

GCSE Physics (9 – 1)

Ultrasound

Name:

Group:



Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.

For markers use	
Question	Mark
1	/6
2	/11
3	/10
4	/6
5	/6
6	/11
Total	/50
%	
Grade	

Information

- The maximum mark for this paper is 50 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. When we hear the word ultrasound most of us think about the scans of a baby in the womb, but ultrasound has a huge range of other fascinating uses.

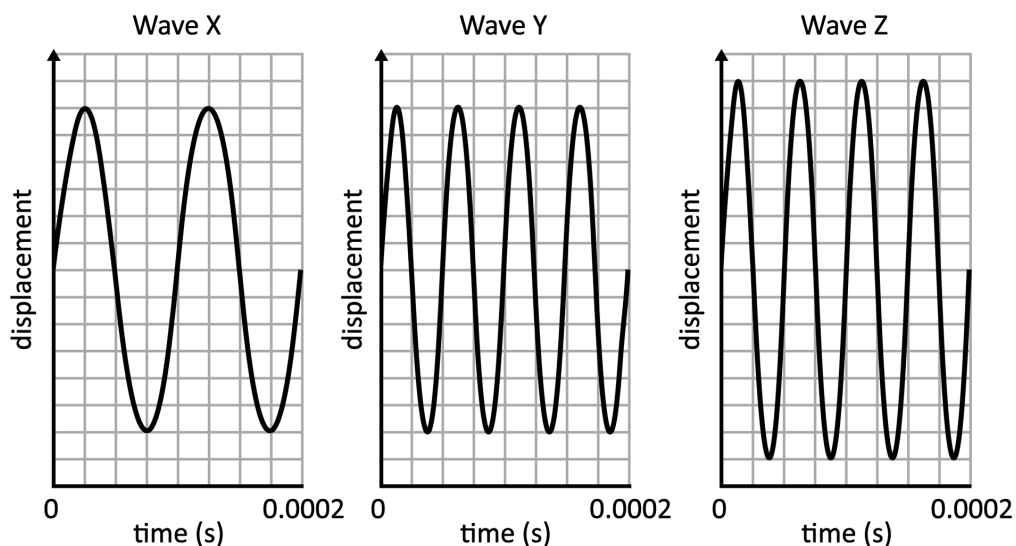
For each of the following questions, **circle** the letter of the correct answer.

- a. What type of wave is ultrasound, and what is its typical frequency?

- A** Longitudinal wave with a frequency above 20 kHz.
- B** Transverse wave with a frequency below 20 kHz.
- C** Transverse wave with a frequency above 20 kHz.
- D** Longitudinal wave with a frequency below 20 kHz.

(1 mark)

- b. The graphs below show the displacement of particles over time for sound waves from three different sources: **wave X**, **wave Y**, and **wave Z**.



Which of the sources are producing ultrasound waves?

A

B

C

D

Wave X only

Wave Y only

Wave Z only

Wave Y and Wave Z

(1 mark)

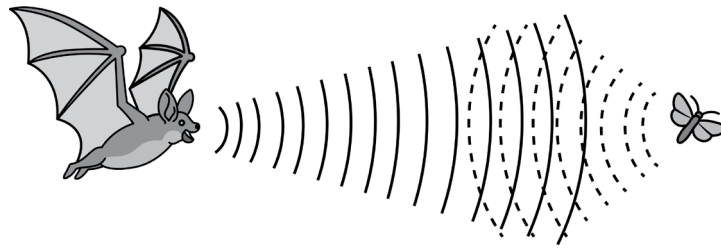
- c. Ultrasound gel is placed on a patient's skin before a scan. When the ultrasound wave travels from the gel into the patient's skin, the wavelength of the wave decreases.

- A** The wave travels at a slower speed.
- B** The wave travels at a greater speed.
- C** The wave becomes a transverse wave.
- D** The wave becomes completely inaudible.

(1 mark)

- d. A bat is hunting in the dark and emits an ultrasound pulse to locate a flying moth. The bat hears the echo from the moth exactly 0.02 seconds later.

If the speed of sound in air is 340 m/s, how far away is the moth?



- | | | | |
|----------|----------|----------|----------|
| A | B | C | D |
| 3.4 m | 6.8 m | 17 m | 34 m |

(1 mark)

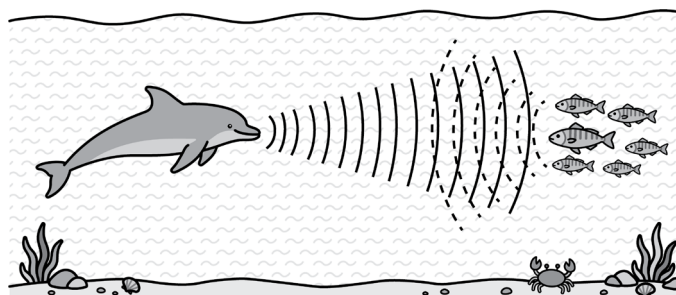
- e. Why is ultrasound used instead of X-rays to produce images of unborn babies?

- A** Ultrasound waves travel faster through the body than X-rays.
- B** Ultrasound waves have a higher frequency than X-rays.
- C** Ultrasound waves are non-ionising and do not damage DNA.
- D** Ultrasound waves can pass through bone easier than X-rays.

(1 mark)

- f. Dolphins use ultrasound clicks to navigate and hunt fish underwater.

Why do these ultrasound waves travel much faster through the ocean than the ultrasound emitted by a bat flying in the air?



- A** Dolphin ultrasound has a much higher frequency than bat ultrasound.
- B** Water is a liquid, so its particles are closer together than in a gas, allowing the wave to pass on energy faster.
- C** Water is denser, which automatically causes all longitudinal waves to become transverse waves.
- D** The amplitude of a dolphin's click is much larger than a bat's squeak.

(1 mark)

(Total for Question 1 is 6 marks)

2. A team of climate scientists are working in Antarctica. They're using an ultrasound scanner to measure the thickness of a large glacier to monitor how much it is melting.

The scanner is placed on the surface of the ice and sends an ultrasound pulse downwards towards the solid rock beneath the glacier. The figure below shows the scientists at work.



- a. What is ultrasound?

.....

.....

.....

.....

(1 mark)

- b. Explain one advantage of using ultrasound to measure the thickness of the glacier, rather than physically drilling a hole through the ice to the rock.

.....

.....

.....

.....

.....

(2 marks)

- c. The scanner emits a pulse of ultrasound into the ice. The echo from the solid rock at the bottom of the glacier is detected by the scanner 0.15 seconds later. The speed of sound in the ice is 3980 m/s.

Calculate the thickness of the glacier.

Thickness = ... m

(3 marks)

- d. The ultrasound pulse used by the scientists has a frequency of 40 kHz.
Calculate the wavelength of the ultrasound wave in the ice.

Wavelength = ... m
(3 marks)

- e. The scientists view the ultrasound signal on an oscilloscope screen.
They notice that the peak representing the returning echo has a much smaller amplitude than the peak of the original pulse emitted by the scanner.

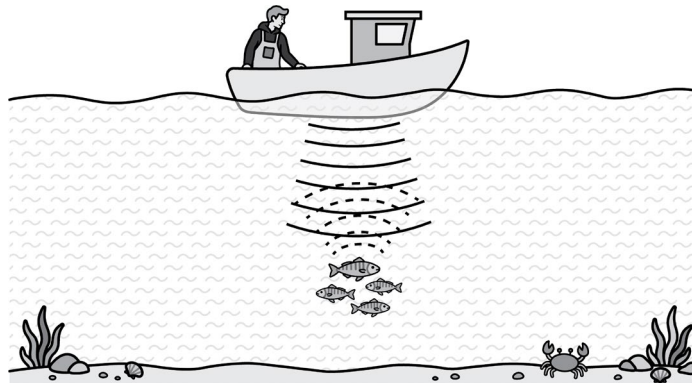
Suggest **two** reasons why the returning wave has a lower amplitude.

.....
.....
.....
.....
.....

(2 marks)

(Total for Question 2 is 11 marks)

3. A fishing boat uses an echo-sounder to measure the depth of the sea bed and to find shoals of fish.
- The equipment sends pulses of ultrasound downwards into the water and detects the returning echoes. The speed of sound in seawater is 1500 m/s.



- a. As shown in the diagram, the boat is situated in water where the sea bed is exactly **12 m** below the echo-sounder.

Calculate the time it takes for an ultrasound pulse to travel to the sea bed and return to the boat.

Time = ... s

(3 marks)

The boat moves to a new location.

The echo-sounder now detects an echo returning after just **0.006 seconds**.

The captain realises this is an echo bouncing off a large shoal of fish, rather than the sea bed.

- b. Calculate the depth of the shoal of fish below the boat.

Depth of fish = ... m

(3 marks)

- c. The ultrasound waves used by this echo-sounder have a frequency of 50 kHz.
Calculate the wavelength of these ultrasound waves in the seawater.
(Use the equation: wave speed = frequency $\times$ wavelength)

Wavelength = ... m
(3 marks)

- d. State **one** reason why it is better to use ultrasound rather than normal, audible sound waves to detect objects like fish underwater.

.....
.....
.....
.....

(1 mark)

(Total for Question 3 is 10 marks)

4. A patient has injured their knee playing football.
The doctor suspects they have a tear in their meniscus, which is a pad of cartilage inside the knee joint.
- The doctor places an ultrasound probe on the patient's skin and sends pulses of ultrasound into the knee to find the exact depth of the tear. The figure shows the scan taking place.



- a. The ultrasound probe emits sound waves with a time period of 0.0005 milliseconds.
Calculate the frequency of the ultrasound waves in Hertz (Hz).

Frequency = ... Hz
(2 marks)

- b. The ultrasound waves pass into the knee tissue.
The wavelength of the waves in the tissue is 0.77 millimetres (mm).
Use your answer to part (a) to calculate the wave speed of the ultrasound through the knee.

Wave speed = ... m/s
(2 marks)

- c. A pulse of ultrasound reflects off the tear in the meniscus cartilage.
The echo is detected by the probe exactly 0.00006 seconds after it was emitted.
Calculate the distance (depth) from the probe to the tear in the cartilage.

Distance to the tear = ...m
(2 marks)

(Total for Question 4 is 6 marks)

5. An aerospace engineer is using ultrasound for non-destructive testing on a titanium jet engine blade. They are checking the blade for internal micro-cracks.

The engineer places the ultrasound probe on the surface of the blade.



A pulse of ultrasound is fired into the metal and reflects off a hidden crack.

- The crack is located at a depth of 5.4 cm inside the blade.
- The returning echo is detected by the probe 0.02 milliseconds (ms) after the pulse was emitted.
- The wavelength of the ultrasound waves in the titanium is 120 mm.

Calculate the frequency of the ultrasound wave being used by the engineer.

Show all of your working clearly.

Frequency = ... Hz
(6 marks)

(Total for Question 5 is 6 marks)

6. A mother mouse communicates with her babies by emitting high-pitched ultrasound squeaks.



The ultrasound waves have a frequency of 85,000 Hz. The speed of sound in the air is 340 m/s.

- a. Calculate the wavelength of the ultrasound waves emitted by the mouse.

Wavelength = ... m

(3 marks)

- b. Ultrasound is widely used in hospitals for scanning unborn babies.

State **two** other practical uses of ultrasound outside of medicine.

.....

.....

.....

.....

.....

(2 marks)

- c. A doctor is trying to diagnose a patient's injury.

They must decide whether to use an ultrasound scan or an X-ray.

Compare and contrast the advantages of using ultrasound and X-rays for medical scans.

.....

.....

.....

.....

This image shows a full page of white paper with horizontal dotted lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(6 marks)

(Total for Question 6 is 11 marks)