Diagram 1 below shows a wave that approaches the boundary between medium 1 and medium 2. AB and CD are two wavefronts of the wave.

Diagram 2 shows the situation a time later when point C of the wavefront CD has just reached the boundary. The speed of the wave in medium 1 is v_1 and the speed in medium 2 is v_2. v_1 is greater than v_2.

Diagram 1

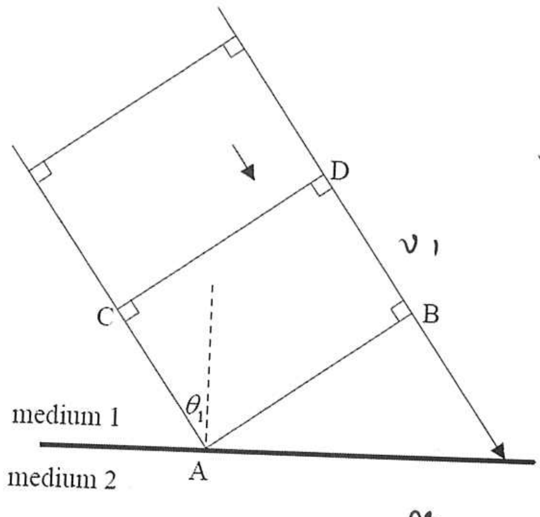
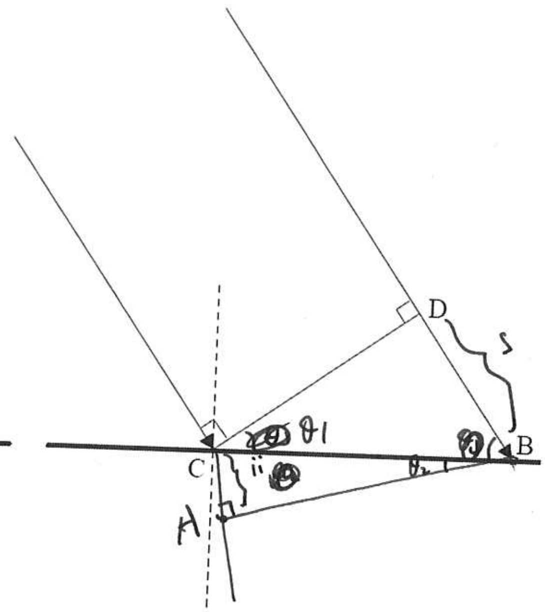


Diagram 2



(b) On diagram 2 above

(i) draw the wavefront AB. [1]

(ii) draw a line to represent the distance travelled by point A. [1]

(iii) label the distance travelled by point B with the letter "s". [1]

(c) Use your completed diagram 2 to derive the relation [6]

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2}$$

where θ_1 is the angle of incidence and θ_2 is the angle of refraction.

$BD = v_1 t$, $AC = v_2 t$.

$BD/\sin\theta_1 = \sin\theta_2/AC$ $\quad \frac{\sin\theta_1}{\sin\theta_2} = \frac{BD}{AC} = \frac{V_1}{V_2}$.

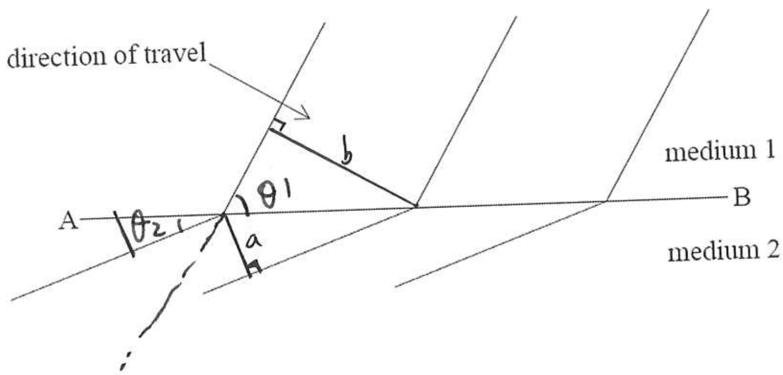
(d) In medium 1 the wave has a wavelength of 4.0 cm and travels at a speed of $8.0\ \text{cm s}^{-1}$. Determine the frequency of the wave in **medium 2**. [2]

$f = \frac{8}{4} = 2\ Hz$.

(e) The angle of incidence is 60° and the angle of refraction is 35°. Calculate the speed of the wave in **medium 2**. [2]

$v_2 = V_1 \times \frac{\sin\theta_2}{\sin\theta_1} = 8.0 \times \frac{0.574}{0.866} = 5.3\ m/s$.

In the scale diagram below, plane wavefronts travel from medium 1 to medium 2 across the boundary AB.



State and explain in which medium the wavefronts have the greater speed. [3]

medium 1.
Elongate wavefront in medium 1, the wavefront in medium 2 is ~~elongated~~ lagged behind;
OR, angle of refraction < incidence ⇒ m1 > m2.

By taking measurements from the diagram, determine the ratio

$$\frac{\text{speed of wave in medium 1}}{\text{speed of wave in medium 2}}.$$ [3]

$\frac{v_1}{v_2} = \cancel{\frac{\sin\theta_1}{\sin\theta_2}} \; \frac{b}{a} = \frac{2.2}{0.9} = 2.4$

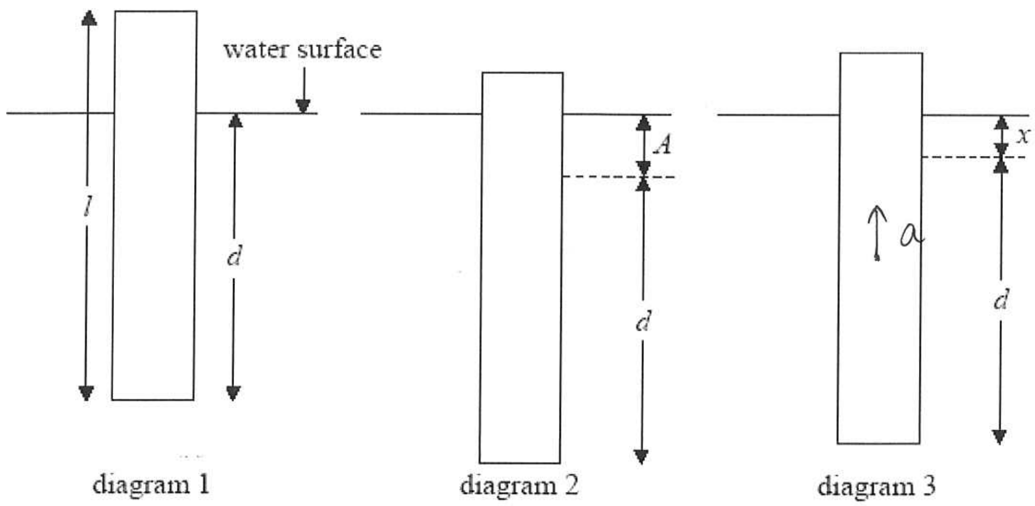
Determine the critical angle if the wave is sent from medium 2 into medium 1

$\cancel{\frac{\sin\theta_1}{\sin\theta_2}}$

$\sin\theta_2 = \frac{1}{c} = 0.409$

1. This question is about oscillations and waves.

(a) A rectangular piece of wood of length l floats in water with its axis vertical as shown in diagram 1.



The length of wood below the surface is d. The wood is pushed vertically downwards a distance A such that a length of wood is still above the water surface as shown in diagram 2. The wood is then released and oscillates vertically. At the instant shown in diagram 3, the wood is moving downwards and the length of wood beneath the surface is $d + x$.

(i) On diagram 3, draw an arrow to show the direction of the acceleration of the wood.

(1)

(ii) The acceleration a of the wood (in m s^{-2}) is related to x (in m) by the following equation.

$$a = -\frac{14}{l}x$$

Explain why this equation shows that the wood is executing simple harmonic motion.

(2)

$a \propto -x$.

① proportional

② opposite direction.

$\cancel{a = -\omega^2 A\cos(\omega t)}$ $T = 1.4\,s$. $\omega = \frac{2\pi}{1.4}$

(iii) The period of oscillation of the wood is 1.4 s. Show that the length l of the wood is 0.70 m.

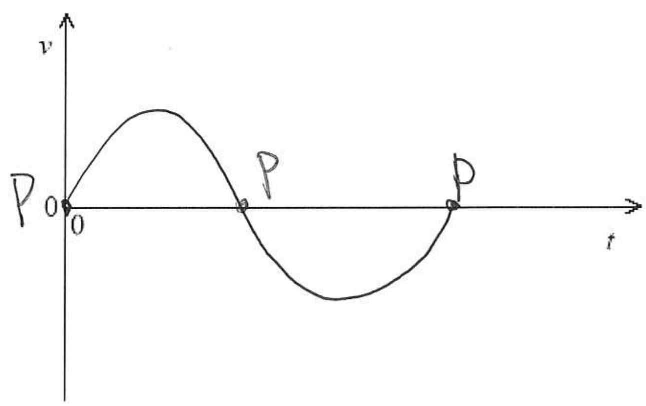
$a = -\omega^2 x$. $-\frac{14}{l}x$ $-\omega^2 x$

$l = \frac{14}{\omega^2}$

$= 14 \times \frac{(1.4)^2}{4\pi^2}$

$= 0.70\,m.$

(b) The wood in (a), as shown in diagram 2, is released at time $t = 0$. On the axes below, sketch a graph to show how the velocity v of the wood varies with time over one period of oscillation.



(1)

absolute value.

(c) The distance A that the wood is initially pushed down is 0.12 m. $-0.12\,m$.

(i) Calculate the magnitude of the maximum acceleration of the wood.

$a = -\left(\frac{2\pi}{1.4}\right)^2(-0.12) = 2.4\,m\,s^{-2}$

(ii) On your sketch graph in (b) label with the letter P one point where the magnitude of the acceleration is a maximum.

(1)

2. This question is about simple harmonic motion (SHM),.

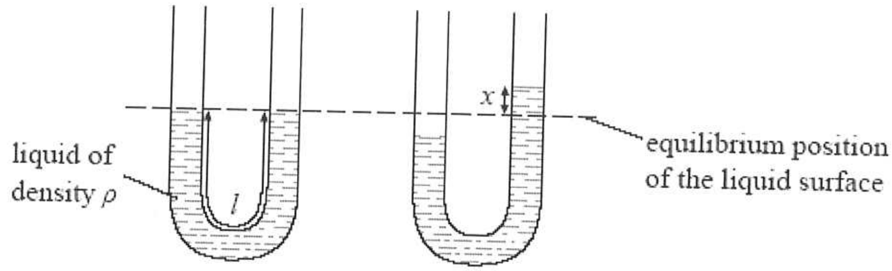
(a) By reference to simple harmonic motion, state what is meant by amplitude.

The largest displacement in the SHM.

(1)

(b) A liquid is contained in a U-tube.

Diagram 1 **Diagram 2**



The pressure on the liquid in one side of the tube is increased so that the liquid is displaced as shown in diagram 2. When the pressure is suddenly released the liquid oscillates.

(ii) The displacement of the liquid surface from its equilibrium position is x. The acceleration a of the liquid in the tube is given by the expression

$$a = -\frac{2g}{l}x$$

where g is the acceleration of free fall and l is the total length of the liquid column. Explain, with reference to the motion of the liquid, the significance of the minus sign.

when l ↓ on ~~xxx~~ the left, distance is +, to stop the l↓ for the oscillation, the liquid slows down by accelebation in − direction. $a \propto -x \Rightarrow$ SHM.

(2)

(iii) The total length of the liquid column in the tube is 0.32 m. Determine the period of oscillation.

$$\frac{2g}{0.32} = \omega^2 = \left(\frac{2\pi}{T}\right)^2$$

$$\frac{2g}{0.32} = \frac{4\pi^2}{T^2}$$

$$T = \sqrt{\frac{4\pi^2}{2g} \cdot 0.32} = 0.79$$

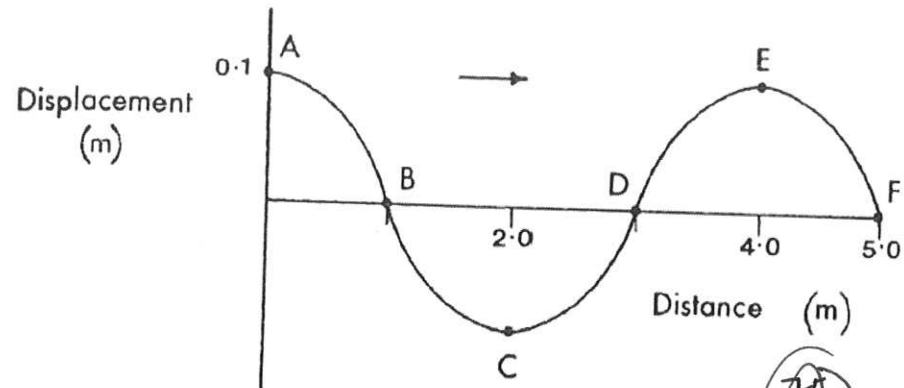
The diagram below represents a wave of frequency 15 Hz at one instant in time. The wave is travelling to the right.

$4 \times 15 = 60$

$v = \frac{\lambda}{T}$

$= \boxed{\lambda f}$

$\lambda = v \cdot T$



(a) What is the wavelength of the wave? 4m

(b) What is the speed of the wave?

(c) Using the letters shown, name any two points on the wave which are in phase.

~~(d)~~ A reflecting barrier is placed

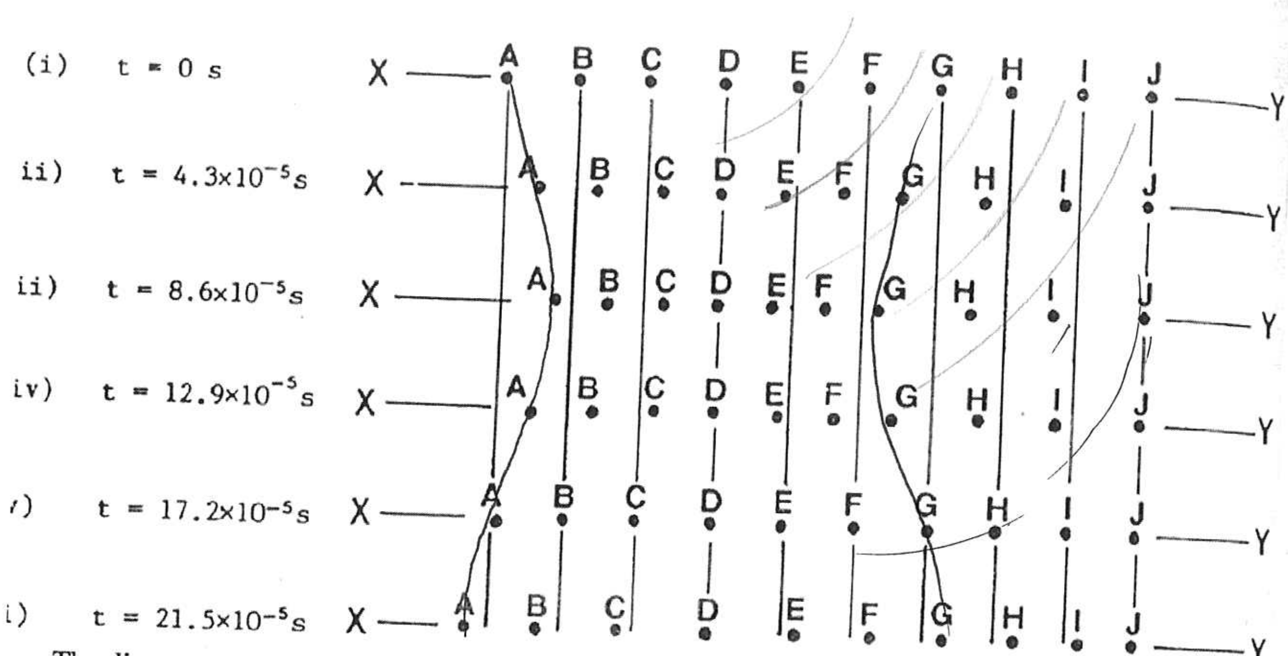
(i) at F

then (ii) at E.

A, E.

For each of these two placements, sketch on the appropriate diagram in the Answer

1. In the diagram (i) A,B,C....J are the equilibrium positions of some air particles which lie along the line XY. Diagrams (ii) to (vi) show the positions of these particles at subsequent time intervals when a wave disturbance is established in the air.



The diagrams are drawn to full scale.

(a) What type of longitudinal wave is represented by the diagram? Sound.

(b) From the diagram determine:

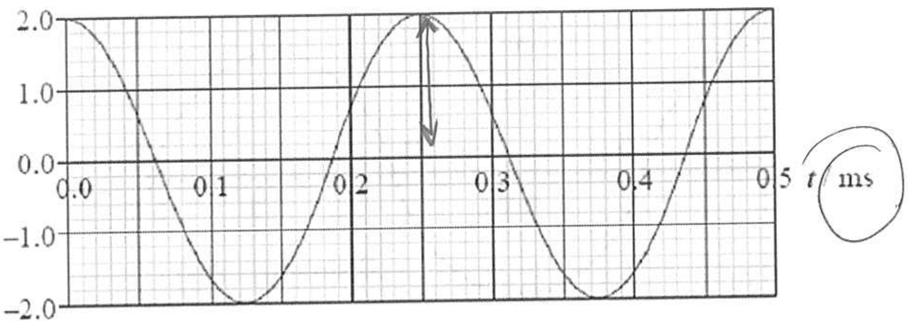
(i) the amplitude; and 0.75

(ii) the wavelength of this wave disturbance. $5.8 \times 2 = 11.6$

(c) Calculate the speed of sound in air. $v = \frac{11.6}{17.2 \times 10^{-5} \times 2} = 3.4 \times 10^4$

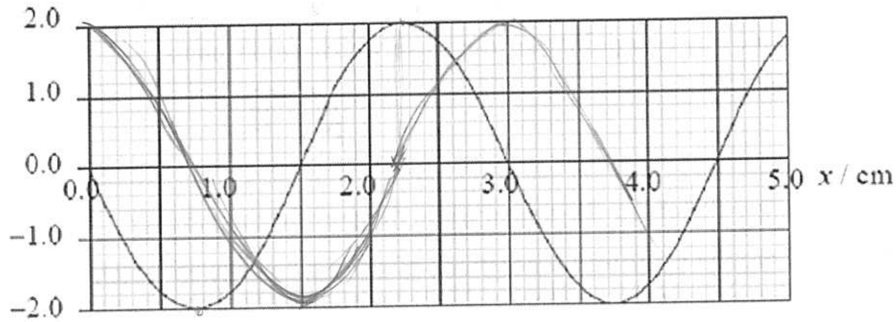
3. A travelling wave is created on a string. The graph below shows the variation with time t of the displacement y of a particular point on the string.

Graph 1 y / mm



The variation with distance x of the displacement y of the string at $t=0$ is shown below.

Graph 2 y / mm



(a) Use information from the graphs to calculate, for this wave,

(i) the wavelength. [1]

0.03m

(ii) the frequency. [2]

$\frac{1}{0.25} = 4\ \text{Hz}$ $\quad \frac{1}{0.25 \times 10^{-6}} = 4 \times 10^{6}\ \text{Hz}.$

(iii) the speed of the wave. [1]

0.03

(b) The wave is moving from left to right and has period T.

(i) On **graph 1**, draw a labelled line to indicate the amplitude of the wave. [1]

(ii) On **graph 2**, draw the displacement of the string at $t = \frac{T}{4}$. [2]