

presents

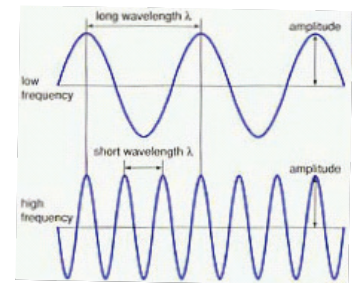
ULTRASOUND



What is ultrasound?

Sound is caused by tiny, fast movements called vibrations, and it travels in waves from its source to its receiver (e.g from vibrating vocal chords to our ears). A sound wave is the transfer of energy through a medium (air, solid or gas).

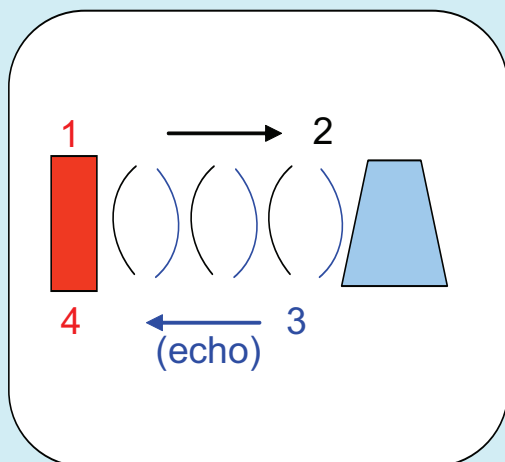
The sound vibrations can vary in size (amplitude) and in speed (frequency). The larger the amplitude the louder the sound, and the faster the frequency the higher the sound (higher the pitch). If a dog barks loudly, the sound vibrations will have a higher amplitude and lower frequency than the sound made when a mouse squeaks.



Humans can hear frequencies of 15 Hertz - 20,000 Hertz (number of vibrations per minute).

Sound waves of more than 20,000 Hertz are known as ULTRASONIC and cannot usually be heard by humans. However, we can use ultrasound in medicine, in boat navigation and in industry (see 'Uses of ultrasound'). Ultrasound is also used by various animals (see 'Animals and ultrasound').

Using ultrasound depends on an echo (or reflection)...



1. An ultrasonic wave is produced and released by an electrical device.
2. The ultrasonic wave hits a solid surface.
3. The ultrasonic wave is reflected off the surface and bounces back (like an echo in an empty cave).
4. The ultrasonic wave is picked up from a receiver.

This is repeated to get the object's shape and direction from the ultrasound device.

Marco Polo!

Marco Polo is a bit like the game 'tig' but the person being 'it' keeps his/her eyes closed!

To begin, select a player to be 'it'; this person must try to tig/tag another player, who then becomes 'it' and attempts to tig another player to become 'it', and so on.

The player who is 'it' must keep his or her eyes closed at all times, so needs to depend on sound to find the other players (who are moving around the room). To help him/her to find the other players, he/she can shout 'Marco', after which all other players must shout back 'Polo'.

Before and after playing the game, you could consider how useful ultrasound might be for the player who is 'it'.



Animals and Ultrasound True or False Answers

True **2.** False- The ultrasound is made in the larynx (voicebox) and usually emitted through the mouth of the bat, although some bats also emitted through their nose. **3.** True **4.** True **5.** True **6.** True **7.** False- Most crickets do not emit ultrasound. **8.** False- Tiger moths emit ultrasound using a pair of organs called 'tymbals'. **9.** True **10.** True **11.** False- No study has shown sharks use ultrasound to navigate. **12.** False- No study has shown gorillas use ultrasound for warning others. **13.** False- Humans cannot hear ultrasound. **14.** True **15.** True **16.** True.

Animals and ultrasound

Can you work out which ones are true or false?

Non-toxic moths can fool bats by mimicking the toxic, ultrasound-producing moths. 1

Most bats emit ultrasound through their noses, but some also do it using their mouths. 2

Dogs can hear 'silent whistles', which humans use to create ultrasound. 3

Bats navigate using ultrasound; they produce and detect the ultrasonic waves. 4

Some crickets produce ultrasound by rubbing their wings together. 5

Ultrasound is useful for detecting pregnancy in animals. 6

Tiger moths can emit ultrasound with their wings. 7

All crickets emit ultrasound. 8

Bats have large ears to detect ultrasound echoes that are reflected off their prey. 9

Some frogs in America keep quiet when they detect ultrasound from bats (bats prey on them). 10

Studies show dolphins, whales and sharks use ultrasound to navigate. 11

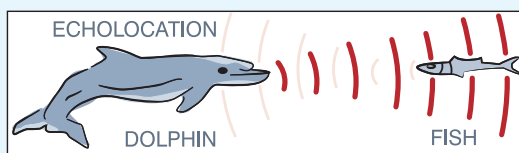
Studies show sloths and gorillas use ultrasound to warn others of danger. 12

Humans can hear the ultrasound emitted from bats. 13

Ultrasound echoes can be detected by sinuses in the lower jaw of the dolphin. 14

Tiger moths hear ultrasound from bats and warn them of their bad taste by emitting ultrasound. 15

The male mouse emits ultrasound when looking for a mate. 16

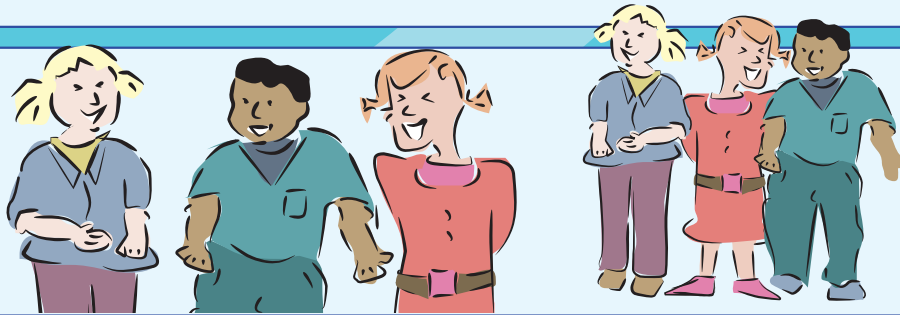


Medical ultrasound debate

The use of ultrasound in medicine has both its advantages and disadvantages, which results in some debate over its use. Here are a few things you might want to consider...

- How useful is ultrasound in medicine?
- Is the relatively small risk of damage to the foetus through ultrasound scanning worth it for the information you gain?
- Would you want to know the sex of the baby or whether it has any physical abnormalities?
- Should we use ultrasound to help humans who are blind (i.e. to help them “see” objects)?

Check out other information on this poster for more details



Some tips for running a debate...

- Provide the debaters with these resources on the topic
- Lay out the ground rules of the debate before the debate begins
- Ensure participants stick to the chosen topic
- Try to involve the whole group in the discussion by:

Using a physical continuum- e.g. Read aloud a controversial statement; individuals who agree completely with the statement should then stand at one side of the room and those that disagree completely should stand at the other. Those that aren't so sure how they feel should stand somewhere along the continuum depending on what views they do have on the topic. Once all of the group is standing somewhere in the continuum, ask whether anyone wishes to share why they are standing at a particular point.

Use a ballot box- Each individual anonymously writes down their views on the topic on a piece of paper, which is then put into a ballot box. One at a time, the pieces of paper are picked from the box and read aloud. The group discusses each one in turn.

Calculating distance with ultrasound

How can ultrasound can be used to detect objects in air and water?

Things we need to remember:

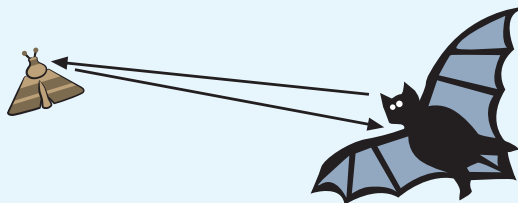
Distance travelled (D) = Speed (S) x Time (T)

Speed of sound in air = approximately 334 metres per second

Speed of sound in water = approximately 1530 metres per second

The time it takes to detect an object by ultrasound is equal to the time it takes for the ultrasound wave to be emitted, bounce off an object and return to the detector. So, we need to halve this time when using the equation above.

Ultrasound and bats:



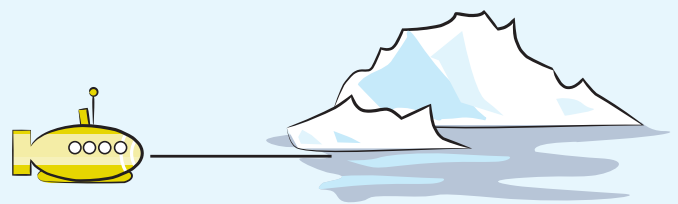
If it took 1 second for a bat to detect the ultrasound, how far away is the prey?

$$\begin{aligned} D &= S \times T \\ &= 334 \text{ metres per second} \times 1 \text{ second} \\ &= 334 \text{ metres in total} \end{aligned}$$

We need to divide this by 2 to get the distance from bat to prey only.

$$\text{So, } 334 / 2 = 167 \text{ metres}$$

Ultrasound and ships:



An iceberg is 3000 metres from a submarine. The submarine emits ultrasound. How long will it take for the submarine to detect the iceberg?

$$\begin{aligned} D &= S \times T \\ T &= D / S \end{aligned}$$

$$\begin{aligned} D &= 2 \times 3000\text{m (the ultrasound wave} \\ &\text{has to go to the iceberg and back)} \\ &= 6000 \text{ metres} \end{aligned}$$

$$\begin{aligned} T &= D / S \\ &= 6000 / 1530 \\ &= 3.92 \text{ seconds} \end{aligned}$$

Advantages and disadvantages of ultrasound

Advantages in Medicine

It is non-invasive (can be used without equipment entering the body).

It is relatively inexpensive.

It is a quick procedure.

No harmful effects have been detected yet.

It is good for examining soft tissues (eye, heart, blood vessels).

If a problem with the foetus is detected, the parents can prepare emotionally and practically.

Ultrasound can be absorbed into the bone and can accelerate fracture healing.

Disadvantages in Medicine

The picture it produces doesn't give as much detail as an x-ray.

It can't be used to examine areas that contain gas (lungs, digestive system).

It does not pass through bone.

More research is required to determine whether long term exposure is harmful.

It can sometimes be wrong in its detection of physical abnormalities.

It can affect foetal brain development in mice (no such evidence for humans).

Abortion

Ultrasound for sex determination has led to parents choosing abortion in some countries, such as China and India, where male offspring are more highly valued.

Can we "cure" human disabilities with ultrasound?

Could we use ultrasound systems to help blind people "see"? This is related to the use of robotic machinery for human function, as researched by Professor Kevin Warwick of Reading University. In 1998, he had a chip implanted directly into the nerves of his arm; this chip was also connected to an ultrasound detector and computer. Professor Warwick was able to sense things moving even when blindfolded, as moving objects were detected by the ultrasound detector, which would then send signals to the implanted chip. The chip in Professor Warwick's arm would send the signal to his brain. See www.kevinwarwick.com for more details.

Uses of ultrasound

IN MEDICINE

- **Detection:**

- To examine unborn babies (foetuses)**

- Ultrasound can be used to examine the number, sex, movement and heart beat of a foetus in the mother's womb, the stage of the pregnancy and whether there are any major physical abnormalities with the foetus.

- To examine muscle, blood flow and pelvis for abnormalities**

- To help guide instruments in the body during operations**

- **Heat production:**

- As therapy for muscle pain (can accelerate wound healing).**

- **Breaking down particles:**

- To clean teeth** (used by dentists to remove plaque without damage or pain).



IN INDUSTRY

- **Detecting:**

- To navigate under water**

- Submarines and boats use SONAR (sound navigation and ranging) to detect objects underwater (see 'Calculating distance with ultrasound').

- As Quality Control**

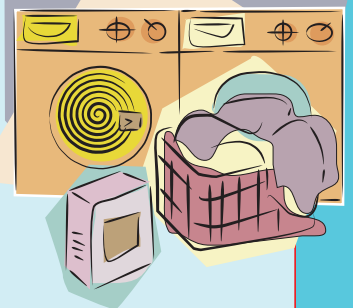
- Ultrasound can be used to detect cracks in metal and plastic that is made in factories. This is because the ultrasonic waves reflect off cracks more than the metal or plastic.

- **Heat production:**

- To heat liquids** (dry corn milling plants enhance ethanol production using heat produced by ultrasound).

- **Breaking down particles:**

- To clean jewellery, lenses and clothes.** Objects are placed in an ultrasound bath, in which ultrasound is passed through water and creates bubbles that remove the dirt. Ultrasonic washing machines are currently under development.



To hear the baby's ultra-quiet sounds?

To create an image of the baby using echoes?

To take a photo of the baby through mum's stomach?

Do you know why we are using ultrasound today?