

Ultrasound Notes

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Ultrasound: sound waves with a frequency above 20000 Hz or 20 kHz.

What is ultrasound used for?

Ultrasound has many uses in modern life, the most well-known of course is ultrasound baby scans. Ultrasound has the following uses:

Foetal scanning – ultrasound waves can be used to see a foetus in the womb and show the development of the foetus. Most exam boards will accept medical scanning instead of foetal scanning.

Note: a question could ask why x rays not used to see a foetus in the womb. For this question we should have an answer that mentions that x rays are ionising and could be harmful to the foetus.

Diagnosing conditions – ultrasound waves can be used to find the cause of swelling or blockages in parts of the body. It can also be used to find tears in muscles or issues with tendons.

Treating some conditions – ultrasound waves can be used to break up kidney stones and gallstones. The wave vibrations are used to shake the stone until it cracks into smaller pieces. These stones can also be removed surgically or passed naturally if they are small enough.

Finding cracks in materials – ultrasound waves can be used to find cracks in metals, for example the turbine blades of a jet engine. Turbine blades with cracks can be found and removed before they become a problem.

How can Ultrasound waves be used to produce an image?

Before we describe how ultrasound waves can be used to produce an image, it's important to remember that all waves can be reflected and absorbed by a material. For most waves of course there is a bit of both, some of the wave is reflected and some is absorbed. How much of reflection or absorption depends on the density of the material the wave is travelling through.

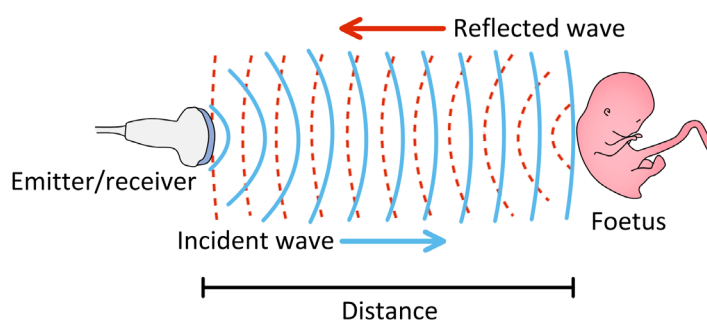
For simplicity, we can break the process of ultrasound waves being used to produce an image into stages.

Stage 1: the transducer in the hand held part emits ultrasound waves, which then pass into the body.

Stage 2: The ultrasound waves are **partially reflected at tissue boundaries** in the body, such as the boundary between fluid and soft tissue. The person doing the scan can adjust the settings so that the majority of the waves are reflected from the boundary that they want to see.

Stage 3: The reflected waves are detected by the transducer, which now acts as a receiver. It converts the energy of the ultrasound waves back into electrical signals.

Stage 4: The ultrasound scanner uses the time it takes for the reflections to return and the speed of sound to calculate the distance from the transducer to the tissue boundaries. This information is used to create a two-dimensional image of the tissues and organs.



Note: the same concept is used by ships sonar to detect the sea floor under the ship. Sonar uses ultrasound pulses to detect the sea floor or shoals of fish.

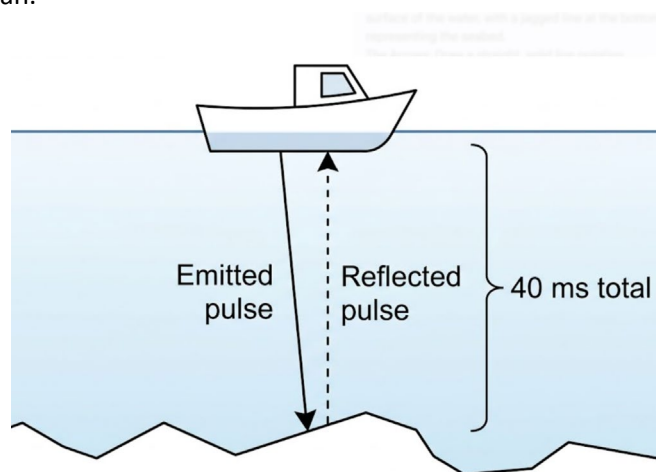
Let's look at an example calculation. We usually see these questions talking about ships using sonar, but the concept is exactly the same whether it's a submarine or a medical scan or a bat! 😊

Exam note: watch out for the "there and back again" trap!

What I mean by this is that these questions usually ask you to calculate the distance from the emitter to the object. However, the time they give us in the question is the total time for the wave to travel there and back again. This means our calculation will give us double the distance! We must remember to halve our final answer to get the right distance.

Check out the example below.

Example 1: A ship uses sonar to measure the depth of the ocean. The ultrasound pulse takes 40 milliseconds (ms) to travel from the ship, hit the seabed, and return to the receiver. The speed of ultrasound in seawater is 1500 m/s. Calculate the depth of the ocean.



Let's do this step by step so we can see each part of the calculation 😊

Step 1: Convert the time from milliseconds into seconds.

There are 1000 milliseconds in a second.

$$\text{time} = 40 \div 1000$$

$$\text{time} = 0.04 \text{ seconds}$$

Step 2: The "there and back again" trap!

The 0.04 seconds we calculated in step 1 is the time it takes for the wave to go down to the seabed **and** come back up. But we only want to find out the distance down! Not down and up.

So, we must halve the time!

$$\text{time to reach seabed} = 0.04 \div 2 = 0.02 \text{ seconds}$$

Step 3: Calculate the distance from the emitter to the object. This is the depth.

$$\text{Distance} = \text{speed} \times \text{time}$$

$$\text{Distance} = 1500 \times 0.02$$

$$\text{Distance} = 30 \text{ m}$$

That's it 😊 They don't really get any more difficult than that.

Exam note: A word of caution though... watch out for unit conversions. These have become very common in GCSE papers in recent years.