1 The photograph shows the image of a fetus inside its mother's uterus. Ultrasound was used to produce this image.

(a) Explain how ultrasound pulses can be used to build up the image of the fetus in the uterus.

(3)

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(b) Explain how the Doppler effect is used to detect the heartbeat of the fetus.

(2)

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(c) The smallest detail that can be seen on the image is half the length of the ultrasound pulse. The thumbnail on the fetus is 0.50 mm thick. The speed of ultrasound in the thumbnail is 2000 m s ^{1}.

Calculate the maximum pulse duration if the thumbnail is to be seen on the image.

(3)

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Maximum pulse duration ....

(Total for Question 8 marks)

2 (a) State what is meant by diffraction.

(2)

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(b) State the principle of superposition of waves.

(2)

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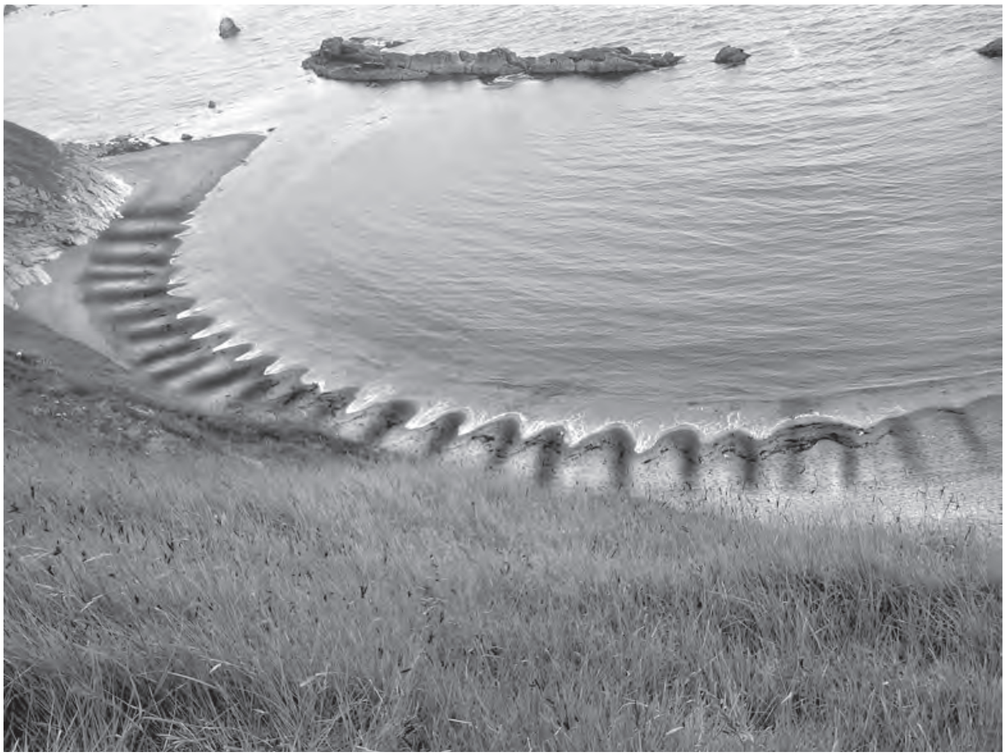
*(c) The photograph shows a beach in England. Waves can be seen passing rocks on their way to the beach. The uneven surface of the sand has formed as a result of diffraction and superposition of these waves.



Use the ideas of diffraction and superposition to explain why the sand surface becomes uneven.

(5)

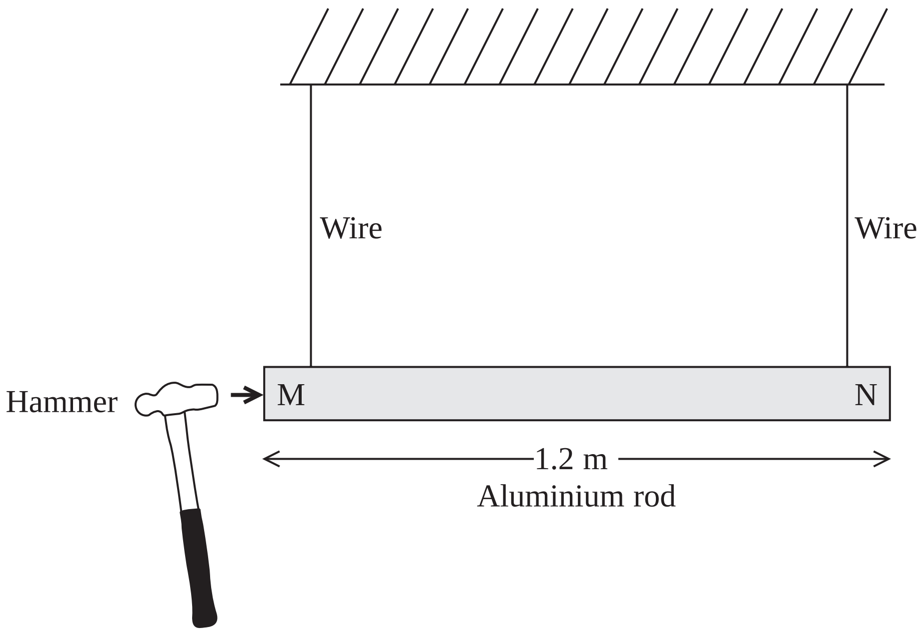
(Total for Question 9 marks)

3 (a) Describe the difference between a transverse wave and a longitudinal wave.

(2)

(b) A teacher sets up the following demonstration to show that the speed of sound in an aluminium rod is greater than in air.

An aluminium rod MN of length 1.2 m is suspended horizontally by two wires as shown in the diagram.



A wave pulse is made to travel along the rod and reflect from end N. The wave pulse is produced by hitting end M gently with a hammer so that the hammer remains in contact with end M until the reflected pulse returns.

(i) State and explain whether the wave pulse is transverse or longitudinal.

(2)

(ii) The hammer remains in contact with end M for a time of 4.8×10^{-4} s.

Calculate the speed of the wave pulse in the rod.

(3)

Speed in rod =

(iii) When the rod is hit, a sound is heard.

Suggest how this sound is created.

(1)

(c) A standing wave is set up in the rod.

Explain how a standing wave is formed.

(3)

(Total for Question = 11 marks)

4 A London radio station broadcasts at a frequency of 95.8 MHz. Calculate the wavelength in air of these radio waves.

Wavelength =

(Total for Question = 3 marks)

5 Warning traffic signs that tell motorists they are speeding are often solar powered.

The speed of an approaching car is measured by transmitting microwaves towards it. These waves are reflected off the car and picked up by a receiver, which uses the Doppler effect to calculate the speed of the car.

(a) A narrow beam of waves is necessary to pick out a single car. Suggest a reason why microwaves are used rather than radio waves.

(2)

(b) (i) State how the frequency of the reflected signal would differ from the frequency of the transmitted signal.

(1)

(ii) Explain how the system detects that a car is speeding.

(2)

(c) If a car is speeding, the warning sign flashes to alert the driver. The warning sign is powered by solar cells covering a rectangular area 0.5 m × 0.3 m. The average intensity of the solar energy radiation hitting the solar cells is 500 W m^{-2}. The solar cells are 8% efficient at transforming light energy into electrical energy, which is stored in a battery.

(i) Calculate how much electrical energy is produced each second by the solar panel.

(3)

Electrical energy each second =

(ii) The panel receives solar energy for 8 hours per day. The warning sign requires 100 J of electrical energy each time it flashes.

Calculate how many times the warning sign can flash in a day.

(3)

Number of flashes =

(Total for Question = 11 marks)

6 The siren of an ambulance emits a sound of a certain frequency. As the ambulance passes a pedestrian, the frequency of the sound he hears changes.

(a) What name is given to this effect?

(1)

(b) Describe and explain how the movement of the ambulance causes the frequency of the sound he hears to change.

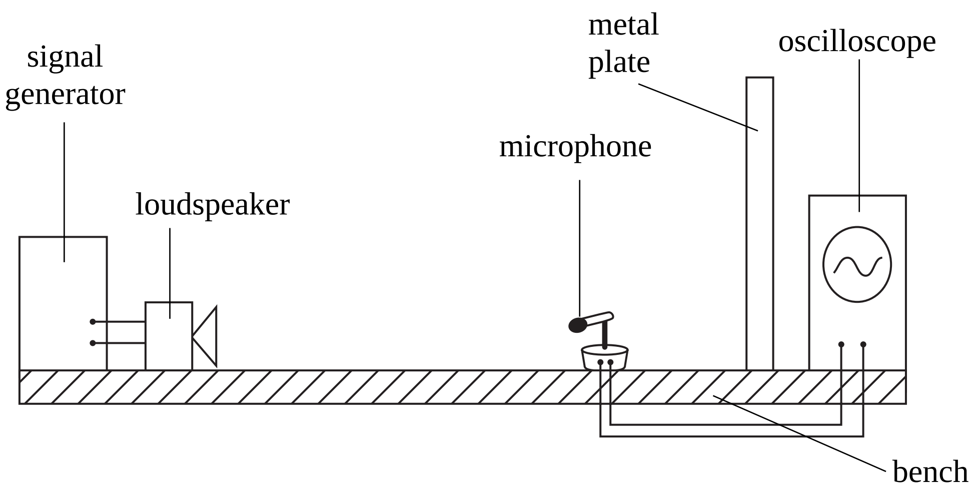
(3)

(c) Suggest how what he hears would be different if the ambulance were moving faster.

(2)

(Total for Question = 6 marks)

*****7 The diagram shows an experiment with sound waves.



A loudspeaker is connected to a signal generator. A microphone is connected to an oscilloscope. Sound waves reach the microphone directly from the loudspeaker and after reflection from the metal plate.
As the microphone is moved towards the loudspeaker, the amplitude of the wave displayed on the oscilloscope varies through a series of maxima and minima.

(a) Explain why the amplitude of the sound varies in this way.

(4)

(b) (i) The distance moved by the microphone between two adjacent maxima is 0.050 m.

Calculate the wavelength of the sound wave.

(2)

Wavelength =

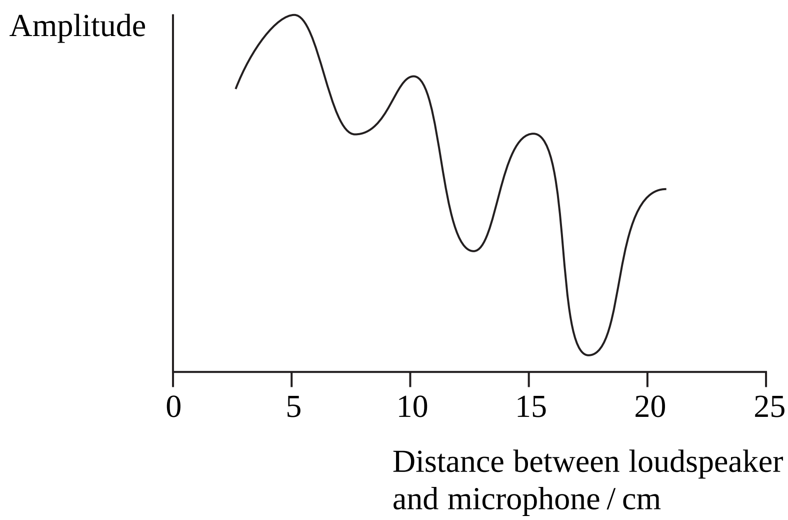
(ii) The frequency of the sound wave is 3.3 kHz.

Calculate the speed of sound in air.

(2)

Speed of sound in air =

(c) The microphone is placed close to the loudspeaker and gradually moved towards the metal plate. The graph shows how the amplitude of the wave displayed on the oscilloscope varies with the position of the microphone.



(i) Explain why the minima never have a zero value.

(ii) As the microphone is moved towards the metal plate, the amplitudes at the minima gradually decrease. Suggest why this happens.

(4)

(Total for Question = 12 marks)