Sound and Music

Sections 4.1 Sound Waves

4.2 Speed of Sound

4.3 Using Sound

4.4 Amplified Sound

In this unit you will learn about what sound is, how it is produced and some uses of sound.

4.1 Sound Waves

At the end of this section you should be able to

1 State that for sound to be produced an object must vibrate. □

2 State that sound is a wave which transfers energy. □

3 State that the frequency of a sound is the number of waves produced in one second. □

4 State that frequency is measured in hertz. □

5 State that the higher the pitch of a sound the larger the frequency. □

6 Identify from oscilloscope traces the signal which would produce:
(a) the louder sound □
(b) the higher frequency. □

7 State that if two sounds are one octave apart, the frequency of one is double the other. □

8 Describe how the frequency produced by a vibrating string can be increased by altering the length of the string and the tightness of the string. □

9 Describe how the frequency produced by a vibrating air column can be increased by altering the length of the air column. □

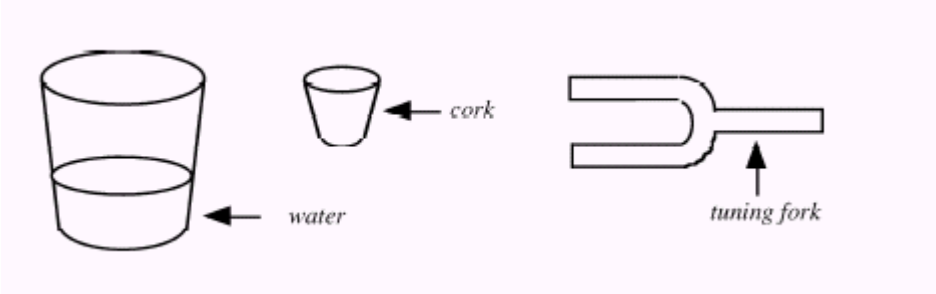
Sound Vibrations

What is sound? What happens to something when sound passes through it?

Experiment 1

Aim: To show how sound energy is produced**.**

Apparatus: Tuning forks, cork and beaker of water.



Method:

- Strike the tuning fork on the cork then move the tuning fork to just touch the water surface.
- Now strike the fork again and hold it against the bench.
- Try various lengths of fork and make a note of the frequency of each.

Results:
When the tuning fork was held in the water, the water

……

The shortest tuning fork had the …… frequency.

The longest tuning fork had the …….. frequency.

Conclusion:

Sound energy is produced when an object ……..

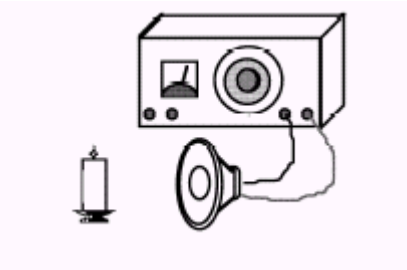
The longer a tuning fork the …… the frequency of vibration.

Energy Transfer

Experiment 2

Aim: To show how sound energy is carried from place to place.

Apparatus: Signal generator, loudspeaker and candle.



Method:

- Adjust the signal generator to about 10Hz and maximum voltage.
- Direct the sound from the speaker towards the candle flame.
- Watch the flame.

Results:

As the sound passes by, the flame……

Conclusion:

As sound is carried from place to place, the air it passes through

……

Read and Answer

Sound is a wave which carries energy from one place to another.
Sound is made when an object vibrates.
For example, when someone plays a xylophone, the metal bars vibrate. This produces the sound.
The sound is carried by the particles of the air vibrating and passing on the energy.

If some of the energy reaches your ears, you hear the sound.

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. What vibrates to produce sound in each of these instruments?

guitar: ……

piano: ……..

clarinet: ……

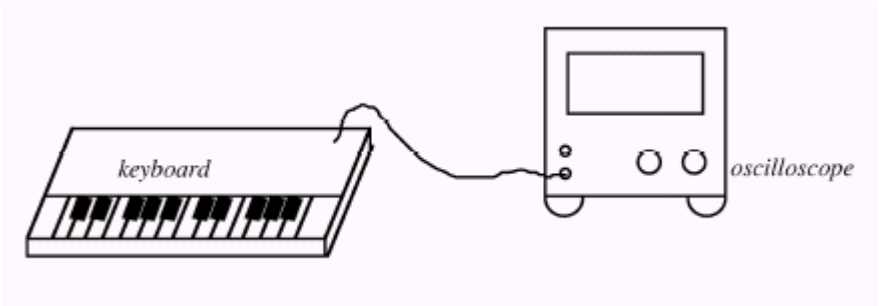
drum: ……

Oscilloscope Patterns

Experiment 3

Aim: To show that sounds vary in frequency.

Apparatus: Oscilloscope, connecting wires and keyboard.



Method:

- Use the keyboard to play different notes and watch 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.
- Do this for low frequency notes (left-hand end of the keyboard) and high frequency notes (right-hand end).
- Try playing the same note at low and high volume and watch the pattern on the screen.

Results:

Try to describe the difference in pattern for low frequency and high frequency notes. (A diagram may help)

……

……

……

Try to describe the difference in pattern for low and high volume

notes.

……

……

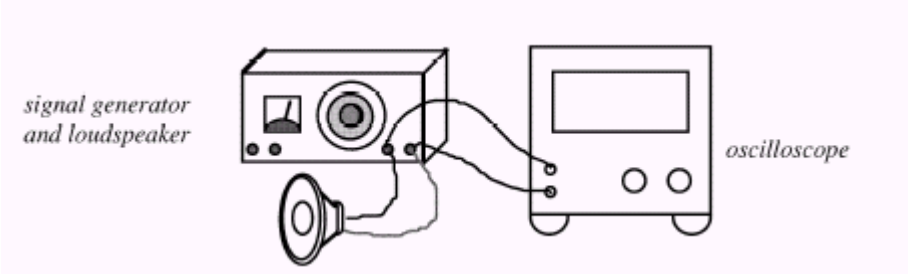
……

Producing Different Sound Waves

Experiment 4

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

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



Method:

- Set the frequency on the signal generator to 100Hz. Adjust the voltage to produce a note from the loudspeaker. Keep the voltage constant.
- Increase the frequency of the note.
- As the frequency is increased watch what happens to the number of waves on the screen of the oscilloscope.
- Complete the first two diagrams in the results section.

- Set the frequency to 500Hz and do not change it.
- Slowly increase the voltage from a low to a high value.
- As the voltage is increased watch what happens to the height of the waves on the screen.
- Complete the next two diagrams in the results section.

Results:

Changing frequency

Low frequency

High frequency

Changing voltage

Low voltage

High voltage

Conclusion:
Complete the conclusion choosing words from this list:

higher, lower, more, less, louder, quieter, larger, smaller.

(You do not have to use all the words!)

As the frequency of the sound is increased, the pitch gets

……..… and ……. waves appear on the screen.

As the voltage is increased, the sound gets ……..

and the height of the waves gets ……

Read and Answer

Frequency and Amplitude

The frequency of a sound is measured in Hertz (Hz).
The frequency of a sound tells us how many sound waves are produced every second. Eg. if a sound has a frequency of 400 Hz, there are 400 waves every second.
The higher the frequency of a sound wave, the higher-pitched the sound is.

If the frequency of a sound is doubled, the note goes up one octave.
For example, 512 Hz is one octave above 256 Hz, 2048Hz is two octaves above 512 Hz (frequency has been doubled twice).
The louder a sound is, the larger its amplitude is. The oscilloscope shows this as a taller wave.

1. Underline the note which would sound the highest-pitched:

40Hz 15000Hz 4800Hz 20Hz

2. What would be the frequency of a note one octave higher than

2400Hz?……

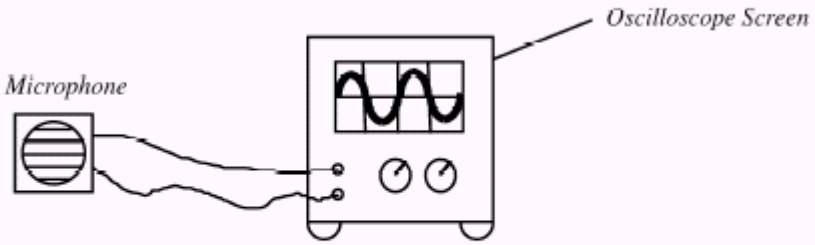
3. Which of these is two octaves below 1800Hz?

450Hz 900Hz 3600Hz

4. A tuning fork vibrates at 256Hz. How many waves does it produce each second?……

5.

An oscilloscope can display a musical note on the screen.

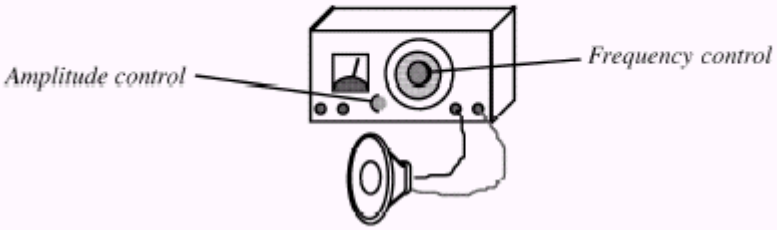


(a) How many waves are seen on the screen?
(b) The frequency of these waves is 50 Hz.
How many waves are produced in one second?

(a)…… (b)……

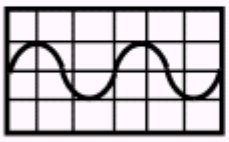
6.

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.

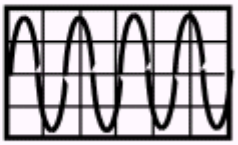


(a) Which control did Jane turn?……

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?

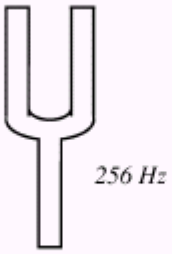
……

(c) What did she do to the frequency of the note?

……

7.

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? ……

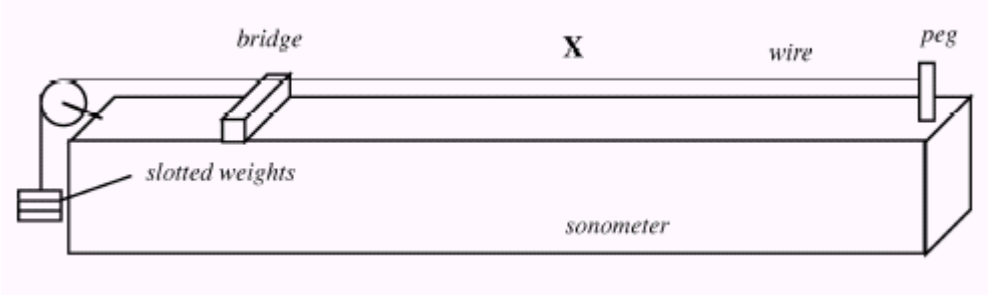
Increasing the Frequency

Musical instruments like the guitar and violin use vibrating strings to produce sound. If the musician wants to change the note made by a string, how do they do this?

Experiment 5

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

Apparatus: Sonometer and slotted weights.



Method:

- Pluck the wire at X when there are a small number of weights pulling the wire.
- Repeat for a larger number of weights.
- Listen to how the frequency of the note changes as the wire becomes tighter.
- Move the bridge but keep the tightness of the wire constant (number of weights).
- Listen to how the frequency of the note changes as the vibrating part of the wire becomes longer.

Conclusion:

As the wire becomes tighter ……

……

As the length of the vibrating wire gets longer ……

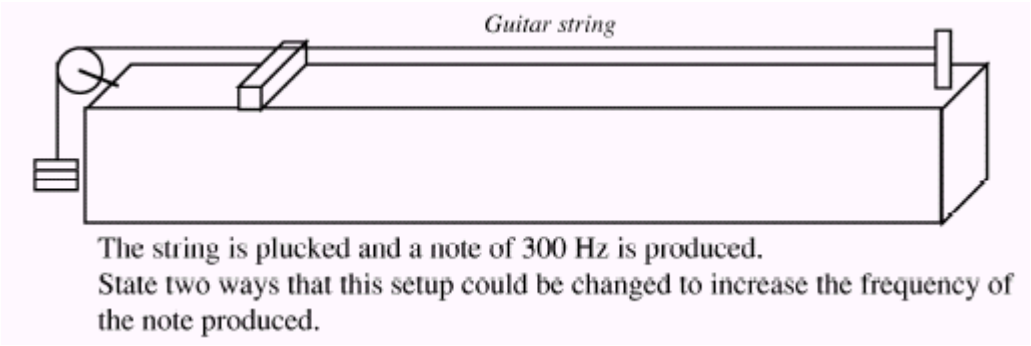
……

Investigation:

If you blow over the top of a measuring cylinder, it makes a noise. How does the length of air in the cylinder affect the frequency of the note?
Investigate this and write down your conclusions.

Read and Answer

1. 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.

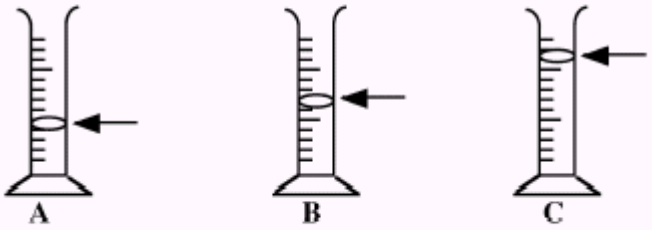
……

……

2.

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.

(a)……

(b)……

(c)……

3.

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?

(a)……

(b)

(c)……

4.2 The Speed of Sound

At the end of this section you should be able to

1 Give an example which shows that the speed of sound in air is less than the speed of light in air. □

2 Describe a method for measuring the speed of sound in air using the relationship between distance, time and speed. □

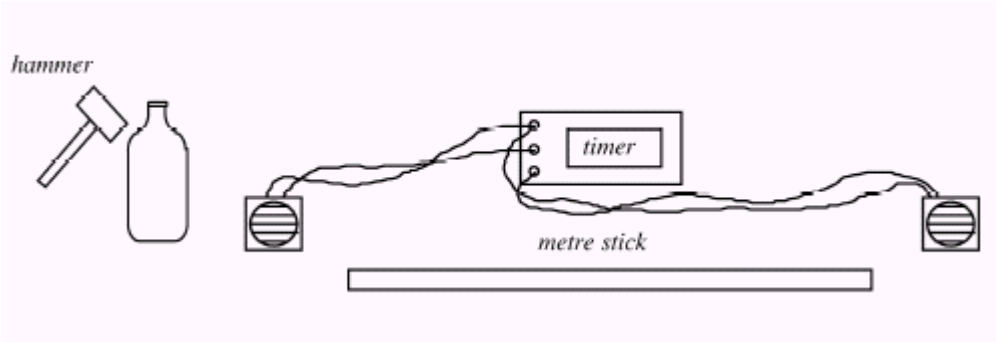
3 Calculate the speed of sound using: $speed = \frac{distance}{time}$ □

You have learned that sound waves are carried through the air as vibrations. At what speed do sound waves travel through the air?

Experiment 6 (Outcome 3)

Aim: To calculate the speed of sound in air.

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



Method:

- Place the microphones 1 metre apart.
- Switch on the timer and reset it to zero.
- Strike the two metal rods together and record the time on the timer.
- Repeat the experiment until 5 times have been collected.
- Calculate the speed of sound in air.

Results:

Conclusion:

The speed of sound in air is ……

Read and Answer

1.

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.

(a)……

(b)……

2.

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.

(a)……

……

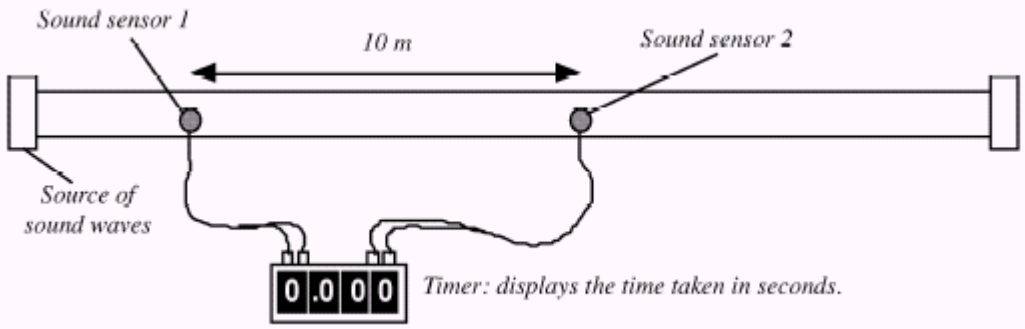
(b)……

……

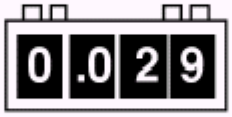
(c)……

3.

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.

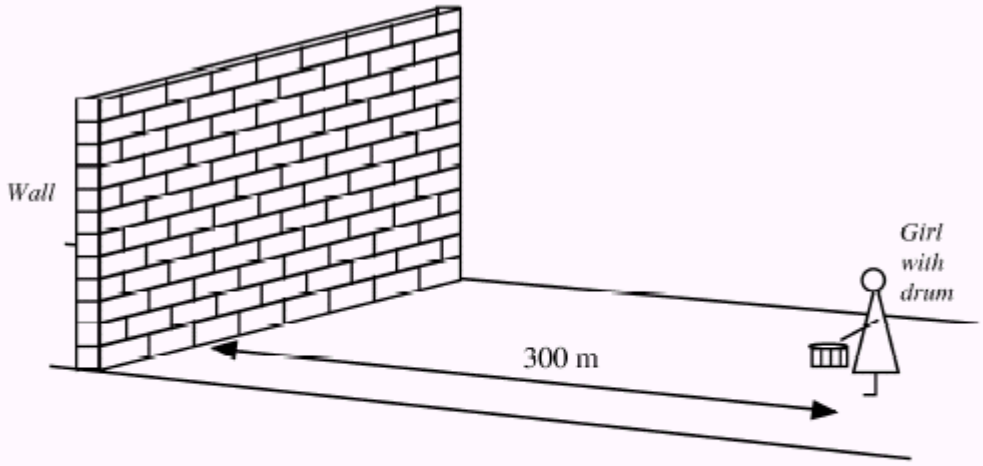


Calculate the speed of the sound.

4.

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.

4.3 Using Sound

At the end of this section you should be able to

1 State that sound can pass through solids, liquids and gases. □

2 State that sound cannot pass through a vacuum. □

3 State that the normal range of human hearing is from 20 hertz to 20,000 hertz. □

4 State that high frequency sounds beyond the range of human hearing are called ultrasounds. □

5 Give one example of a use of ultrasound in medicine. □

6 Give one example of a non- medical use of ultrasound. □

7 State that sound levels are measured in decibels. □

8 Give two examples of noise pollution. □

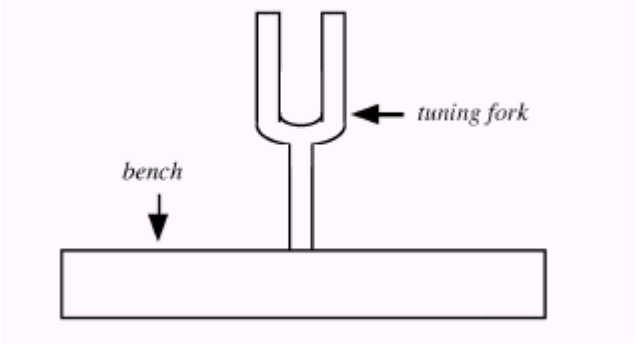
9 State that excessive noise can damage hearing. □

Solids, Liquids and Gases

Experiment 7

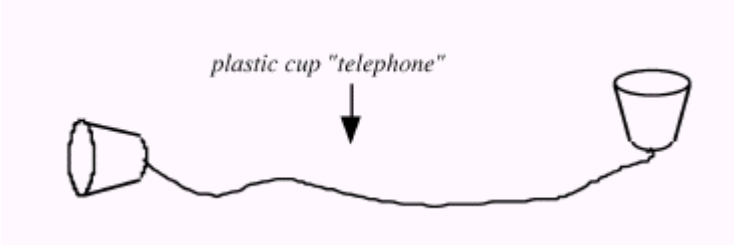
Aim: To investigate the transmission of sounds through solids.

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



Method:

- Strike the fork on the cork and hold the tuning fork on the bench as shown.
- Get someone to listen to the vibrating forks by resting their ear on the bench.
- Use the "telephone" to communicate with someone else.



Results:

What did the sound waves pass through to get from the tuning fork to your ear? ……

What did the sound waves pass through to get from one plastic cup to the other? ……

Are these objects solids, liquids or gases? ……

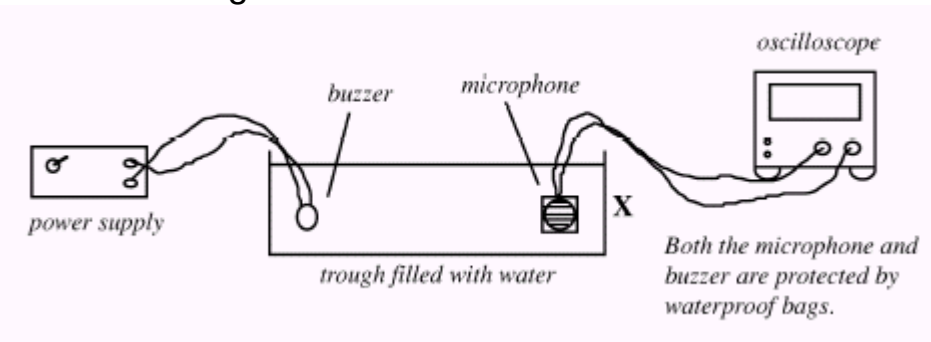
Conclusion:

……

Experiment 8

Aim: To investigate the transmission of sound through liquids.

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



Method:

- Place the buzzer and microphone under water as shown.
- Turn on the buzzer.
- Watch the oscilloscope screen to see if any sound is detected.

Results:

Was sound detected by the microphone? ……

What would sound have to travel through to get from the buzzer to

the microphone? ……...

Conclusion:

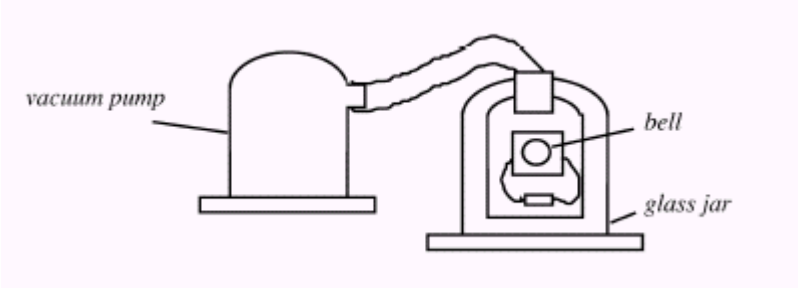
……..

Silence in a Vacuum

Experiment 9 Teacher Demonstration

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

Apparatus: Bell jar and vacuum pump.



Method:

- The bell is set ringing.
- The air is pumped out of the jar.
- The air is let back into the jar.

Results:

When the air is pumped out of the jar what happens to the sound

of the bell? ……

As the air is allowed back into the jar, what happens to the sound

of the bell? ……

Conclusion:

Can sound travel through a vacuum? ……

Sound can travel through solids, liquids and gases.
Sound cannot travel through a vacuum because there are no particles to vibrate to carry the sound energy.

Read and Answer

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?

(a)……

explanation……

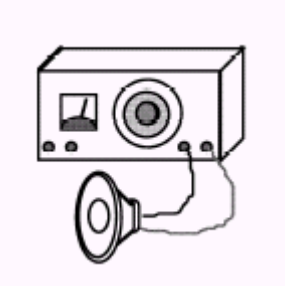
(b)……

Range of Hearing

Experiment 10

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

Apparatus: Signal generator and loudspeaker.



Method:

- Set the signal generator to give a 1000 Hz note from the loudspeaker.
- Gradually increase the frequency until you can no longer hear the sound.
- Gradually decrease the frequency from 1000 Hz until you can no longer hear the sound.
- Compare your range of hearing with others in your class.

Results:
The lowest frequency I could hear was …….

The highest frequency I could hear was ……..

Conclusion:
My range of hearing is from about…… to ……

The normal range for human hearing is from about **20Hz** to **20000Hz**.
You may have measured different values for a few reasons. The loudspeaker may not be able to produce very high and low sounds well. As we get older our range of hearing gets smaller.

Ultrasound

Read and Answer

1. Read *Seeing With Sound* in Nelson Standard Grade Physics pages 68 – 69 then use these words to complete the passage.

depth waves damage tissue reflect frequency sonar

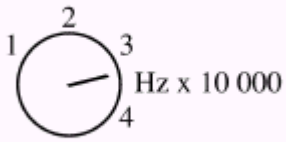
Ultrasound is sound with a higher ……. than humans can hear. Ultrasound can be used in ships to find the …… of water below the ship. This technique is called ……

Ultrasound is also used in medicine. A pregnant woman can have an ultrasound scan. The high …… sound ……. are sent into the body and …… off different layers of …… such as muscle and bone. When the sound waves are received back at the scanner they can be built up into a picture of the unborn baby. This is safer than taking an X-ray photograph because X-rays can…… an unborn baby but ultrasound does not.

2.

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.

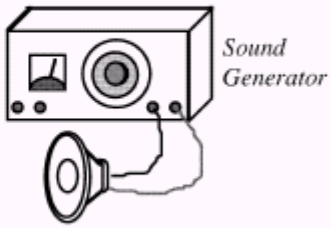
(a)……

(b)……

3.

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?

(a)……

(b)……

(c)……

(d)……

Noise Level

To find out how loud a noise is we measure its sound level. Sound level is measured in decibels (dB).

Experiment 11

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

Apparatus: Sound level meter.

Method:

- Measure the sound level in various areas of the classroom and school.

Results:

location	sound level (dB)

Draw a bar chart of the sound level against location.

Noise Pollution

Unwanted noise that causes a nuisance is called noise pollution. Traffic noise, loud roadworks and loud music could all be examples of noise pollution.

Read and Answer

Read Nelson Standard Grade Physics page 70 then answer these questions.

1. What is the unit of sound level ?……

2. Give the approximate sound level of each of these:

Loud conversation……..

Leaves rustling…….

Disco, 1m from speaker……..

3. What is the maximum level of noise allowed in factories?……...

4. Why is it dangerous to listen to loud noise, especially over a long time?

…….

5.

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?

source of noise	sound level in
silence	0
whisper	20
normal conversation	60
warning level	
heavy traffic	90
	120

(a)……

(b)……

……

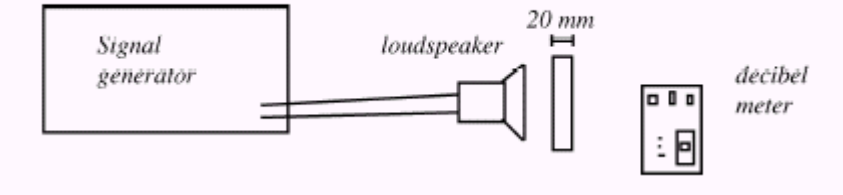
(c)……

Reduction of Sound by Different Materials

Experiment 12 (Outcome 3)

Aim: To investigate which materials are best for reducing noise.

Apparatus: Signal generator, loudspeaker, sound level meter, 20mm thick pieces of different material.



Method:

- Set up the apparatus as shown, but with no material between the loudspeaker and sound level meter.
- Turn up the voltage on the signal generator until the sound level meter reads about 80 dB.
- Take one of the pieces of material and insert it between the loudspeaker and the sound level meter.
- Note the new reading of sound level.
- Repeat for the other materials, making sure your experiment is a fair test.
- Record your results in a table and bar chart below.

Results:

4.4 Amplified Sound

At the end of this section you should be able to

1 State that the output signal from an amplifier has the same frequency but a bigger amplitude than the input signal. □

2 State the function of each of the three major components needed to amplify speech (microphone, amplifier, loudspeaker). □

3 Define voltage gain of an amplifier in terms of input and output voltages. □

4 Calculate voltage gain using: $\textit{voltage gain} = \frac{\textit{output voltage}}{\textit{input voltage}}$ □

5 Explain why your recorded voice sounds different to you. □

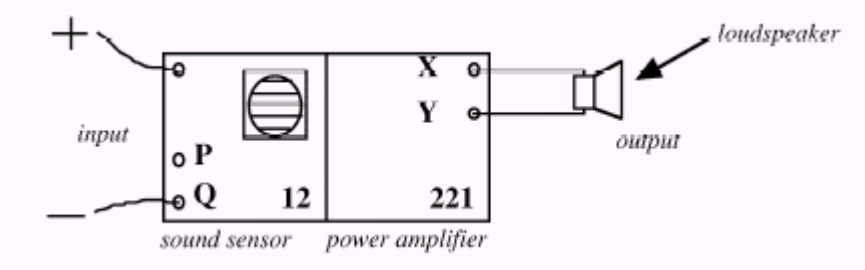
6 State the advantages of a compact disc compared to a tape cassette. □

Increasing the Amplitude

Experiment 13

Aim: To find out how an amplifier affects a signal.

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



Method:

- Construct the circuit and switch it on.
- Connect the oscilloscope to points P and Q and say “Ah” into the microphone.
- Observe the pattern on the oscilloscope.
- Connect the oscilloscope to points X and Y and say “Ah” into the microphone.
- Observe the pattern

Results:

In what way is the oscilloscope pattern different at the output from the input?

……

In what way are the traces the same?

……

Conclusion:

An amplifier changes the ……of the input signal.

The sound sensor (microphone) picks up the sound wave and changes it to an electrical signal.

…….. energy → ……. energy.

The electrical signal from the sound sensor would be too weak to drive the loudspeaker. The amplifier increases the amplitude of the signal (gives the signal more energy).

The loudspeaker then uses this stronger signal from the amplifier to produce a louder version of the sound wave.

…….energy → ……. energy.

Read Physics Through Applications page 120 then make a list of four electronic devices which use an amplifier.

…… ……

…… ……

Voltage Gain

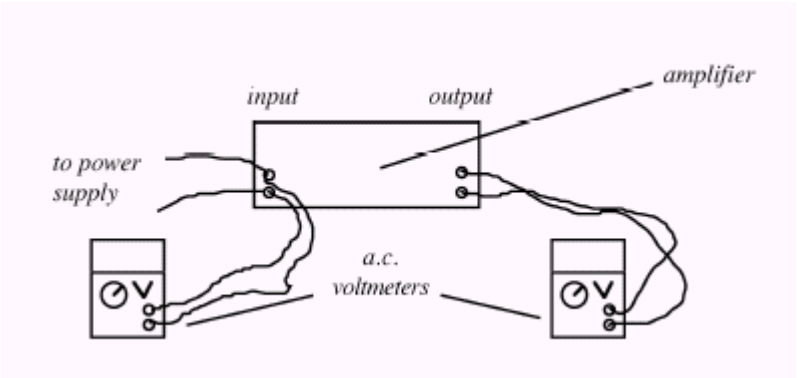
The voltage gain of an amplifier tells us what number the amplifier multiplies voltages by.
Voltage gain is calculated by:

$$\text{Gain} = \frac{V_{out}}{V_{in}}$$

Experiment 14 (Outcome 3)

Aim: To calculate the voltage gain of an amplifier.

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



Method:

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

Results:

V_{in}	V_{out}	Voltage Gain

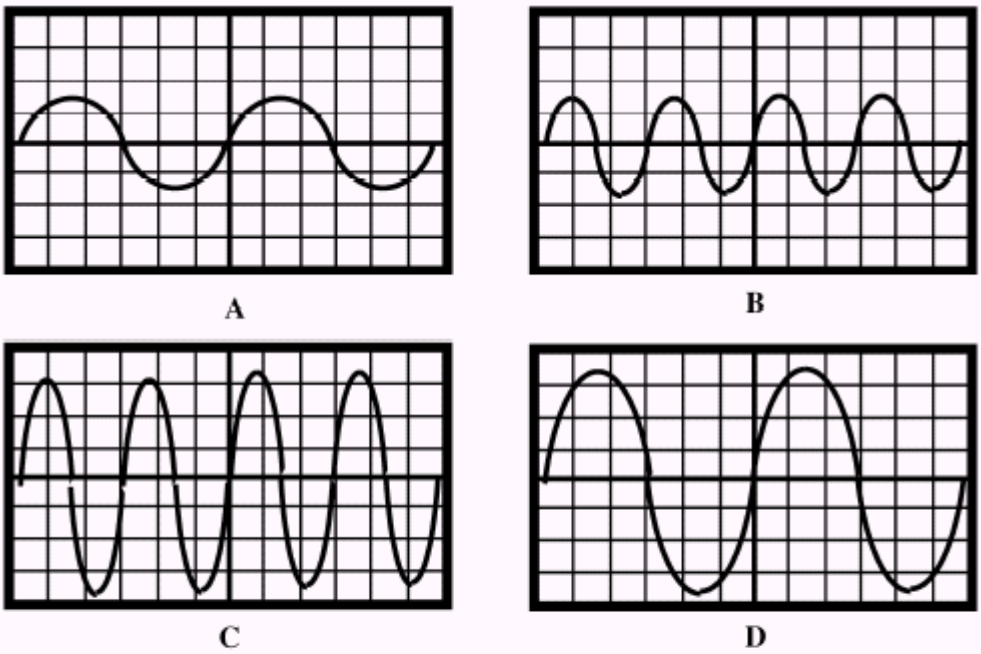
Conclusion:

The gain of this amplifier is ……

Read and Answer

1.

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.

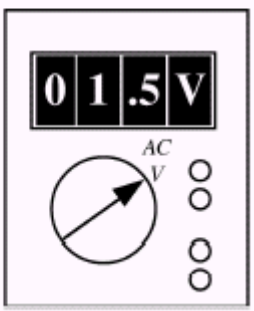
(a) Trace ……

(b) ……

2.

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?

(a) Gain=……

(b)

Sound Recording

Experiment 15

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

Apparatus: Tape recorder and audio cassette.

Method:

- Set the tape recorder to record.
- Speak into the microphone and record your voice.
- Play the recording and listen carefully.
- Listen to a recording of someone else's voice.

Results:
Does the recording of your voice sound exactly like your voice to

you?……..

Does the recording of someone else's voice sound exactly like

their voice? ……

Read and Answer

Read Physics Through Applications pages 208 – 209.
Complete the passage.
The particles in a cassette tape behave like tiny ……..

The ……..…… head in the cassette recorder lines these up so that they form a record of the sound wave.

The ……... head reads this signal to reproduce the sound.

When we listen to a recording of our own voice, the sound gets to our ears by passing through the……

Normally when we hear ourselves talking the sound travels to our ears through the …… and also through the …….

This is why your voice sounds strange when you listen to a recording of yourself.

Read Physics Through Applications pages 210 –211

Complete the passage.

A gramophone record (stereo LP) is an analogue record of sound waves. This is read by a needle which touches the surface of the record. There is always some background noise and the needle gradually wears away the surface of the record, reducing the quality of the sound.

A CD is a …… record of sound waves. This is read by a …… beam which reflects off pits on the surface of the CD. Because nothing rubs on the surface of the disc, it is not worn away. There is also very little background noise compared to an LP or cassette tape.

Read and Answer

1.

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?

(a)……

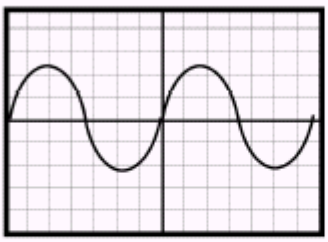
……

(b)……

……

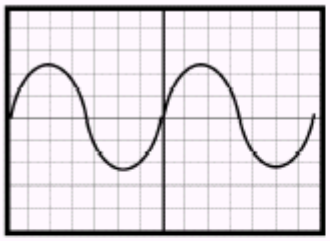
2.

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

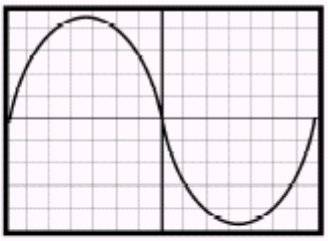


Laura now whistles a louder sound with the same frequency into the microphone.
Which trace shows the new wave pattern produced on the oscilloscope if the controls are not changed?

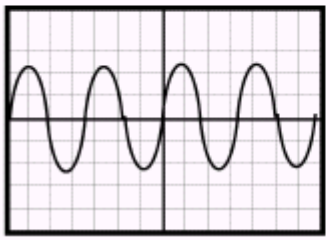
A



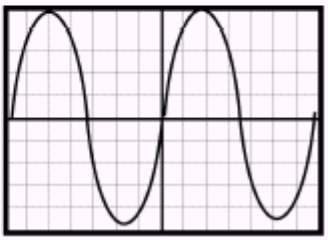
B



C



D



Answer……

3.

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,

Microphone……

Amplifier……

Loudspeaker……