4.2 Travelling Waves

Question Paper

Course	DP IB Physics
Section	4. Waves
Topic	4.2 Travelling Waves
Difficulty	Medium

Time allowed: 80

Score: /60

Percentage: /100

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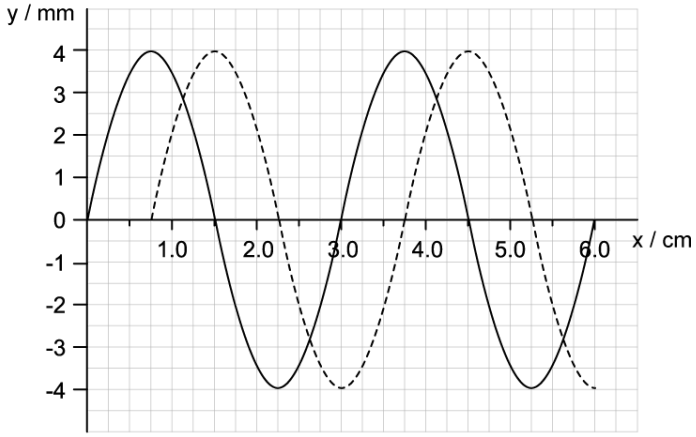
Question 1a

A wave on the surface of a ripple tank moves from the source at the rear of the tank to the front. The graph shows the variation with distance *x* of the displacement *y* of the surface of the water.

The solid line shows displacement at t = 0 and the dashed line shows the displacement at t = 0.154 s.



(a) Describe the difference between transverse and longitudinal waves.

[2 marks]

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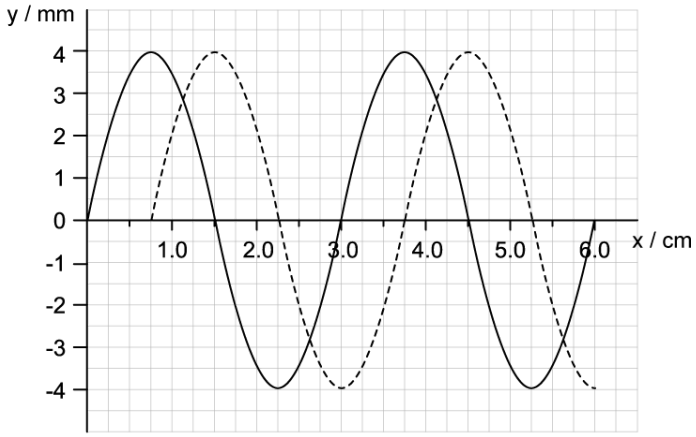
Question 1b

(b) Calculate for the wave on the ripple tank



(i) the speed

[2]

(ii) the frequency

[2]

[4 marks]

Question 1c

The graph shows the motion of the water waves at a point where displacement ≤ 6.0 cm.

c)
Describe the appearance of the wave after being displaced by twice this distance.

[3 marks]

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Question 1d

The initial amplitude of the ripples is 0.38 cm.

(d)
Sketch a graph of displacement against time to show the motion of the surface of the water for the first 3.0 s.

[3 marks]

Question 2a

A sound wave in air has a speed of 330 m s^{-1}. The distance between a rarefaction and compression is 1.3 m for this particular soundwave.

(a) Calculate the time period of the sound wave.

[3 marks]

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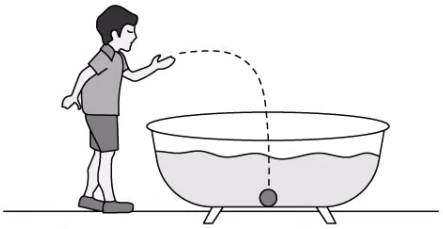
Question 2b

A stone is dropped into a metal bath filled with water, and the sound of it landing is heard by a person in the room.

The sound waves generated by the impact of the stone travels to the person at different speeds through the metal of the bath, the water and the air.



The metal of the bath is 0.5 cm thick, the water is 23 cm deep, and the ears of the person are 160 cm above the base of the bath.

You may use the following values:

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

Speed of sound in metal = 3000 m s^{-1}

Speed of sound in water = 1500 m s^{-1}

(b)

(i)
Explain why the person only hears the sound once, rather than twice

[1]

(ii)
Calculate the time difference between the sound arriving at the person's ear from the inside (through the water) and the outside (through the metal) of the bath

[3]

[4 marks]

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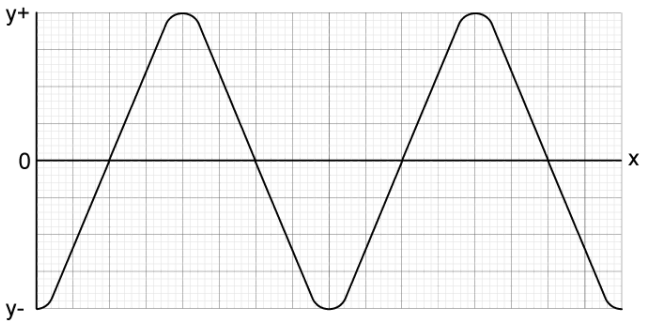
Question 2c

The graph shows the displacement *y* of the particles in air due to the progression of the sound wave *x* from the source to the ear.

Positive displacement indicates movement towards the person and negative displacement is away from them.

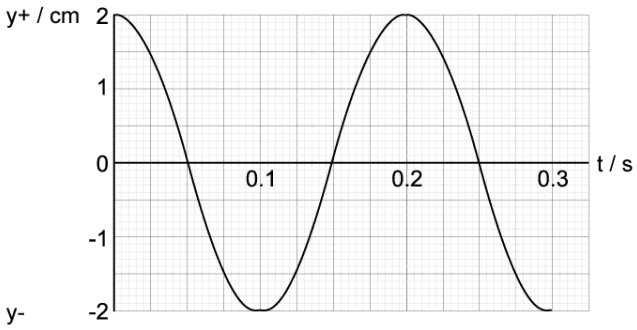


(c)
Annotate on a sketch of the graph the position of at least two compressions and two rarefactions.

[2 marks]

Question 2d

The graph shows the variation with time *t* of the displacement *y* of a particle in the metal of the bath.



(d) For the longitudinal wave:

(i) Calculate the frequency of the wave

[1]

(ii) Determine the speed it is moving at when t = 0.15 s

[2]

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[3 marks]

Question 3a

(a)

(i) Outline what is meant by an electromagnetic (EM) wave.

[2]

(ii) Compare EM waves to ultrasound waves.

[1]

[3 marks]

Question 3b

When doctors want to use medical imaging to observe a foetus in the uterus, ultrasound is used rather than x-rays.

Ultrasound produces images which are less detailed.

(b)

(i)
Describe why ultrasound is chosen over x-rays despite the lack of resolution of the images produced.

[2]

(ii)
Explain why ultrasound images have lower resolution.

[2]

[4 marks]

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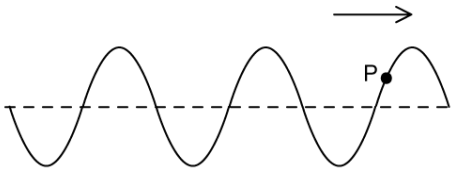
Question 3c

Electromagnetic waves can be modelled using a stretched string with a wave passing along it. In the diagram, a wave is travelling to the right. The equilibrium position of the waveform is marked with a dashed line and a point, P is indicated.



The frequency of the wave is 0.5 Hz.

Annotate the diagram as instructed below.

(c)

(i) Starting at point P, identify the wavelength of the wave.

[1]

(ii) Indicate the motion of point P from the instant until 0.5 s later.

[2]

[3 marks]

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Question 3d

The string is being oscillated at one end to cause a frequency f of 0.5 Hz and wavelength, λ of 30 cm.

(d)

(i)
Determine the speed of the wave

[1]

(ii)
Deduce the change which must be made to reduce the wavelength to 20 cm. Assume that the length of the string is constant

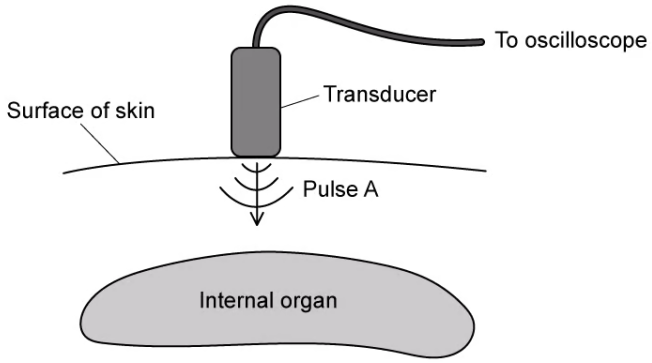
[2]

[3 marks]

Question 4a

Ultrasound scanners are used in hospitals to establish the depth of internal organs under the skin. A pulse of ultrasound is emitted from a transducer, which also detects reflections of the pulse from internal organs.

Reflected pulses are displayed on the screen of an oscilloscope.



(a) Explain how the energy is transferred in the ultrasound.

[2 marks]

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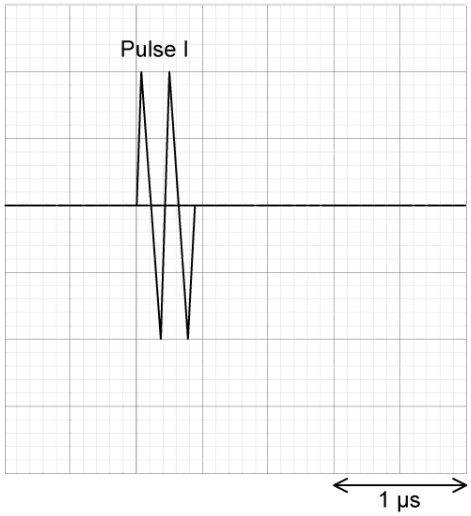
Question 4b

The display shows the appearance of the first pulse, Pulse I on an oscilloscope.



(b) Determine the frequency of the pulse of ultrasound.

[3 marks]

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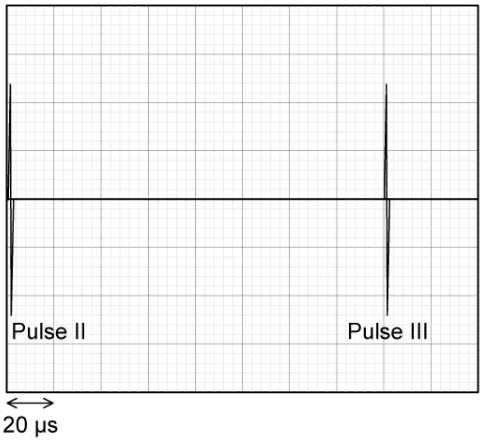
Question 4c

The scanner emits ultrasound pulses at regular time intervals. A display of two successive pulses, II and III would show a separation between them.

The reflection of pulse II must be detected before pulse III is emitted. This means that the equipment has a maximum depth within the body which it can clearly create an image from.



(c) Calculate this maximum depth.

- Speed of ultrasound in body tissue = 1540 m s^{-1}
- The time-base is set to 20 μs div^{-1}.

[3 marks]

Question 4d

(d)
Calculate the wavelength of an electromagnetic wave with a frequency equal to that of the ultrasound wave.

[2 marks]

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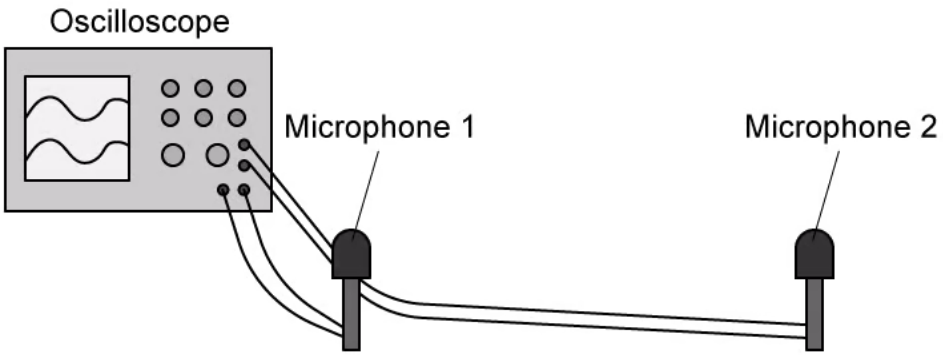
Question 5a

A common investigation to determine the speed of sound uses two microphones connected to a double-beam oscilloscope.



(a) Outline how this equipment can be used to find the speed of sound.

(i) List any additional equipment required

[2]

(ii) Briefly outline the method

[2]

(iii) Indicate the measurements to be taken

[1]

You may choose to draw a diagram as part of your answer.

[5 marks]

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Question 5b

(b)
Sketch a graph to show the traces which would be observed on the double-beam oscilloscope at a point where:

(i) No result would be measured and recorded

[1]

(ii) A result would be measured and recorded

[1]

[2 marks]

Question 5c

The teacher planning the investigation to be set up on lab benches where the furthest distance that could be measured is 2.0 m.

(c) Suggest a sensible range of frequencies for the signal generator.

[3 marks]

Question 5d

The students consider how their measurements would be different if they could conduct the experiment under different conditions.

(d)
Without further calculation, explain what changes would be made to the frequency range used for an experiment conducted

(i) underwater

(ii) in a gas tank filled with Helium

[3]

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[3 marks]

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