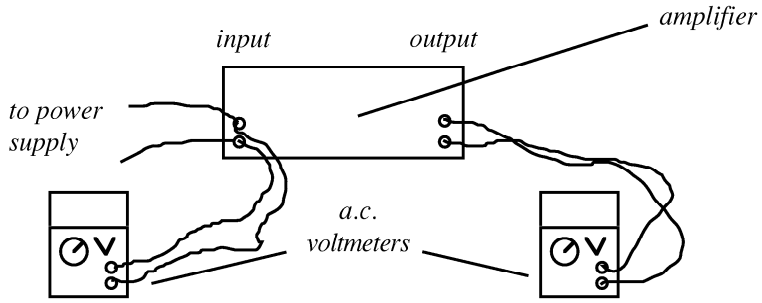
- Construct the circuit and switch it on.
- Connect the oscilloscope to points P and Q and say "A" into the microphone.
- Observe the pattern on the oscilloscope.
- Now, connect the oscilloscope to points X and Y and say "A" into the microphone.
- Observe the pattern.
- In what way is the oscilloscope trace different at the output from the input?
- In what way are the traces the same?
- Does an amplifier change the amplitude or the frequency of the input signal?
- An amplifier is used to boost low amplitude electrical signals so that a higher electrical signal will drive the loudspeaker.
- Make a list of electronic systems which require an amplifier.

ACTIVITY 14

Outcome 3 ✔

Title: Voltage gain.

Apparatus: Variable a.c. power supply, amplifier (with power supply), connecting wires and 2 a.c. voltmeters.



Instructions

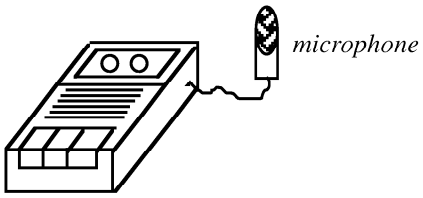
- Adjust the power supply until both voltmeters give a reading.
- Record the reading on both meters.
- Calculate the voltage gain of the amplifier
- Repeat for other input voltages.

ACTIVITY 15

Title: Sound recording.

Aim: To investigate how recorded sounds differ from the original.

Apparatus: Tape recorder and audio cassette.

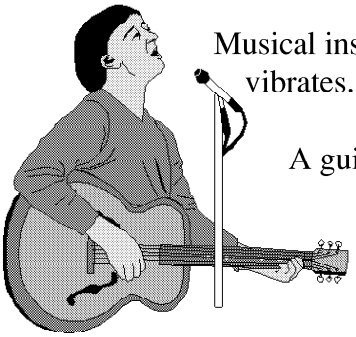


Instructions

- Set the tape recorder to record.
- Speak into the microphone and record your voice.
- Play the recording and listen carefully.
- Does the recording sound exactly like your voice?

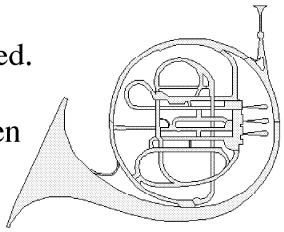
SOUND WAVES

Vibrations



Musical instruments produce sound when part of the instrument vibrates.

A guitar string vibrates when it is plucked.



A trumpet blasts out sound when the air inside it vibrates.

Energy is transferred from the vibrating object to the listener by sound waves which travel through the air. These sound waves make the air vibrate.

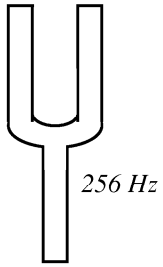
Frequency

Each note or sound has a frequency which is measured in hertz (Hz).

A tuning fork has the frequency engraved on it.

Vibrating forks will produce 256 vibrations every second. This means that 256 sound waves are produced in one second.

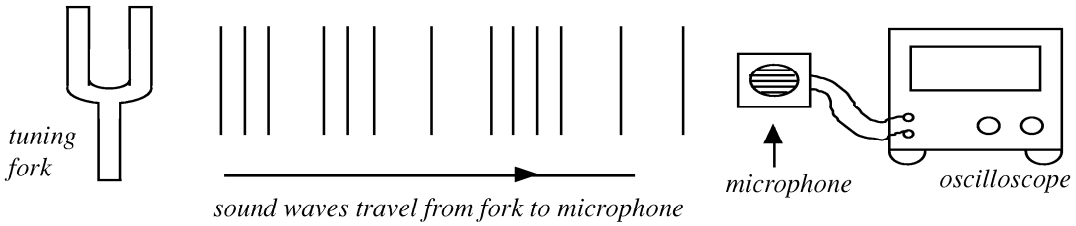
Frequency = number of waves produced in one second.



A whistle produces a higher frequency sound than a vibrating drum. The whistle has a much higher pitch. The higher the pitch means the higher the frequency.

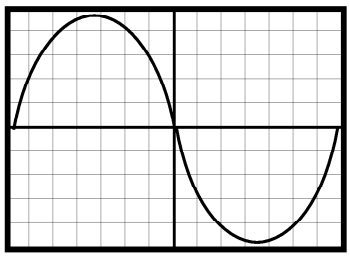
Detecting Sound

Sound can be taken in by a microphone and a trace displayed on an oscilloscope.



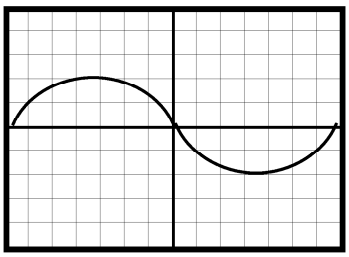
Loud and Quiet

A loud sound transfers more energy so the oscilloscope trace will have a large amplitude. The amplitude of a wave is the distance from the middle of the wave to the top or bottom of the wave.



Loud note has large amplitude

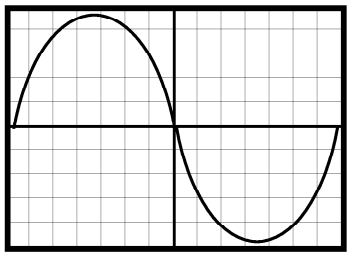
Quiet note has small amplitude



A soft / quiet sound transfers less energy so the oscilloscope trace will have a small amplitude.

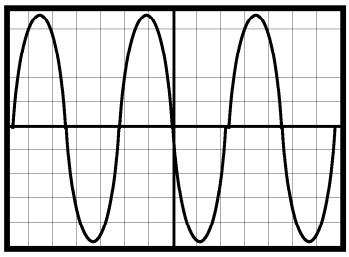
High and Low Frequency

The effect of changing the frequency of a note can be seen on the oscilloscope screen.

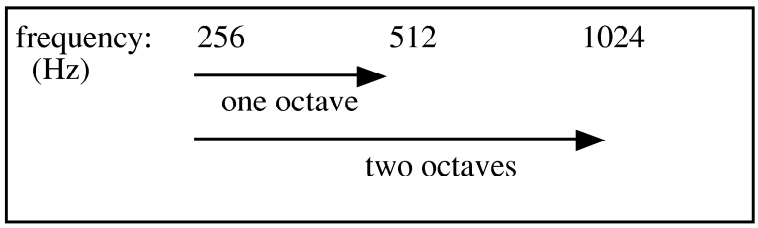


Sound A has low frequency

Sound B has high frequency



Sound B has a higher frequency than sound A. If the frequency is doubled, we say that sound B is an octave higher than sound A



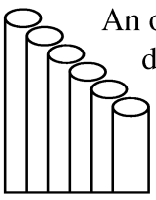
Changing the Note

A musician tunes a guitar by making the string tighter or looser.

While playing the guitar, the note is changed by altering the length of string which vibrates.

- Short strings produce a higher frequency than long strings.
- Tight strings produce a higher frequency than slack strings.

Organs have pipes of different sizes which produce the notes. The shorter the pipe, the higher the note.



An organ produces a variety of musical notes which depend on the length of the air column which vibrates. The shorter pipes have the shorter air columns which produce the higher frequency notes.

SPEED OF SOUND

During a thunderstorm, the lightning flash is seen a short time before the roll of thunder is heard. This is due to the fact that light travels much faster than sound through the air.
In air:

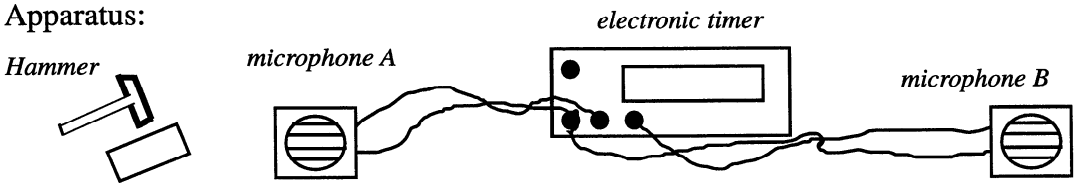
Speed of light	= 300 000 000 m/s
Speed of sound	= 340 m/s

Calculating the Speed of Sound

In a laboratory the speed of sound can be calculated using the formula below.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Apparatus:



A loud sound is made. As the sound reaches microphone A, the timer starts. When the sound waves reach microphone B, the timer stops. The distance between the microphones is measured with a metre stick.

Example:

Time: 0.0030 s, 0.0029 s, 0.0031 s, 0.0027 s, 0.0029 s

$$\textit{Average time} = \frac{0.0146}{5} = 0.0029$$

Distance travelled = 1 metre

$$\textit{Speed} = \frac{\textit{distance}}{\textit{time}}$$

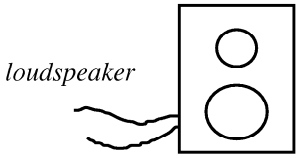
$$= \frac{1}{0.0029}$$

$$= 345 \text{ m/s}$$

USING SOUND

Sound can travel through solids, liquids and gases. The only place that sound cannot pass through is a vacuum.

A vacuum is an empty space, so there are no particles to pass on the vibrations.



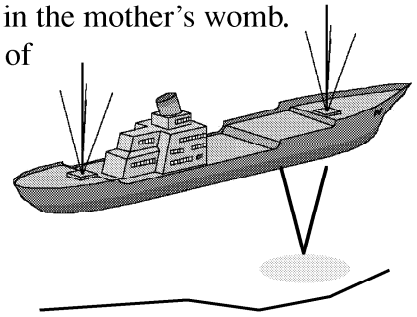
When listening to music, you hear sounds with a wide range of frequencies. We can detect sounds that range from 20 hertz to 20 000 hertz. As we get older, the upper limit gradually falls to about 15 000 hertz.

Some animals can detect higher frequency sounds than humans.

Ultrasound

Sound beyond the upper limit of human hearing (20 000 Hz) is called ultrasound.

Ultrasound can be used in hospitals to scan the baby in the mother's womb. This can be used by a computer to produce an image of the baby on a screen.

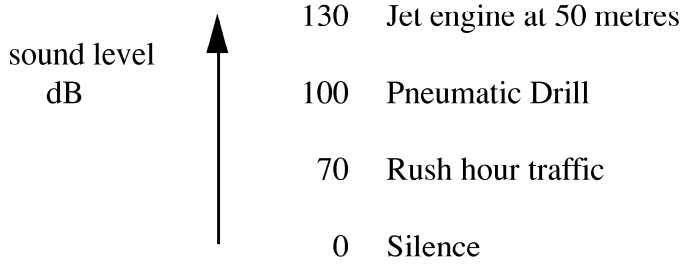


A system called sonar is used by fishermen at sea. The ultrasound signal is transmitted towards the sea bed and an echo is detected.

Shoals of fish are located by this method.

SOUND LEVELS

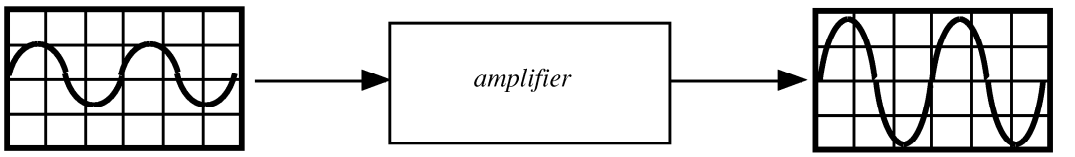
The sound level varies depending on the source of the sound. The sound level is measured in decibels (dB).



When sound levels rise to unacceptable levels, the problem is described as noise pollution. There are many sources of noise pollution, such as aircraft noise or pneumatic drills. Exposure to high sound levels over a long time can damage our hearing. Listening through stereo headphones would produce a harmful effect if the volume is turned to maximum.

AMPLIFIED SOUND

A stereo system can be used to listen to a compact disc (CD) or a radio programme. No matter what function is selected, the signal passes through an amplifier which turns a small amplitude electrical signal into a higher amplitude one.

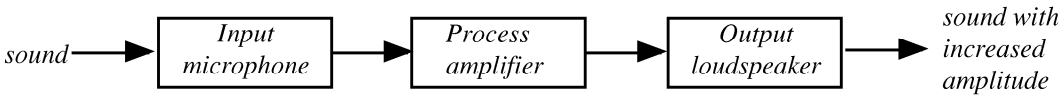


small amplitude input signal *large amplitude output signal*

Only the amplitude of the signal is changed. The frequency does not change.

When announcements are made at airports and stations, the message has to be changed from sound into electrical signals and back to sound.

An electronic system of 3 parts is used to amplify the sound given out by the announcer.



Part of the system	Function
microphone	converts sound into an electrical signal
amplifier	makes the electrical signal stronger (bigger amplitude)
loudspeaker	converts electrical signal back to sound

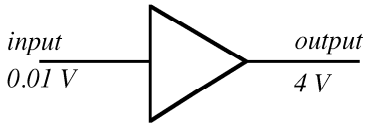
Voltage Gain

The performances of different amplifiers can be compared by finding the gain of the amplifier.

$$\text{Voltage gain} = \frac{\text{Output voltage}}{\text{Input voltage}}$$

Example:

Find the voltage gain of the following amplifier.



$$\textit{Voltage gain} = \frac{\textit{Output voltage}}{\textit{Input voltage}}$$

$$= \frac{4}{0.01}$$

$$= 400$$

N.B. Voltage gain is just a number. It has ***no*** *unit.*

Playback

A recording of your own voice will sound a bit strange when it is played back from a cassette.

This is because we normally hear our own voice by:

- vibrations of bones in our skull and
- vibrations in the air being detected by our ears.

When we listen to a recording of our own voice we hear it by:

- vibrations in the air being detected by our ears only.

A CD (compact disc) is a source of high quality sound. As the CD spins inside the CD player, light from a laser reflects off the CD. There is no wear and tear of the disc surface and there is very little background noise.

SOUND AND MUSIC PROBLEMS

Sound waves

1. An orchestra has various sections - like string, brass, percussion etc.....

(a) How do all musical instruments produce sound energy?

(b) Complete the following:

Sound is a _____ which transfers _____.

2. Frequency is measured in

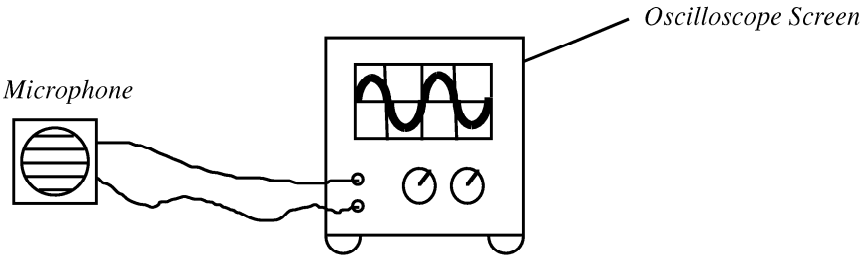
A watts

B decibels

C hertz

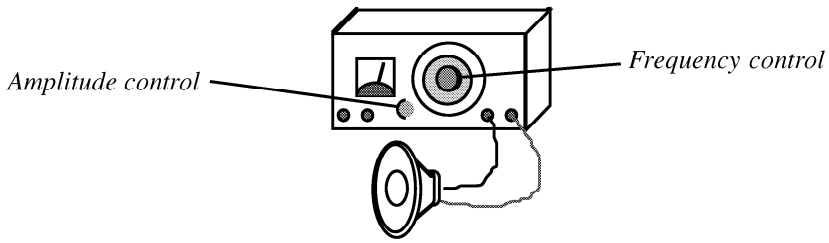
D volts

3. An oscilloscope can display a musical note on the screen.



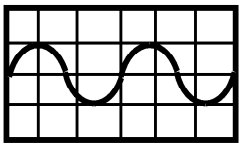
(a) How many waves are seen on the screen?
(b) The frequency of these waves is 50 Hz.
How many waves are produced in one second?

4. Jane uses a signal generator to increase the pitch of the note emitted by the speaker. The signal generator has an amplitude control and a frequency control.

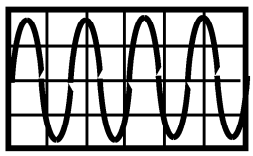


(a) Which control did Jane turn?

Jane now connects an oscilloscope to the generator and adjusts the amplitude and frequency controls.



Oscilloscope trace before Jane adjusts the controls

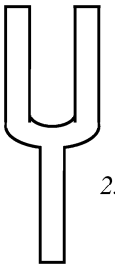


Oscilloscope trace after Jane adjusts the controls

(b) What did Jane do to the loudness of the note emitted? Explain your answer.

(c) What did she do to the frequency of the note? Explain your answer.

5. Jason generates sound by striking tuning forks.

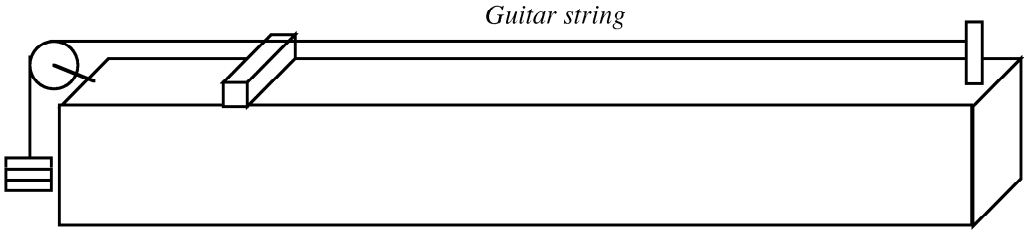


He strikes the tuning fork and produces a note of frequency 256 Hz. The second tuning fork he strikes produces a note one octave higher than the first.

(a) What is the frequency of the second tuning fork?

(b) What would be the frequency of a note one octave below the original note?

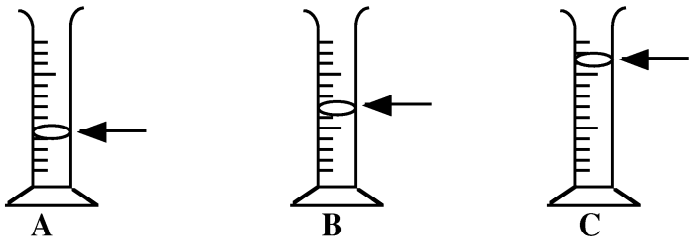
6. Guitar strings are being tested using the setup shown below.



The string is plucked and a note of 300 Hz is produced.
State two ways that this setup could be changed to increase the frequency of the note produced.

7. A set of identical measuring cylinders are filled with different volumes of water. A tune can be played by blowing across the mouth of the cylinders.

(a) Explain why each cylinder produces a different note.



(b) Which cylinder produces the highest frequency. Explain your answer.
(c) List the cylinders in order of increasing frequency.

8. Two students are investigating how the frequency of sound produced by a stretched wire alters as the thickness of the wire is varied. Their results are shown here.

Thickness of wire (mm)	Length of wire (m)	Frequency of sound (Hz)
1	0.5	800
1	1	400
2	0.5	400
3	0.25	530
4	0.5	200

(a) Which factor, other than thickness, affects the results?
(b) Construct a new table, with headings and units, to show **three** results which the students should use to enable them to make a conclusion from their investigation.
(c) What conclusion can the students make from their investigation?

Speed of sound

9. A block of flats have to be demolished. When the explosive is detonated, the observers, who are a safe distance away, hear nothing. They see the flats collapsing and sometime later hear the sound of the explosion.

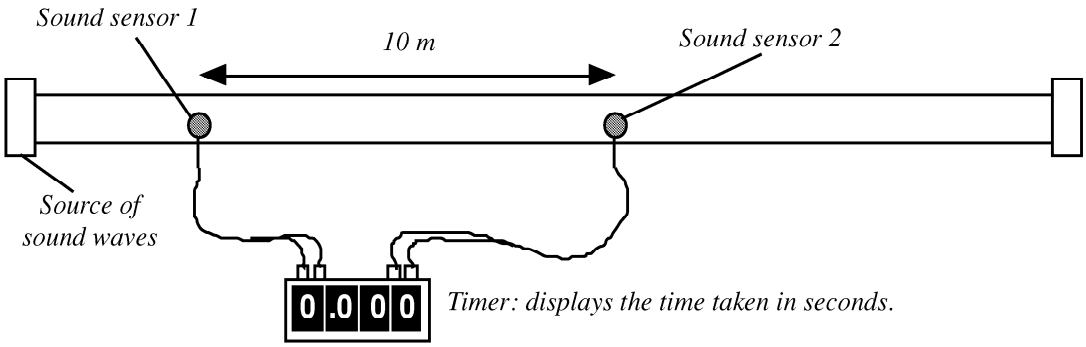
   (a) Explain why nothing is heard immediately.
   (b) Give another example of this effect.

10. Two pupils are given the task of measuring the speed of sound in air. They are given an air horn and a flag. Describe how they could measure the speed of sound in air.

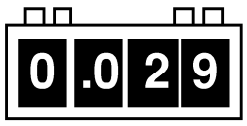
    You should:

    (a) state any extra apparatus they would need
    (b) the measurements to be taken
    (c) how the speed is calculated.

11. Sound waves pass through a long pipe. When the sound reaches sound sensor 1 the timer is switched on. After the sound has travelled 10 metres the sound reaches sound sensor 2 and the timer is switched off.



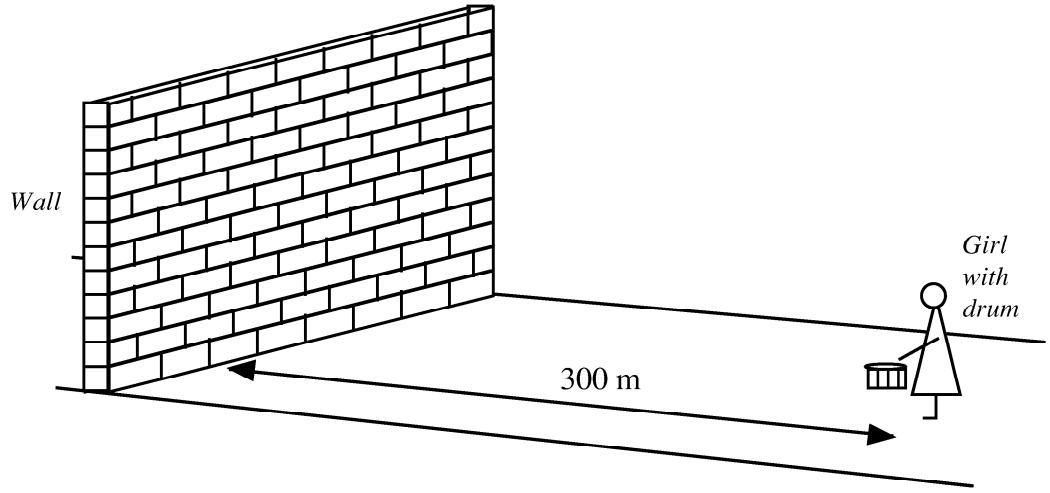
The final display on the timer, in seconds, is shown below.



Calculate the speed of the sound.

12. A student wants to find the speed of sound in air using the echo from a wall.

She stands 300 metres away from a large wall as shown.



She now hits a drum and at the same time starts a stop clock.
When she hears the echo of the drum she stops the clock.

The reading from the stop clock is 1.8 seconds.

Use these figures to calculate the speed of sound in air.

Using sound

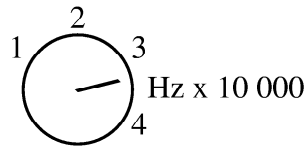
13. Sound can travel through air. Name four other substances through which sound can travel - include a solid, a liquid and a gas.

14. Two astronauts are working on the surface of the Moon. They are about 5 metres away from each other. One astronaut has a sound sensor on the outside of his spacesuit. The other astronaut hits two metal hammers together.

(a) Will the sound sensor detect the sound? Explain your answer.
(b) One of the astronauts hits a rock with a hammer. Will a sound sensor in the nearby spacecraft detect the sound?

15. In class, a signal generator is adjusted to the frequency shown.

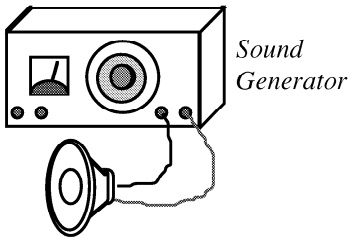
Robert tells the teacher that he can hear the note from the loudspeaker.



(a) Why does his teacher tell him that he is mistaken?
(b) State a frequency that would probably be heard by the whole class.

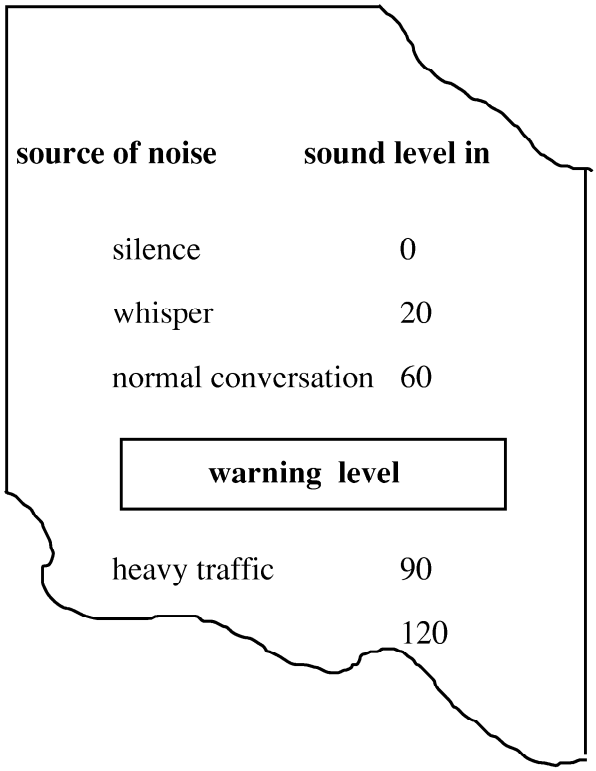
16. A special sound generator is being tested in a school laboratory.

A detector with a meter is needed to pick up the sound since the frequency is beyond the range of human hearing.



(a) What is the name of this type of sound?
(b) Which mammal might be able to hear this sound?
(c) This type of sound has an important medical use. Describe what it is used for.
(d) It is not only medical staff who use this type of sounding equipment. In what industry might it be used and how is it put to good use?

17. This poster appears on the wall of a hospital waiting room but part of the poster has been torn and some words are missing.



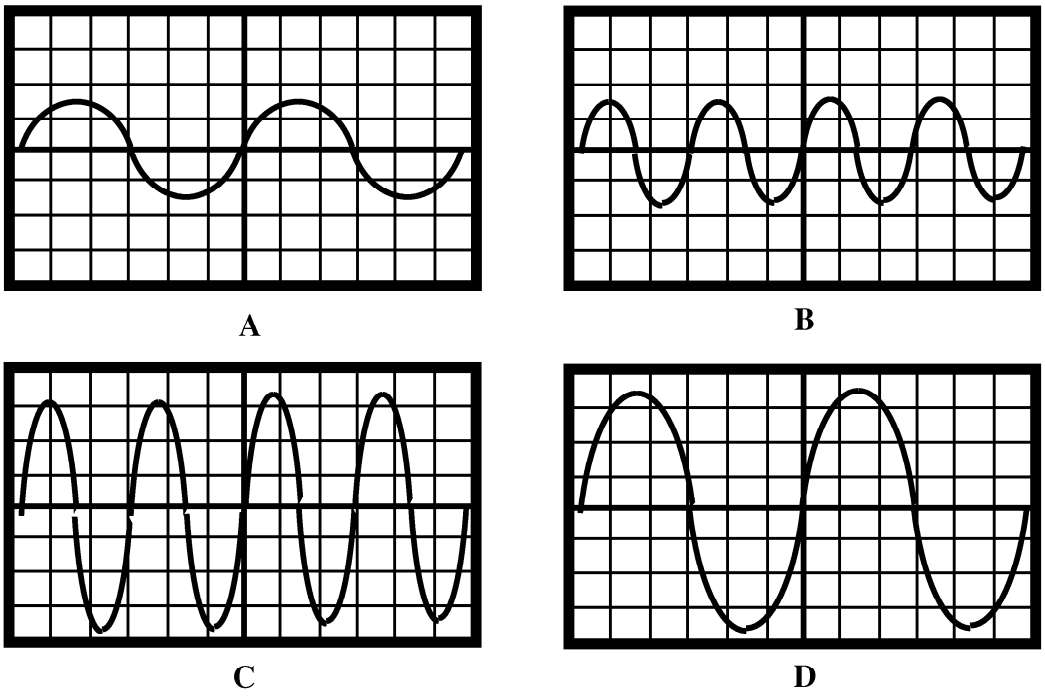
(a) What is the missing word after "sound level in ”?

(b) The source of sound with a level of 120 is also torn out of the poster. This source is a source of noise pollution. Give some possible examples of noise pollution.

(c) Why does the lower section of poster carry a warning?

Amplified sound

18. Four oscilloscope traces are shown. The oscilloscope controls are all at identical settings.

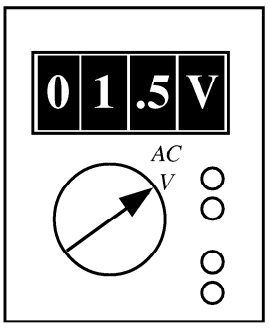


Trace A is the input signal to an amplifier.

(a) Which trace shows the output signal of the same amplifier?
(b) The input signal has a frequency of 200 Hz. State the frequency of the output signal.

19. Debbie, the science technician, is checking the amplifier used in the school tannoy system.

She connects a voltmeter to the input terminals of the amplifier and obtains the reading shown.



When she checks the output voltage from the amplifier the new reading is 30 V.

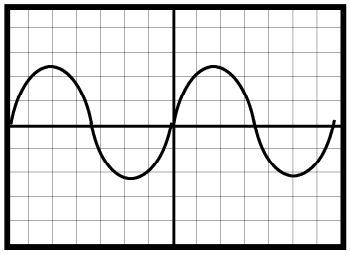
(a) How will she calculate the voltage gain of the amplifier?

(b) What is the gain of this amplifier?

20. Music albums are available in tape cassette or compact disc (CD) format. Cassettes are less expensive, yet CDs are very popular and sell in great numbers.

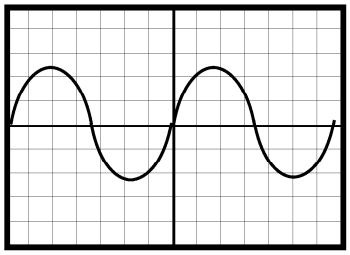
    (a) State two advantages of a CD compared to a tape cassette.
    (b) A tape cassette can be used to record your own voice and then played back. However the recording is not immediately recognisable as your own voice. Why is this?

21. Laura whistles into a microphone connected to an oscilloscope.
    The trace produced on the oscilloscope is shown below.

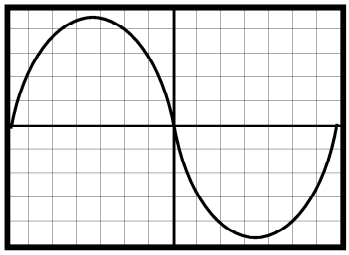


Laura now whistles a louder sound with the same frequency into the microphone.
Which trace shows the new wave pattern produced on the oscilloscope if the controls are not changed?

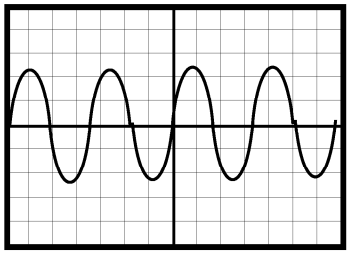
A



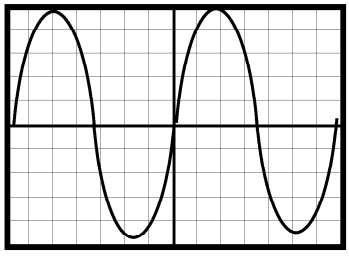
B



C



D



22. A public address system is used at airports to give passengers information.
    It is made up of three components, as shown below.

State the function of each of these components,