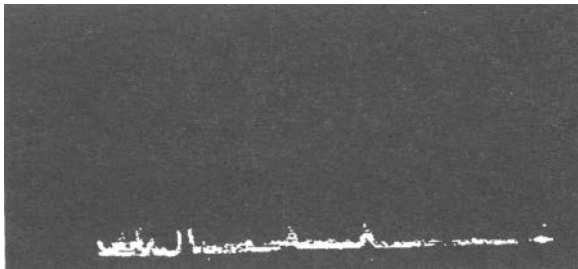


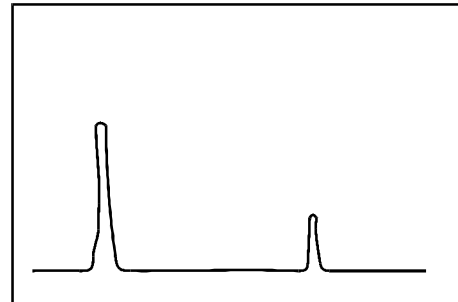
Ultrasound and Doppler Effect practice questions

1. An ultrasound A-scan is a test that is commonly carried out to check that a fetus is developing correctly and growing at the expected rate. A typical use would be to monitor the growth of a baby's head.

The photograph on the left and the simplified diagram on the right show a scan of the baby's head.



Trace seen on monitor



Simplified diagram of trace

What quantity is represented by the horizontal axis of the trace?

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(1)

Explain briefly how the two peaks of the trace are formed.

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(2)

Explain briefly how the trace could be used to obtain a measurement of the size of the baby's head.

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(3)

If ultrasound is used to image a moving object such as the heart, a Doppler shift is observed.

Explain what is meant by the term *Doppler shift*.

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(2)
(Total 8 marks)

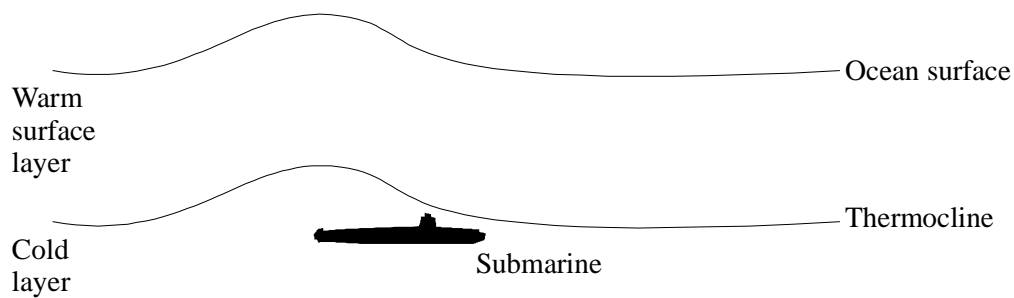
2. An ocean can be considered to be made up of two layers: a layer of warm water and a layer of cold water. The interface between them is called a thermocline.

Why does the warm surface water float above the cold deep ocean water?

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(1)



A surface ship uses sonar to detect submarines. Explain why the ultrasound waves travelling through the water partially reflect from the thermocline.

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(1)

Explain why a submarine travelling in the cold water just below the thermocline is very difficult to detect using surface sonar.

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(2)

Some scientists believe that the passage of a submarine could distort the thermocline and cause the surface of the ocean to bulge as shown. They think that they may be able to detect this bulge using radar from a satellite.

Explain why sonar cannot be used from a satellite.

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(1)

A satellite is in orbit 6.0×10^7 m above the surface of the Earth and uses radar to measure the distance to the ocean surface. Calculate the time between the emission and detection of a radar pulse which strikes the surface of the ocean directly below the satellite.

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Time =

(2)

The satellite's timing equipment is capable of measuring time to a precision of 1.0×10^{-9} s.

Calculate the minimum change in the height of the ocean which the satellite is capable of detecting.

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Minimum change =

(2)

Suggest a possible problem in detecting submarines in this way.

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(1)

(Total 10 marks)

3. A food packaging factory is moving soup through a 0.075 m diameter pipe when an obstruction occurs in the pipe. An ultrasound probe, connected to an oscilloscope, is moved along the pipe to find the obstruction (figure 1). The oscilloscope trace is shown below (figure 2).

Figure 1

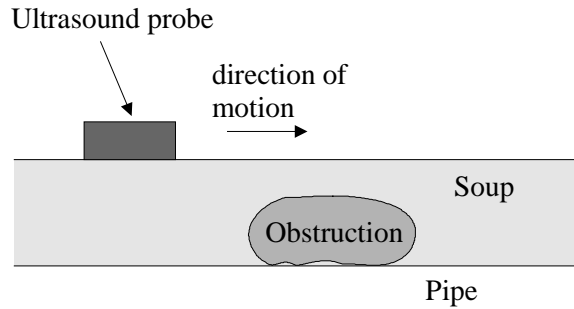
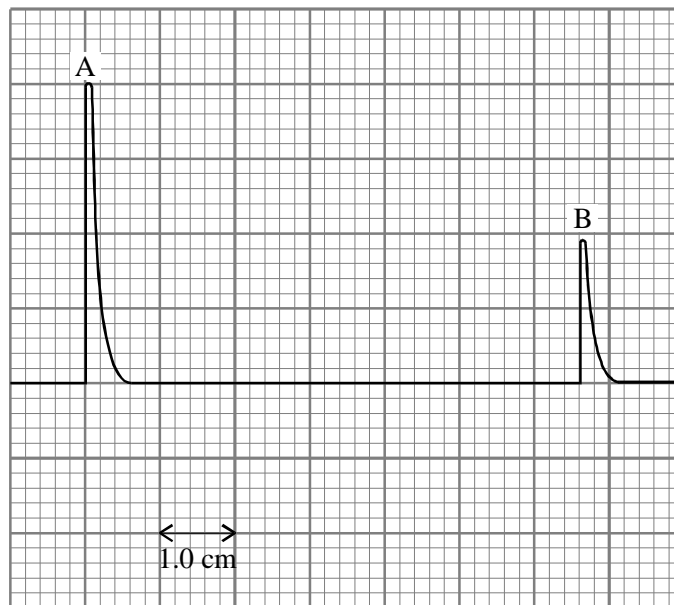


Figure 2



Oscilloscope time base = $20 \times 10^{-6} \text{ s cm}^{-1}$.

On figure 2, pulse A is the outgoing signal from the probe and pulse B is the reflected signal from the other side of the pipe

Calculate the speed of the ultrasound in the liquid in the pipe.

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Speed =

(2)

State one way in which the oscilloscope trace will change when the ultrasound probe is above the obstruction.

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(1)

After the obstruction has been cleared, a “Doppler” ultrasound probe is used to measure the speed of the soup in the pipe. Describe the principle of this method.

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(3)

What must be measured to determine the speed of the soup?

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(1)

Someone says that this would be easier if the soup contained lumps like vegetables. Comment on this suggestion.

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(1)

(Total 8 marks)

4. There are concerns among fishermen that dwindling fish stocks in the world's oceans are result a of modern fishing, techniques. Fishing trawlers can detect shoals of fish using ultrasound.

Describe the movement of water molecules when an ultrasound wave passes.

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(2)

Ultrasound pulses can be transmitted into the sea and the reflected waves can be detected and used to find the position of a shoal of fish.

Explain why **pulses** of ultrasound are used.

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(1)

A shoal of fish is at a depth of 300 m. Calculate the time interval between transmitting the pulse and receiving its echo.

(The speed of ultrasound in water = 1500 m s^{-1} .)

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Time interval =

(2)

A **continuous** ultrasound signal can be used to determine the speed of the shoal of fish.

Name the effect used in this method.

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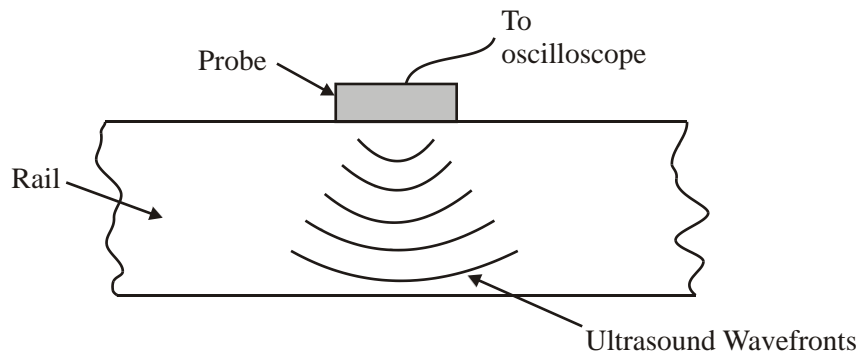
Briefly explain the physics principles of this effect.

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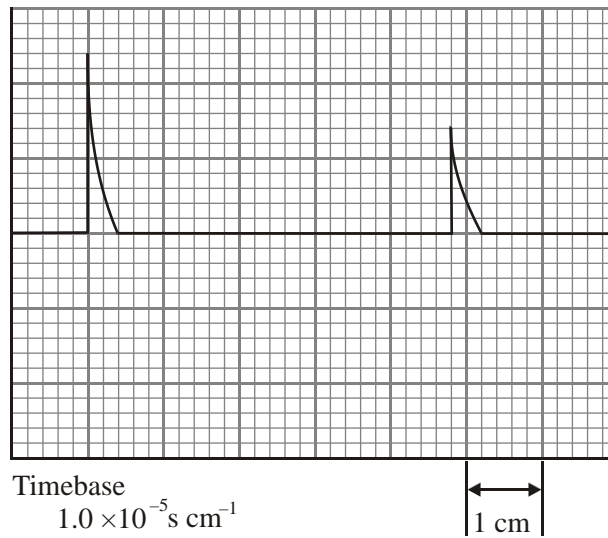
(3)

(Total 8 marks)

5. In testing railway lines for faults, an ultrasonic probe is placed on a rail.



Every 1.0×10^{-1} s, the probe emits a short pulse of ultrasound. The speed of ultrasound in steel is 5100 m s^{-1} . The probe, which also acts as a receiver, is connected to an oscilloscope which displays the trace shown below.



How can you tell that the left peak represents the emitted pulse?

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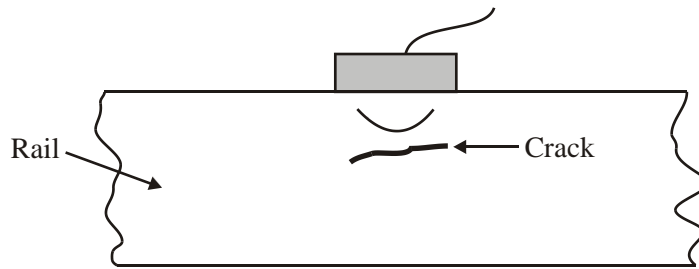
(1)

Calculate the depth of the rail using a measurement from the oscilloscope trace.

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(3)

The probe is now moved to another position on the rail where there is a crack one third of the way down from the top.



Describe how the oscilloscope trace will change.

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(2)

The ultrasound diffracts round the crack because the crack behaves like an obstacle.
 Draw wavefronts on the above diagram to show what this means.

(2)

When trains pass over rails, the rails deform, but then return to their original shape.
 State two properties necessary for the rail material.

1

2

(2)

(Total 10 marks)