***1** Ready-meals that can be heated in a microwave oven always have the instruction that the food should be stirred properly before eating. This is because 'hot and cold spots' within the oven lead to uneven heating of the food.

A microwave source within the oven emits coherent waves in all directions. The waves are reflected off the walls and so the microwaves arrive at one spot by several different routes. The waves interfere with each other and set up standing waves.

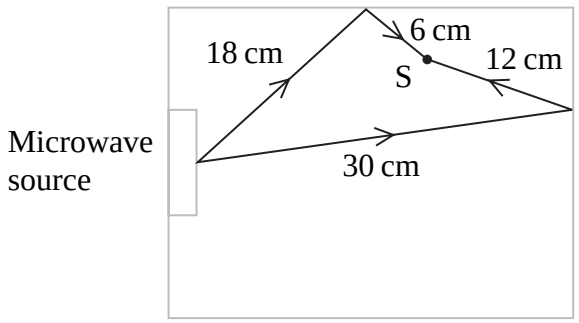
(a) Explain what is meant by the following words:

(2)

Coherent

Standing wave

(b) The diagram shows the path of two microwaves arriving at point S.



The wavelength of the microwaves is 12 cm.

Explain why S is a 'cold spot'. Assume that no other microwaves arrive at that point.

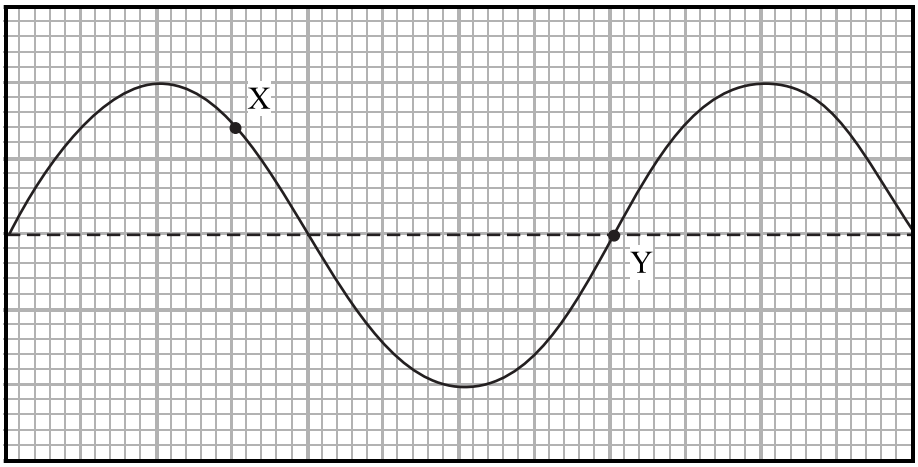
(4)

(c) Uneven heating can be reduced by placing the food on a rotating turntable. Explain why this will reduce the uneven heating of the food.

(2)

(Total for Question = 8 marks)

2 The diagram shows the shape of a wave on the surface of a tank of water at one instant of time. The wave is travelling to the right.



On the diagram

(a) mark a point on the water surface whose motion is exactly 180° out of phase with the motion at X. Label this point A,

(1)

(b) draw an arrow at point Y to show the direction in which the water at Y is moving at the instant shown,

(1)

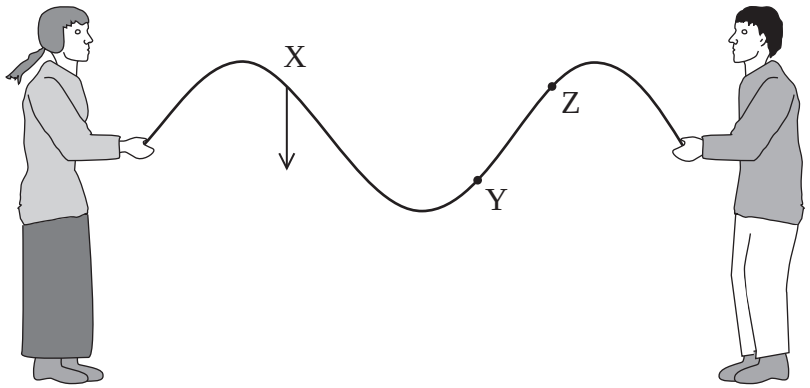
(c) mark a point on the water surface that is at rest at the instant shown. Label this point B.

(1)

(Total for Question = 3 marks)

3 Two students demonstrate standing waves to the rest of the class using a rope.

The diagram shows the appearance of the standing wave on the rope at one instant. Each part of the rope is at its maximum displacement.



(a) (i) Mark the position of **one** node on the diagram. Label this point N.

(1)

(ii) The arrow at point X shows the direction in which the point X is about to move. Add arrows to the diagram to show the directions in which points Y and Z are about to move.

(2)

(b) The frequency of the vibration shown in the diagram is 1.5 Hz. When a rope is vibrating with its fundamental frequency there is one antinode. Calculate the fundamental frequency of this wave.

(2)

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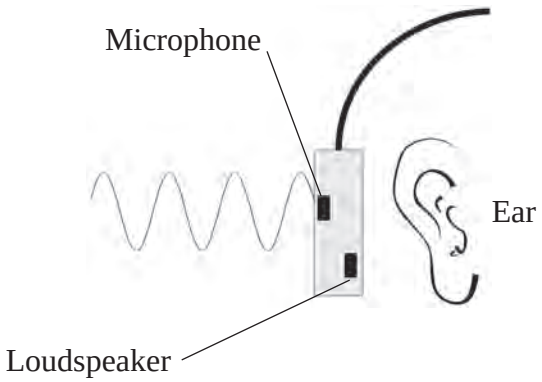
Frequency = ...

(Total for Question = 5 marks)

4 Noise cancelling headphones were first invented to cancel the noise in aeroplane and helicopter cockpits. They work using the principle of superposition of waves.

Sound waves enter and pass through the headphone and are detected by a microphone. An electronic circuit sends a signal to the loudspeaker so that it produces an 'opposite wave'.



(a) Compare the properties of the two sound waves necessary to produce complete cancellation of the two waves that reach the ear.

(3)

(b) In practice the incoming sound is reduced in volume rather than cancelled completely.

Noise-cancelling headphones work well when the noise is from a jet engine. They are not very effective at cancelling speech or music. Explain why.

(3)

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(Total for Question = 6 marks)

***5** (a) A 60 W filament light bulb is used as a ceiling light. The bulb is 2.5 m above the floor and is 5.0% efficient at converting electrical energy into visible light.

Calculate the visible light intensity (radiation flux) on the floor directly below the bulb.

Assume that at a distance r from the source the energy is spread over a total area $4\pi r^2$.

(3)

.....

.....

.....

Visible light intensity = ...

(b) Increasingly a different type of light bulb is being used. It is a coiled fluorescent bulb. A 10 W bulb of this type could replace the 60 W filament bulb and give the same visible light intensity on the floor.

Approximately 25% of national power production is used for lighting.

Discuss why some countries have announced that filament bulbs will be banned in the next few years.

(3)

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(Total for Question = 6 marks)

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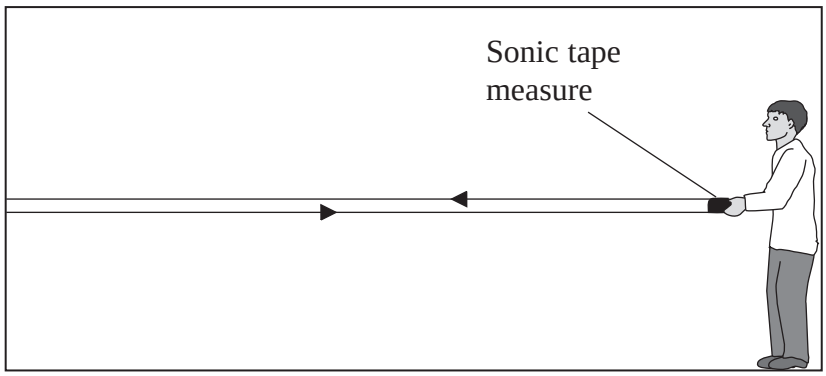
6 A sonic tape measure uses ultrasound to measure distances in buildings. It sends out pulses of ultrasound towards a distant wall and records the time interval between a pulse being sent and its return.



(a) For one particular measurement the time interval was 25 ms.

Calculate the distance from the sonic tape measure to the wall.

Speed of sound = 330 m s^{-1}

(3)

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.....

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Distance = ...

(b) Why is the ultrasound transmitted in pulses?

(1)

.....

.....

(Total for Question = 4 marks)

7 An electronics student is using light emitting diodes (LEDs) to make a traffic light model. He uses red, orange and green LEDs. The table gives information about these LEDs. They are identified as 1, 2 and 3.

LED	Frequency / 10^{14} Hz	Wavelength / 10^{-9} m	Colour
1	5.66	530	
2	5.00	600	
3	4.41	680	

(a) Complete the table by filling in the colour of light emitted by each LED.

(1)

(b) Calculate the energy of the lowest energy photon emitted by this traffic light model.

(3)

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.....

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.....

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Energy = ...

(Total for Question = 4 marks)

8 The photograph shows a projector with an automatic focusing system that detects the distance to the screen so it can adjust the position of the lens to produce a clear image.

The part of the projector labelled X emits a pulse of infrared radiation and detects the pulse after it is reflected from a screen.

(a) The screen is 2.5 m from the projector.

Calculate the time taken between the emission and detection of the pulse.

(2)

Time taken =

(b) State why the infrared radiation is emitted in pulses rather than as a continuous beam.

(1)

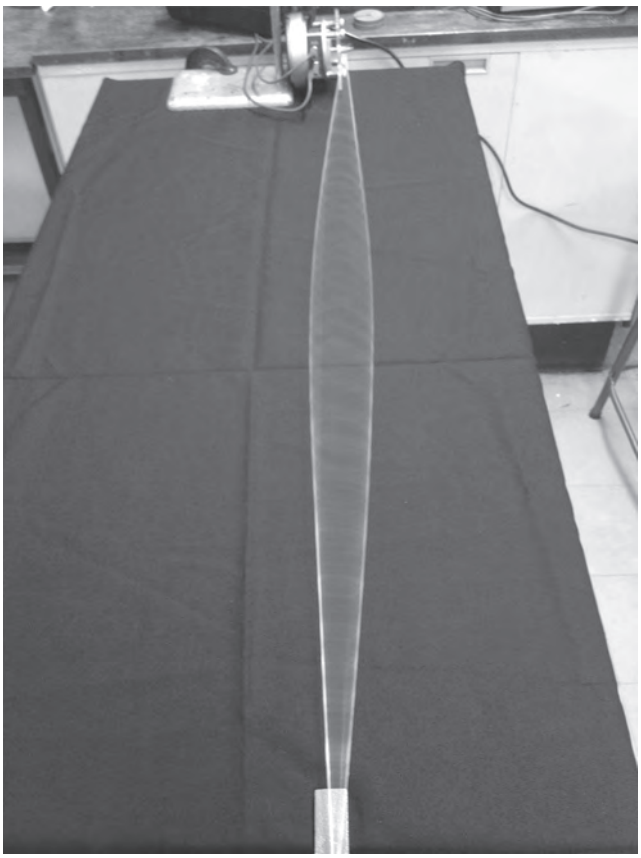
(c) Suggest why infrared radiation is used rather than visible light.

(1)

(Total for Question = 4 marks)

9 A student investigates the effect of changing the frequency of waves on a string held in tension.

The string is fixed at one end and has a vibration generator attached to the other end. When the vibration generator is switched on a wave is produced on the string as shown in the photograph.



(a) Name the type of wave produced on the string and explain how it has been formed.

(4)

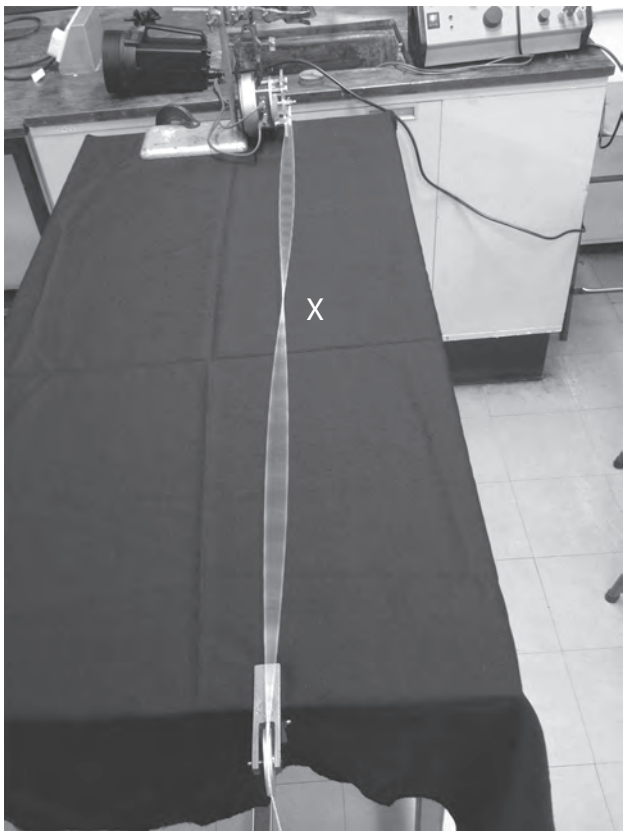
(b) The length of string between the vibration generator and the fixed end is 1.8 m. The string is vibrating with a frequency of 330 Hz.

Calculate the speed of the waves on the string.

(3)

Speed of the waves =

(c) The frequency of the vibration generator is changed from 330 Hz. The new wave produced on the string is shown in the photograph below.



(i) The student is able to touch the string at point X without disturbing the pattern.

Explain why.

(2)

(ii) Calculate the new frequency of the vibration generator.

(1)

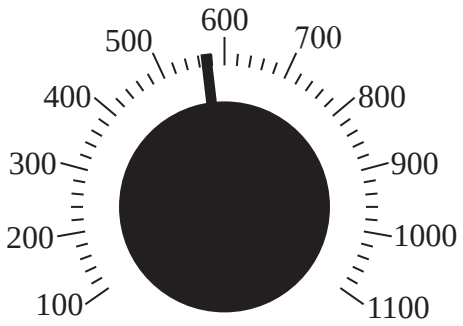
Frequency =

(iii) The vibrating string is now illuminated using a strobe lamp without adjusting the frequency of the vibration generator. The lamp flashes on and off many times a second at a frequency which may be varied by the student. The picture below shows a section of the string that now appears to be two separate strands.

Calculate the maximum possible frequency of the strobe lamp which will cause the appearance of two separate strands and explain why this is a maximum frequency.

(2)

(d) The frequency of the vibration generator is adjusted by turning the dial shown below. The student measures the frequency of vibration by reading from the scale shown on the dial.



Explain a disadvantage of this method of measuring the frequency.

(2)

(Total for Question = 14 marks)