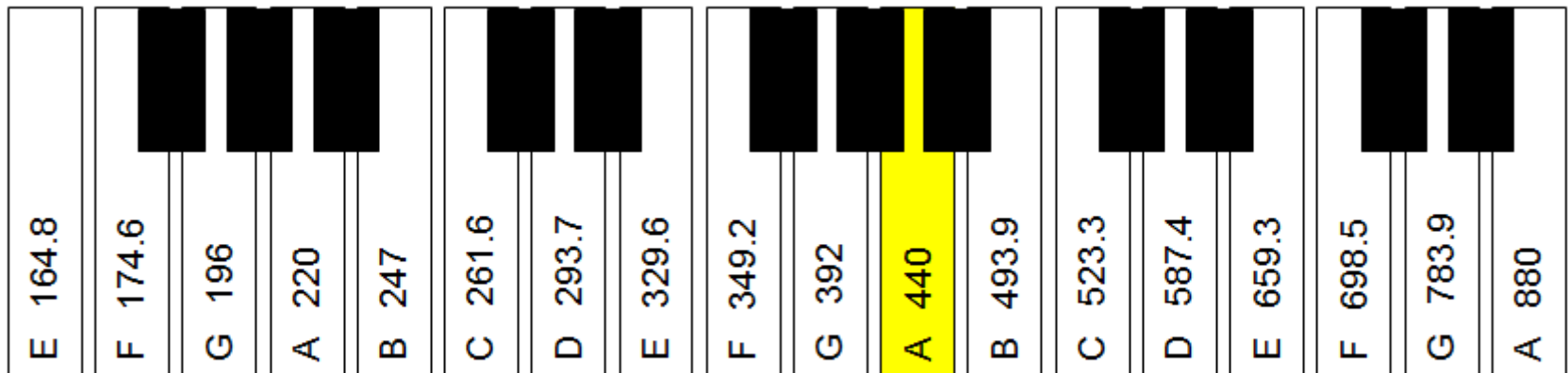


Sound (11-16)

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Sound waves

Sound waves travel through the air by the air molecules vibrating backwards and forwards. This 'backwards and forwards' motion of the molecules in a sound wave means that sound waves are **LONGITUDINAL WAVES**. The faster the vibration the higher the pitch of the note and the bigger the vibration the louder the note.

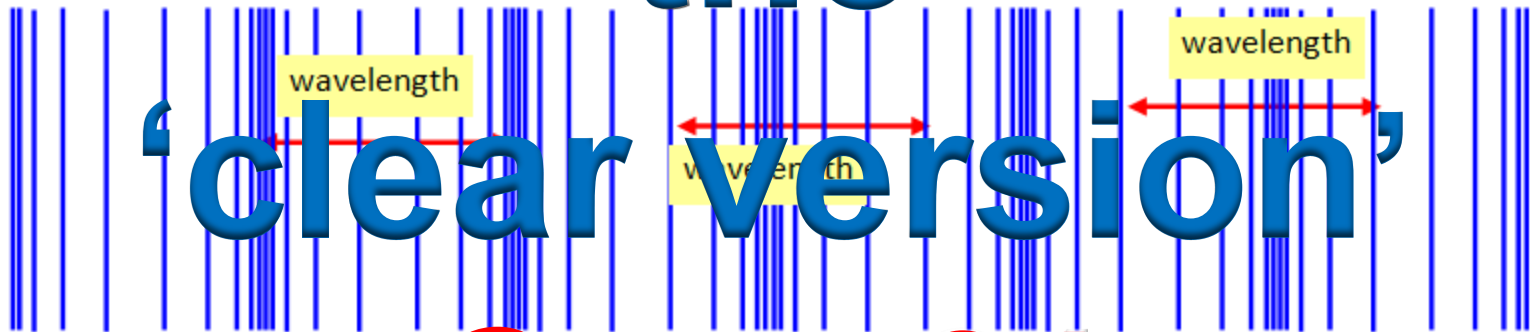
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Sound waves can't travel through vacuum. It needs a material to carry the vibrations.

On the Moon where there is almost no air sound would not travel from one place to another. You could see an explosion but not hear it.

the



LONGITUDINAL WAVE
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Notes and noise

Some sounds are pleasant and some are unpleasant. That is the difference between noise and music. You can see the shape of the sound wave by looking at the trace that it makes on an oscilloscope screen.

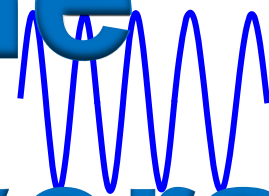
On the oscilloscope a noise will look like a ragged jumble of ups and downs, usually with sharp peaks and troughs.

A pure note will be a smooth wave with a regular shape. The size and shape of the wave produced by a pure note will depend on the pitch of the note and how loud it is.

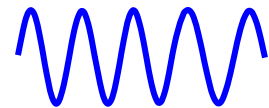


A "pure note"

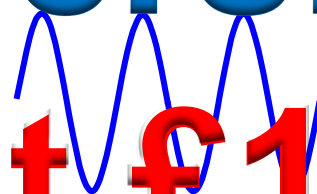
noise



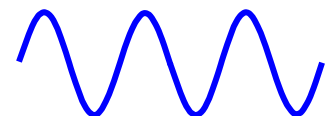
A loud, high pitched note



A soft, high pitched note



A loud, low pitched note



A soft, low pitched note

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'Quality' of notes

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A note sung by a man will sound different from the same note sung by a woman, and if played on different instruments it will also sound different each time.

smooth

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These slightly different sounds all have the same pitch or frequency it's just the shape of the wave that is different. The more jagged the wave the harsher the sound.

harsh

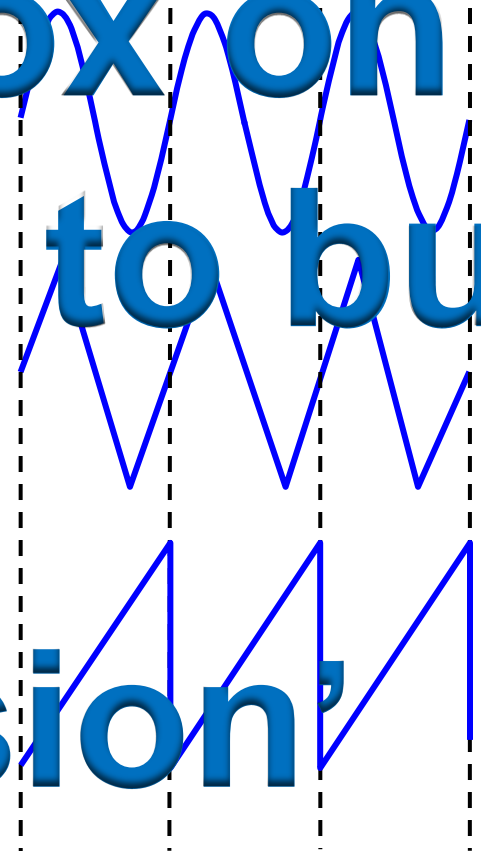
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very harsh

It is the combination of different types of sound that gives different parts of music its own characteristic sound!

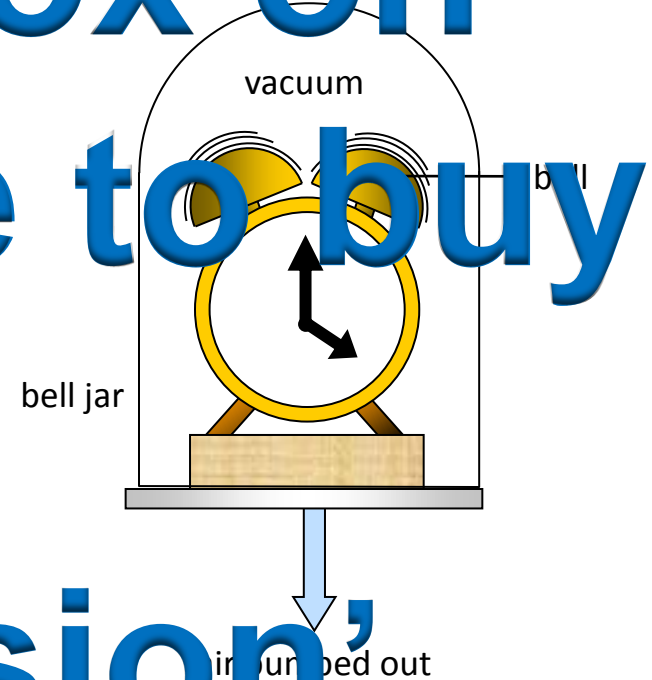
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Sound in different materials

Sound waves travel at different speeds in different materials:

Material	Speed of sound (m/s)
Air (at 293 K)	320
Water	1500
Steel	6100



The more tightly the molecules of the material are held together the faster the sound will travel.

If there are no molecules for the sound wave to vibrate it cannot travel and so:

Sound waves can't travel through a vacuum

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Musical scales

There are actually two different musical scales:

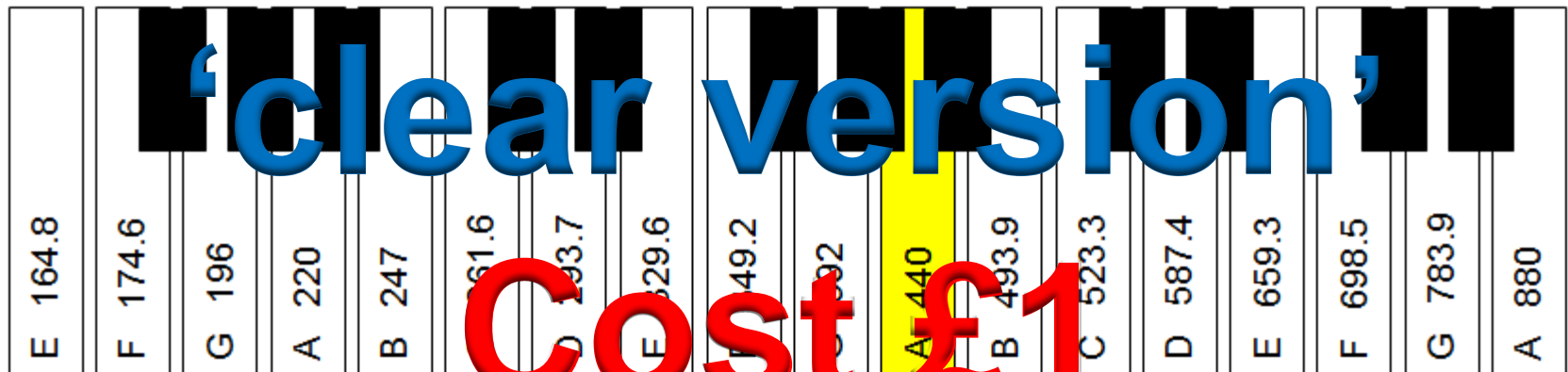
(a) the scientific scale based on middle C having a frequency of 256 Hz, also known as the diatonic scale, and

(b) the musicians' scale based on A having a frequency of exactly 440 Hz, also known as the equally tempered scale. On this scale middle C has a frequency of 261.6 Hz (shown below)

The frequency ratio for two notes one octave apart is 2:1 while for a fifth it is 1.5:1

On the equally tempered scale the frequency ratio for each semitone is 1.0595:1.

The ratio for the tone interval is the sixth root of 2 and that for the semitone the twelfth root of 2.



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Organ pipes

An organ pipe in a cold church will be shorter than normal but the air molecules in it will be moving slowly and so the pitch of the note that comes from it will be lower than it should be – the note will be flat.

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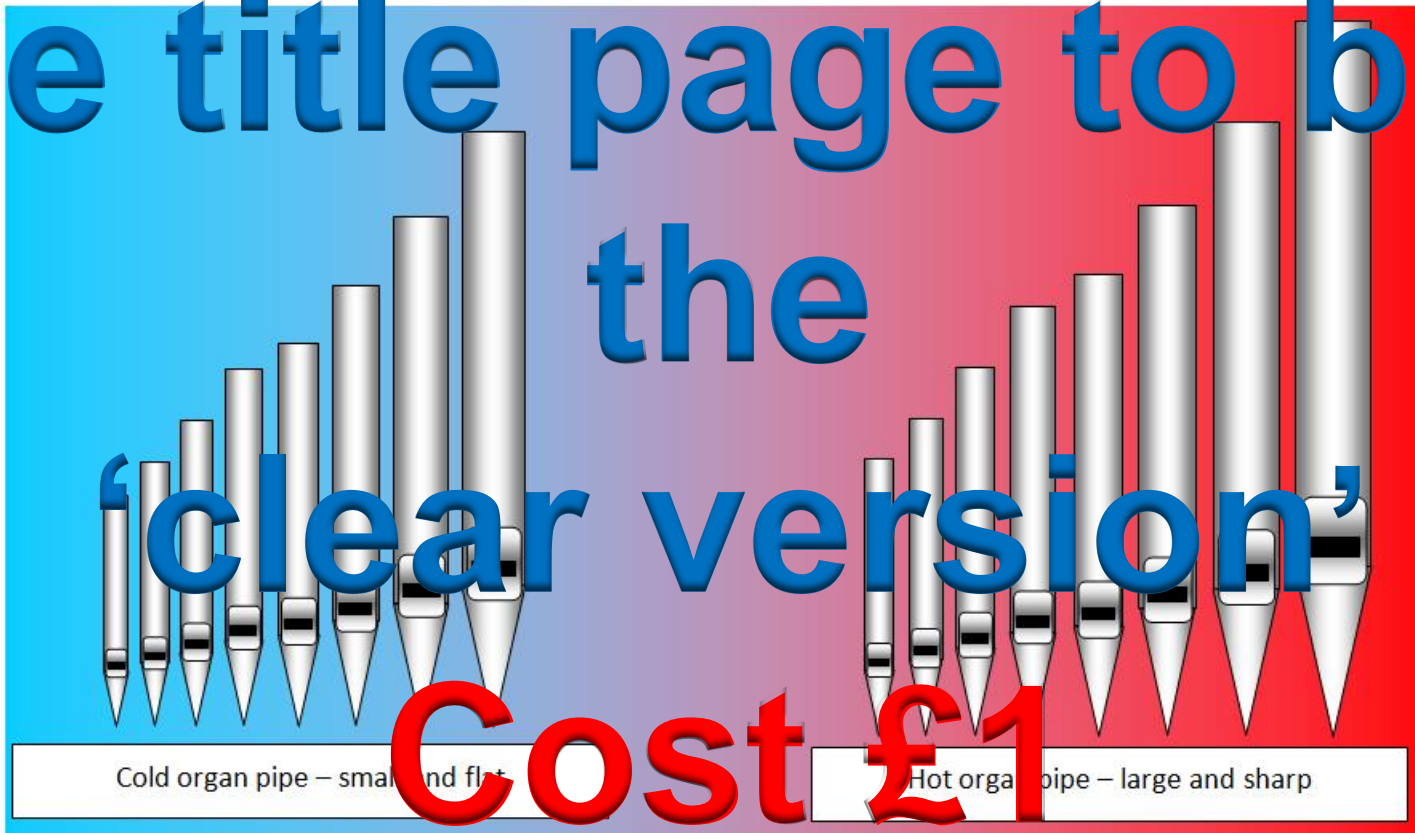
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Cold organ pipe – small and flat

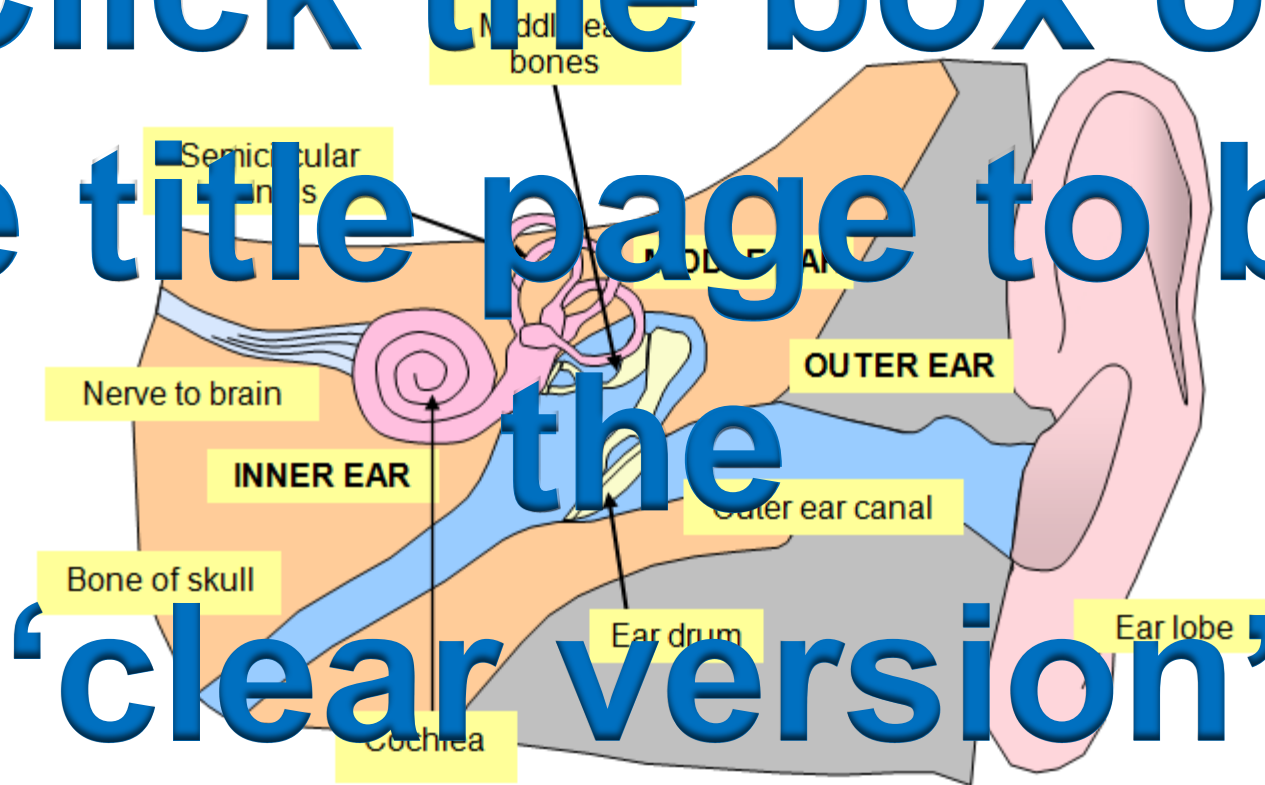
Hot organ pipe – large and sharp



The ear (1)

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The ear (2)

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The sound is 'received' by your outer ear and then travels along the outer ear canal until it reaches the eardrum. The eardrum is a thin membrane like the skin of a drum. This vibrates when the sound waves hit it.

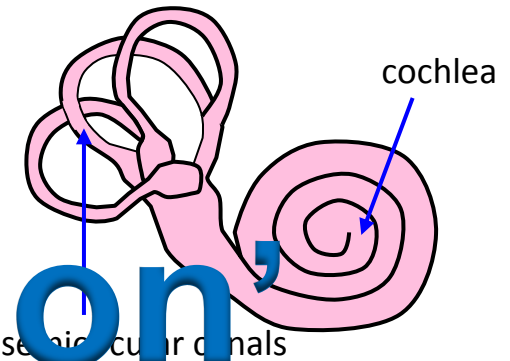
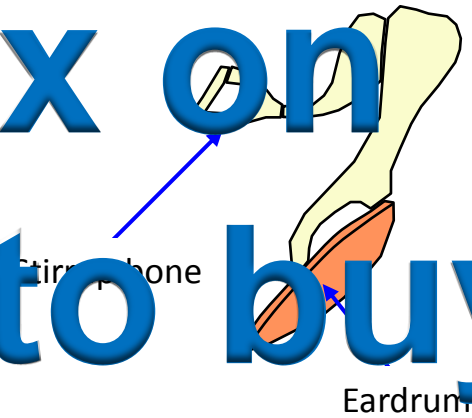
Vibrations on the other side of the eardrum move the middle ear bones. These bones act like a series of levers, magnifying the movement produced by the eardrum until the final bone, the stirrup bone, starts vibrating.

The stirrup bone transmits the vibrations to the inner ear – a hollow organ filled with liquid and with the inside covered in fine hairs. The hairs are sensitive to movement and convert it to a series of electrical impulses. These signals are then carried by the nerve to the brain – you can hear the sound.

'clear version'

The inner ear is also important in giving you a sense of balance. The movement of the fluid in the three semicircular canals tells you whether your head is upright or not and if not what position it is in.

Middle ear bones



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The speed of sound in air

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The speed of sound in air is about 320 m/s

The reason for the difference in the speed of sound in the different materials is that sound waves are carried by molecules bumping into each other. In air the molecules are far apart and not held together tightly. In steel the molecules are held together tightly and so the vibrations pass through steel much faster.

Two things affect the speed of sound in air

(i) the wind - if the wind is blowing in the same direction that the sound is travelling then the speed of sound is increased.

(ii) the temperature - the colder the air the slower the sound travels.

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The loudness of sounds

Decibel level	Typical sound source
160	Longer of skin pulling
150	Jet taking off. Permanent hearing damage possible.
140	Jet engine at 30m. Air raid siren.
130	Very loud rock group. Pain.
120	Automatic road drill. Jet engines at 150m. Damage to hair cells in the inner ear.
110	Car horn at 6m. Pop group at 2m
100	Heavy road traffic
90	Very loud orchestra. Heavy truck (MOT test 92 decibels at 8m). Underground train
80	Alarm clock. Loud hi-fi.
70	Busy street traffic. Vacuum cleaner. Building noise.
60	Normal conversation at 1m
50	Quiet street.
40	Quiet radio in a house.
30	Rustle of paper. Tick of watch when held to your ear.
20	Whisper. Quiet country lane
10	Rustle of leaves in a light breeze.
0	Threshold of hearing.

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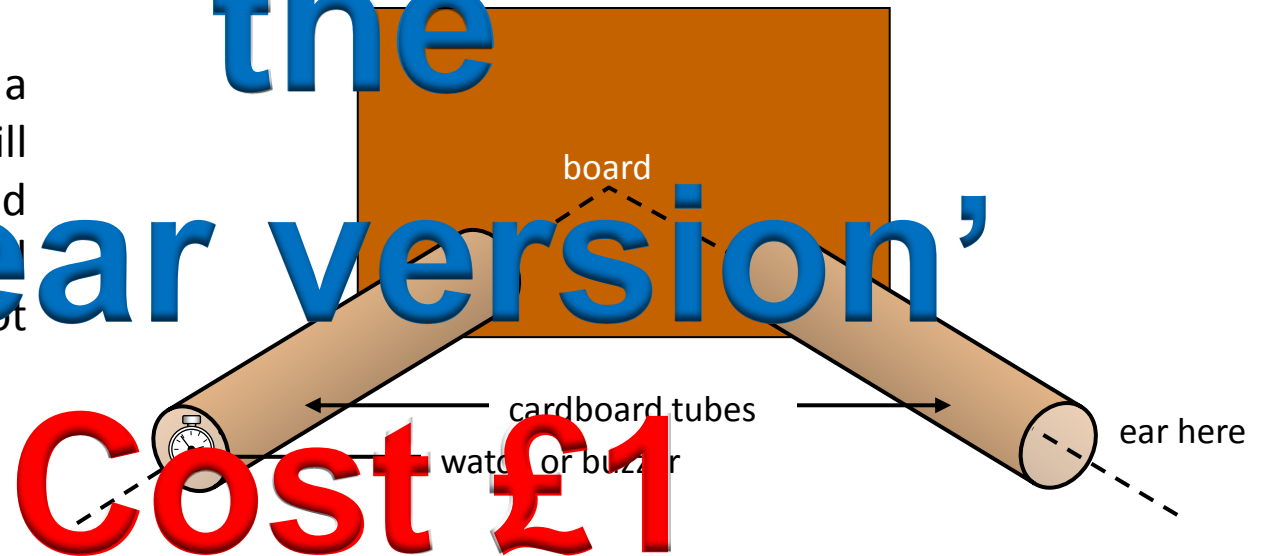
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Reflection of sound

Sound obeys the same laws of reflection but the amount of sound that is reflected from different materials is different. The walls of rooms used to hear sounds are often covered with soft material or even projections like egg boxes to reduce the sound reflection. The reflection of a sound is an echo.

In concert halls it is important to have enough sound reflection but not too much. Too little and the building is described as "dead" or "dry", too much and the echoes from the walls interfere with the original music.

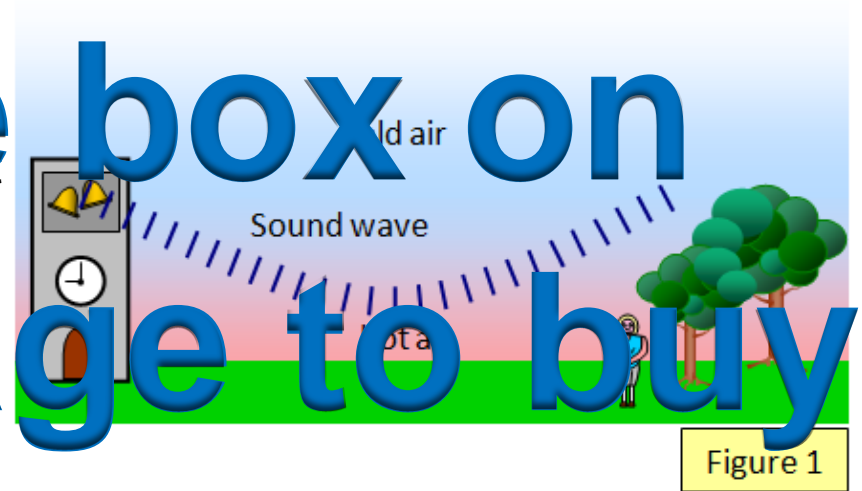
The more people in a room the "deader" it will be as regards the sound because the human body does not reflect sound very well.



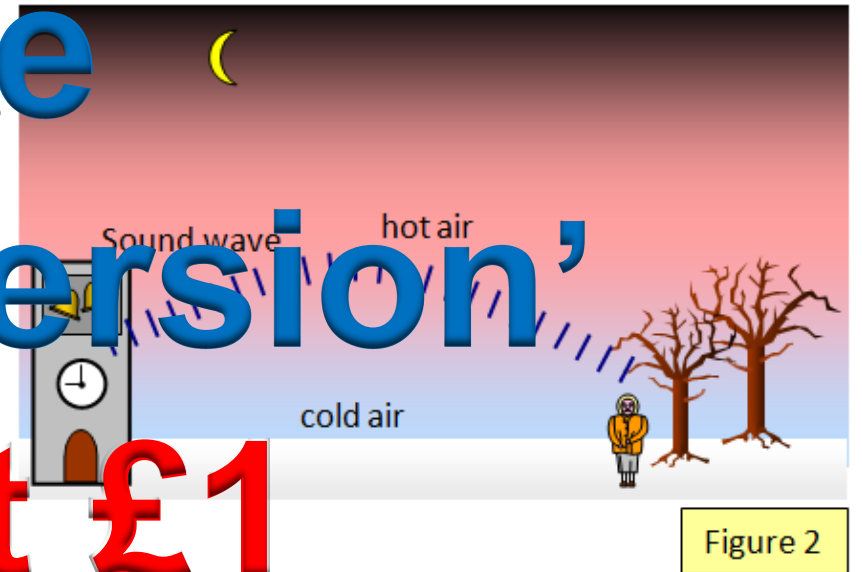
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Refraction of sound

On a hot day the air near the ground is hot so the sound wave bends upwards from the hot air into the cold air (Figure 1).



On a cold night the air near the ground is cold and so the sound wave bends downwards (Figure 2) This is why you can sometimes hear sounds from long way away if the night air is cold.



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Faster than sound

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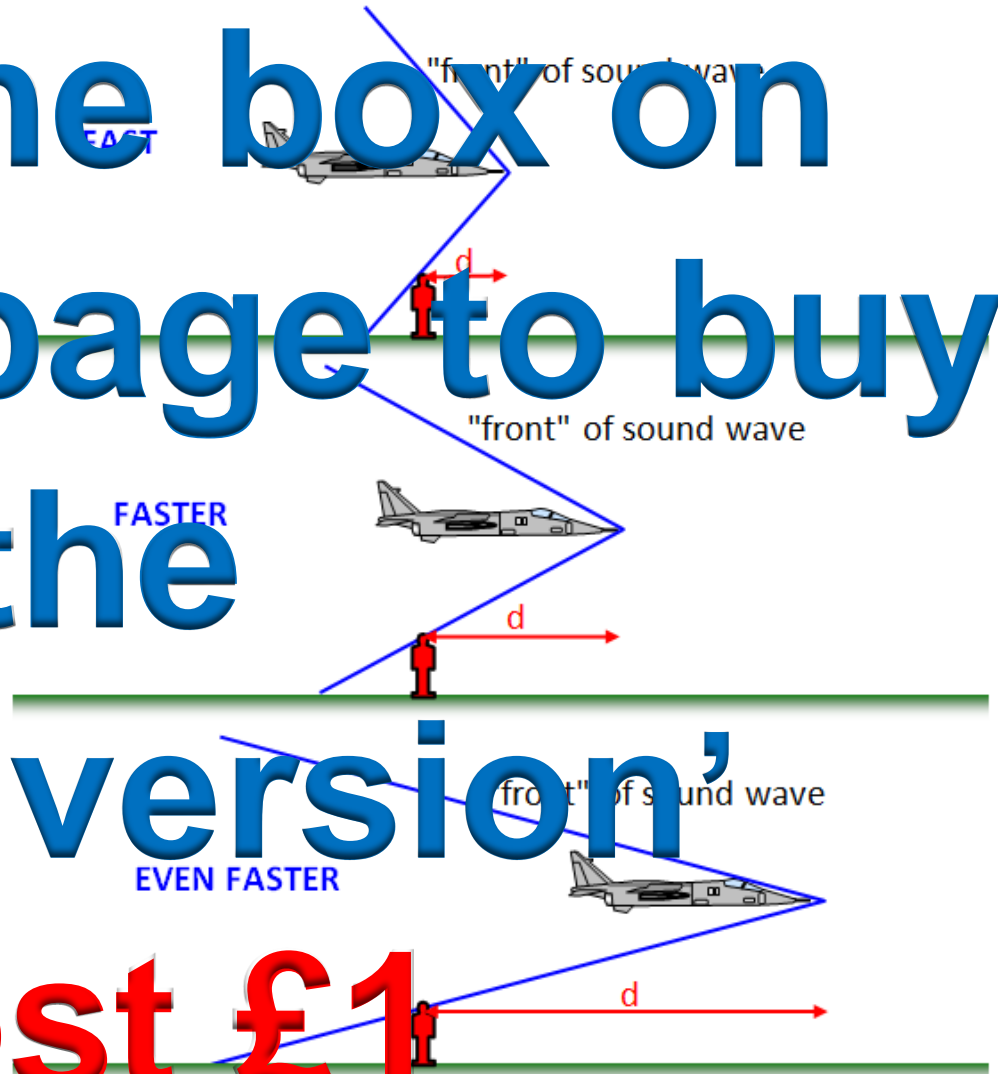
The blue cone shows the front of the sound wave. The observer does not hear the sound until part of that blue cone reaches them. By that time the plane will have already travelled past them. This distance gets bigger as the plane flies faster.

FASTER

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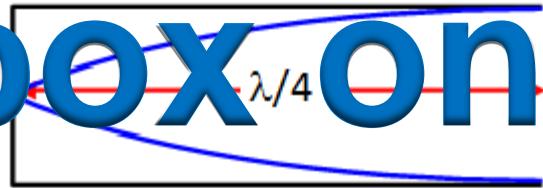
EVEN FASTER

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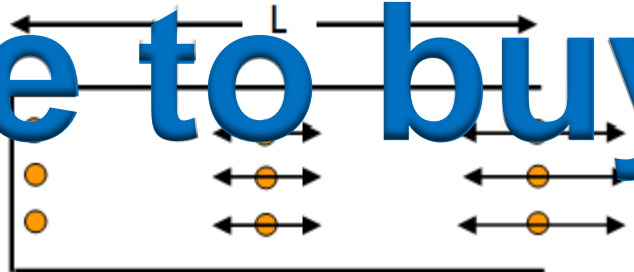
Sound in tubes

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The diagrams show how a sound wave "fits in" to the size of tube that makes it. They also show the vibrations of the molecules of the gas in the tube.

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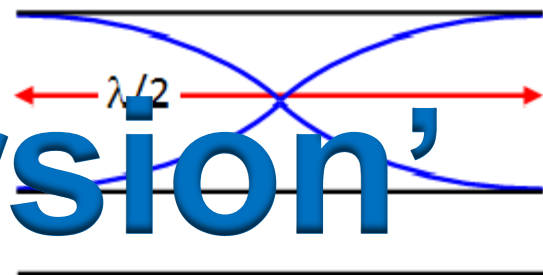


molecular vibrations

The note that a tube emits depends on three things:

- (a) the length of the tube
- (b) the gas in the tube
- (c) the temperature of the gas in the tube

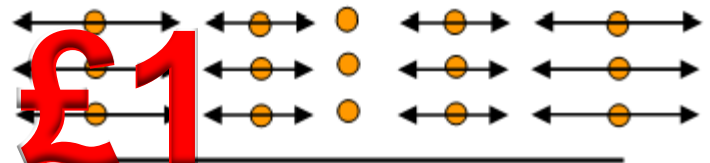
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The longer the tube is the lower the frequency of the note that it can emit. When a tube is heated it expands and so is longer!

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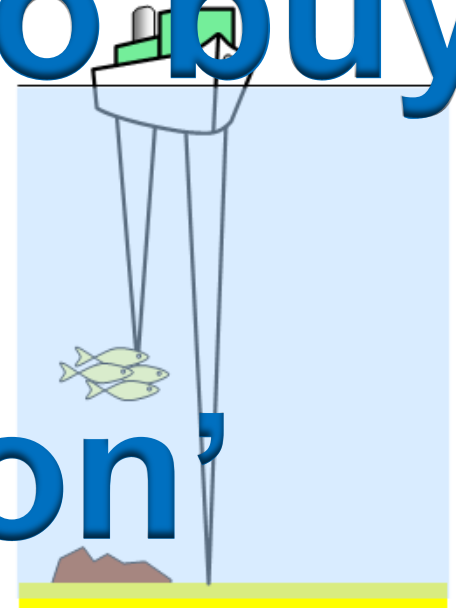


Ultrasonics

Ultrasonics is the word used to describe the range of sound beyond the limit of human hearing. It has a frequency of at least 30 kHz.

Uses and effects of ultrasonics:

1. Pregnancy scan. Ultrasonic scans are used to look for unborn babies because the sound waves are safer than X-rays
2. Sonar – depth measurement at sea. The speed of sound in water is greater than that in air because the molecules of water are closer together.
3. Producing fine sprays
4. Physiotherapy – the high frequency sound heats up the damaged tissue and so aids healing.
5. Cleaning – the dusts/litherals shaken off by the vibrations
6. Ultrasonic welding – welding without heat pollution
7. Mixing emulsion paints
8. Burglar alarms – involving a Doppler motion sensor



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Sound questions

1. A large tuning fork will make a note than a small tuning fork.

2. Frequency is the that an object makes every

3. A note with a low pitch has a frequency.

4. A large organ pipe is likely to make a note than one of the same length but thinner.

5. An acoustic guitar uses the body of the guitar to make the sound

6. Sound travel through a vacuum

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