Exhibit message

To show a visual representation of sound waves using an oscilloscope and to demonstrate how the waves change with pitch manipulation.

Quick Fact

The first cathode ray **oscilloscope** (CRO) was made in 1897 by Karl Ferdinand Braun. In 1936 John Logie Baird combined the CRO with the principle of radio broadcasting to produce television.

Graphic panel text

What does your voice LOOK like?

The look of sound

When you look at the screen (oscilloscope), you will see a squiggly line which represents the sound waves of your voice.

- When you speak in a high pitch you see waves that are closer together. This represents a high frequency.
- When you make a loud noise you see large waves.

Same note, different sound

Most sounds, including your voice, are made up of more than one pitch (frequency). This mixture of frequencies is called timbre ("tom-ber"). The timbre of your voice will be different from someone else's—even when singing exactly the same note.

How does singing or whistling look?

When you sing or whistle a note you may notice the waves have a regular pattern. This is one way of distinguishing a musical sound from noise.

Seeing pitch and volume

The oscilloscope uses a microphone to convert sound waves into electrical signals, then draws a graph of how the signal changes as time passes.

Want to know more about seeing sound waves on an oscilloscope?

Oscilloscopes are used to visualise sound waves. Oscilloscopes can show us the frequencies, of sound waves and can indicate the volume or loudness of sounds.

The oscilloscope picks up sound and sound waves with a microphone. The microphone converts the sound waves into electrical signals.

The oscilloscope graphs the **longitudinal wave** information of a sound wave and displays it as a **transverse wave**. The line you see on the screen (oscilloscope) shows the changes in air pressure of the sound waves as time passes.

Remember that a sound wave is a longitudinal wave of alternating areas of high and low pressure, called compressions and rarefactions.

On the oscilloscope compressions (areas where the air pressure is higher than normal) appear above the equilibrium line, and rarefactions (areas where the air pressure is lower than normal) are graphed below the equilibrium line. The equilibrium line represents normal air pressure.

The highest points (peaks) of the graphed line above the equilibrium line are called **crests** and the lowest points below the line are called **troughs**. The distance between a crest or a trough and the equilibrium is the **amplitude**. The higher the crest (or lower the trough), the larger the amplitude. Large amplitudes correspond to large changes in air pressure either above (crest) or below (trough) normal air pressure. A large peak means a greater change in air pressure and hence, a louder sound.

The distance between two crests (or troughs) is called the **wavelength**. Waves with short wavelengths (crest or trough close together) have high frequencies, while waves with longer wavelengths (crests far apart) have low frequencies.

The **frequency** of a wave is the number of complete wave cycles (from crest-to-crest, or trough-to-trough) completed in one second. If a wave completes 200 cycles per second it has a frequency of 200 cycles per second, or 200 hertz (Hz). High frequency sound waves are heard as high pitches. Low frequency sound waves are heard as low pitches. A frequency of 262 Hz corresponds to a note around middle 'C'.

Extra for experts

Doubling the frequency of a note produces a note one octave higher. For example, a note an octave higher than one with a pitch corresponding to a frequency of 100 Hz is 200 Hz. A note one octave higher than that will have a pitch corresponding to a frequency of 400 Hz. In music, notes an octave apart have the same letter name and are separated on the piano by 12 black and white keys.

So, if you look at the note middle 'C' on the piano with a pitch corresponding to 261.6 Hz and go an octave higher you will be at the next 'C'12 keys along at 523.3 Hz.

Most sounds, including musical notes, speech and noise, are made up of more than one frequency. The combination of different frequencies gives a characteristic bumpy shape to the wave seen on the oscilloscope.

Each bump on the graphed line corresponds to the constructive or destructive interference resulting from the combination of waves of different frequencies and amplitudes. The characteristic combination of frequencies is what gives each voice, or instrument its unique identity, and is called **timbre**.

In contrast, a tuning fork will produce a note with a pure pitch made up of one frequency. A graph of this wave is smooth and regular, called a sine wave.

A **musical note** is one which is periodic, producing a steady pattern on the oscilloscope. Even the multiple-frequency, 'bumpy' curves produced from the sound of a musical instrument show periodicity. They have a repeated pattern. The smooth sine wave from the single frequency produced by the tuning fork is also periodic but, as a musical sound, lacks interest. **Noise**, on the other, hand does not appear periodic.

Helpful terms

Compression: Area of a longitudinal wave where particles are more squished up and pressure is therefore higher than normal.

Frequency: The number of times a vibration occurs in one second (hertz or Hz). Fast vibrations have high frequencies and produce high notes or pitches.

Period: The length of time required to complete one cycle of a wave.

Pitch: The perceptual phenomenon of how high or low a tone seems. The pitch of a tone corresponds to its frequency. High frequencies are perceived as high pitches while low frequencies are heard as low pitches.

Rarefaction: Area of a longitudinal wave where particles are more spread out and pressure is therefore lower than normal.

Sound wave: Longitudinal waves of air pressure differences caused by a vibrating source and travelling outwards from that source.

Sound: The brain's interpretation of sound waves detected by the ear.

Vibration: A single object or particle moving backwards and forwards (or up and down) rapidly.

Wave: A disturbance travelling outwards in all directions from a vibrating source. It is important to note that the individual particles that the wave is travelling through do not travel with the wave, but are disturbed in a local area only.

Wavelength: The distance between one wave crest, trough or matching phase and the next one. Waves with longer wavelengths have slower frequencies.

Further information

- *Musical Acoustics, Third Edition*. D E Hall. Wadsworth Group (Brooks/Cole), California, 2002.
- *Measured Tones: the interplay of physics and music, second edition.* I Johnston. Insitute of Physics Publishing Ltd, Bristol, 2002.
- *The Physics Classroom: Lesson 2 – Sound Properties and Their Perception,* and *Lesson 3: Behaviour of Sound Waves*. The Physics Classroom and Mathsoft Engineering & Education, Inc, 2004. http://www.physicsclassroom.com/Class/sound/soundtoc.html
- *Oscilloscope Tutorial*. The University of Dublin, Trinity College. www.cs.tcd.ie/courses/baict/bac/jf/labs/scope/oscilloscope.html

Basic physics books, such as:

- *Conceptual Physics, 9th edition*. P Hewitt, 2002. Addison Wesley, Boston, Illinois.
- *Jacaranda Physics 2*. G Lofts, et al, 2004. John Wiley & Sons, Milton, Qld.
- *Physics, Principles with applications, 6th edition*. D C Giancoli, 2004. Prentice-Hall, New Jersey.