Name: _____ Class: _____ Date: _____

Sec 3 Physics

Worksheet 15: Waves

1 Water waves were produced in a ripple tank using a vibrator of frequency 3 Hz. Which of the following values of speed and wavelength could the waves have had?

	speed	*wavelength*
A	1 cm/s	3 cm
B	2 cm/s	1 cm
C	5 cm/s	15 cm
D	12 cm/s	4 cm

[ ]

2 A wave source of frequency 1000 Hz emits waves of wavelength 0.1m. How long does it take for the waves to travel 2500 m?

A 4 s
B 25 s
C 40 s
D 100 s

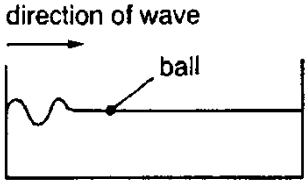
[ ]

3 The table shows examples of transverse and longitudinal waves. Which line in the table is correct?

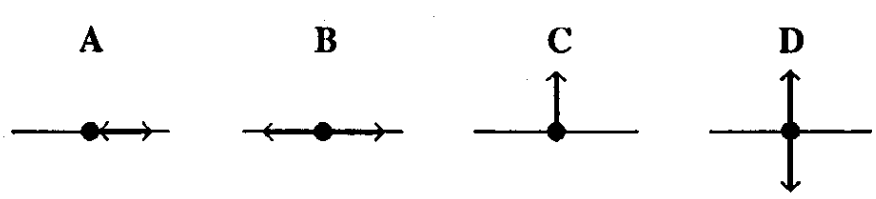
	transverse	***longitudinal***
A	gamma rays	sound
B	infra-red	radio
C	infra-red	water waves
D	radio	light

[ ]

4 The diagram shows a ball floating in a tank of water.

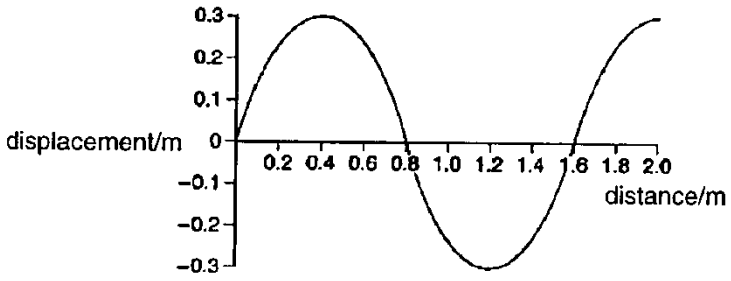


Which diagram shows the movement of the ball when the wave passes?



[ ]

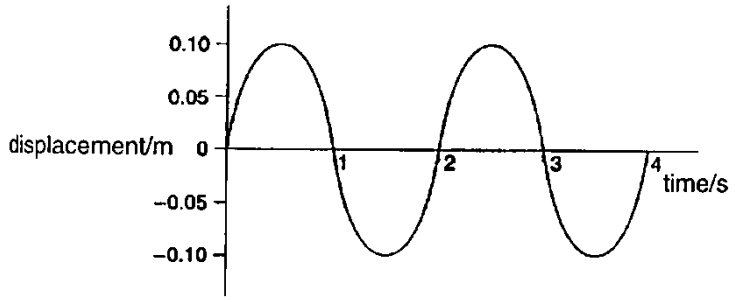
5 A long rope is stretched out on the floor. One end of the rope is then shaken. The graph shows the rope at a particular moment in time.



Which is the wavelength of the wave motion?

A 0.36 m **C** 0.8 m
B 0.6 m **D** 1.6 m [ ]

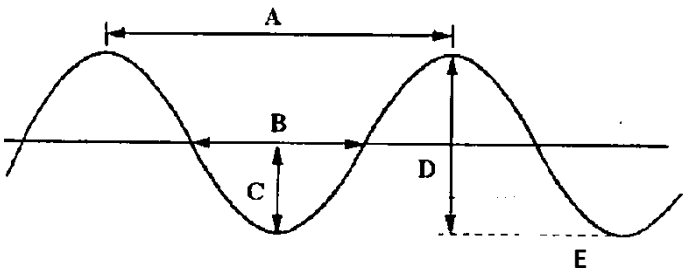
6 The diagram shows how displacement varies with time as a wave passes a fixed point.



What is the frequency of this wave?

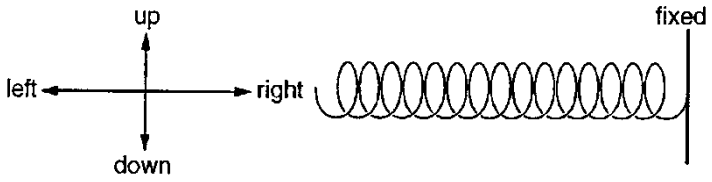
A 0.25 Hz **C** 1.0 Hz
B 0.50 Hz **D** 2.0 Hz [ ]

7 The diagram shows a cross-section of a water wave. Which distance is the amplitude of the wave?



[ ]

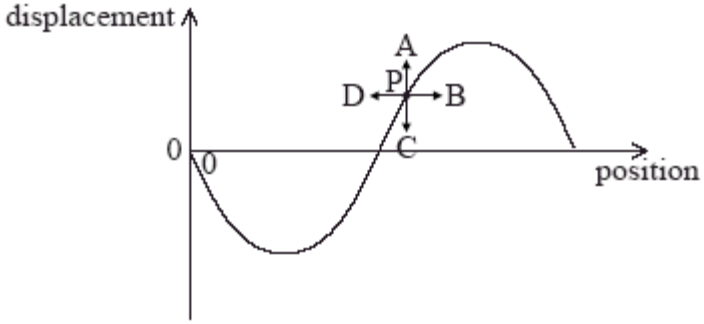
8 A lightly coiled spring is fixed at one end and held by hand at the other.



Which hand movements cause first a compression and then a rarefaction to travel along the spring?

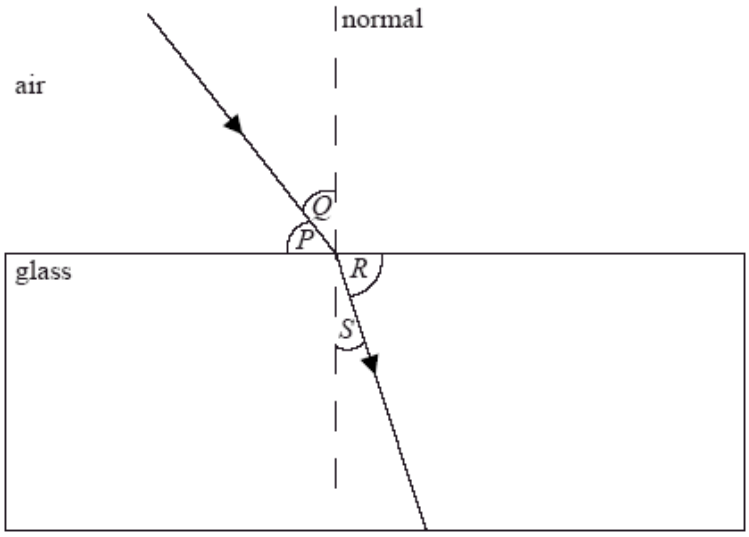
A down then up
B up then down
C left then right
D right then left [ ]

9 A transverse wave travels from left to right. The diagram below shows how, at a particular instant of time, the displacement of particles in the medium varies with position. Which arrow represents the direction of the velocity of the particle marked P?



[ ]

10 Light travels from air into glass as shown below.



What is the refractive index of glass?

A $\frac{\sin P}{\sin S}$

B $\frac{\sin Q}{\sin R}$

C $\frac{\sin P}{\sin R}$

D $\frac{\sin Q}{\sin S}$ [ ]

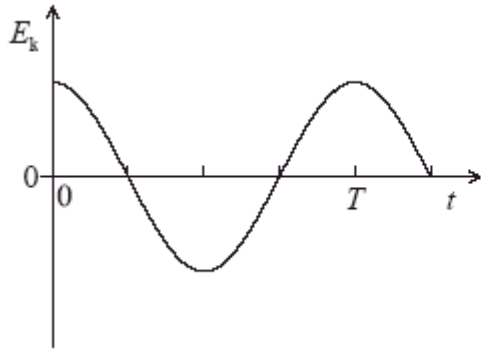
11 Which of the following electromagnetic waves has a frequency **greater** than that of visible light?

A Ultraviolet
B Radio
C Microwaves
D Infrared [ ]

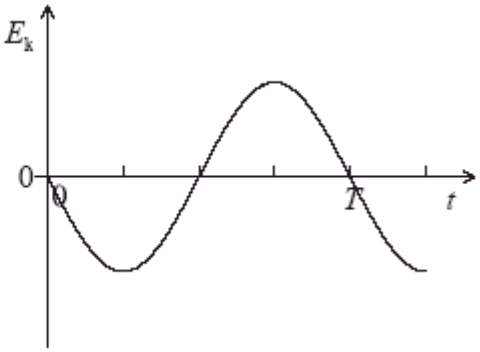
12 A particle oscillates with simple harmonic motion with period T.

At time $t = 0$, the particle has its maximum displacement. Which graph shows the variation with time t of the kinetic energy E_k of the particle?

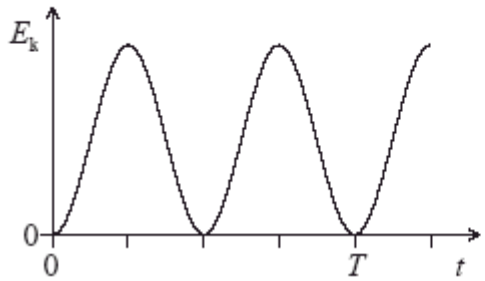
A.



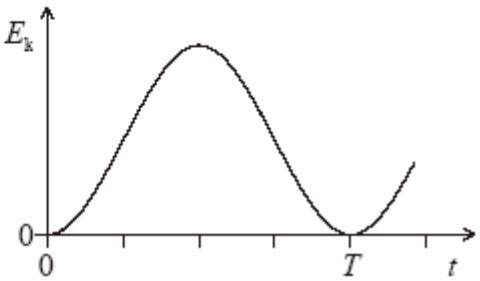
B.



C.

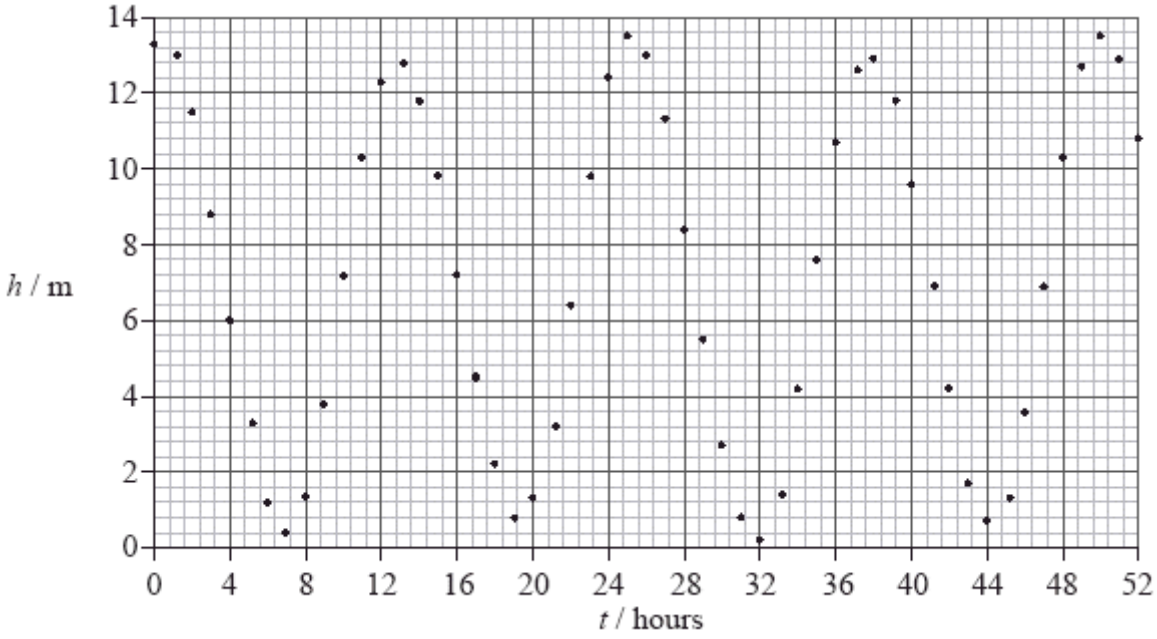


D.



[ ]

13 The graph shows measurements of the height h of sea level at different times t in the Bay of Fundy.



Which of the following gives the approximate amplitude and period of the tides?

	Amplitude	Period
A	6.5 m	6 hours
B	13 m	12 hours
C	6.5 m	12 hours
D	13 m	6 hours

[ ]

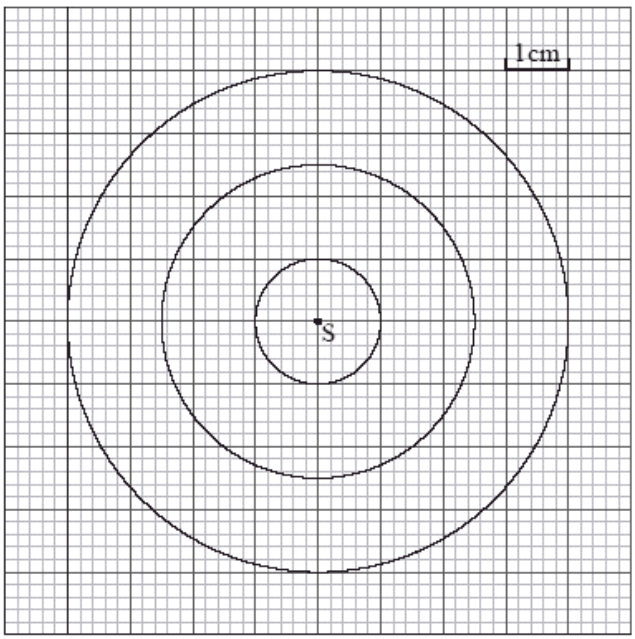
14 Which of the following is a value of wavelength that is found in the visible region of the electromagnetic spectrum?

A 4×10^{-5} m
B 4×10^{-7} m
C 4×10^{-9} m
D 4×10^{-11} m [ ]

15 Two waves meet at a point in space. Which of the following properties always add together?

A Displacement
B Amplitude
C Speed
D Frequency [ ]

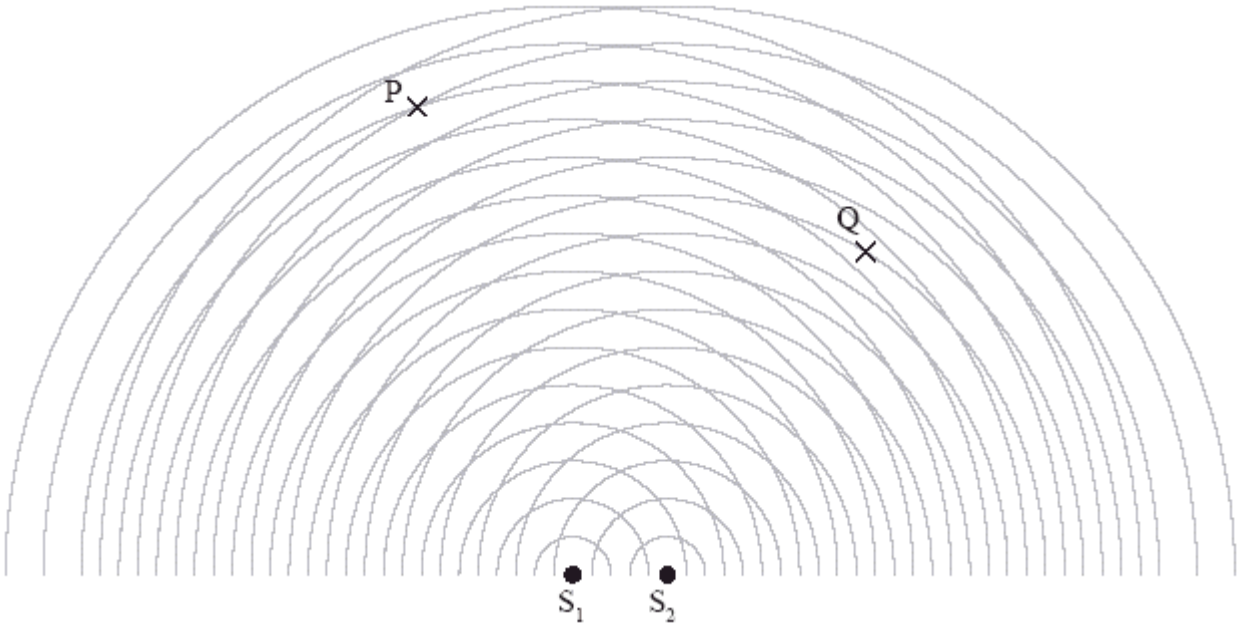
16 The diagram below is a snapshot of wave fronts of circular waves emitted by a point source S at the surface of water. The source vibrates at a frequency f = 10.0 Hz.



The speed of the wave front is

A 0.15 cm s^{-1}.
B 1.5 cm s^{-1}.
C 15 cm s^{-1}.
D 30 cm s^{-1}. [ ]

17 Two coherent point sources S_1 and S_2 emit spherical waves.



Which of the following best describes the intensity of the waves at P and Q?

	P	Q
A	maximum	minimum
B	minimum	maximum
C	maximum	maximum
D	minimum	minimum

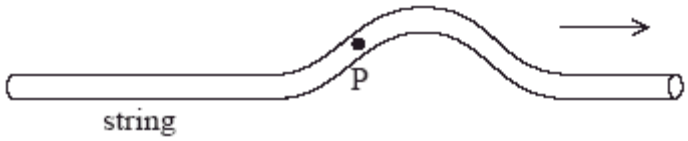
[ ]

18 Monochromatic light travels from air into water. Which of the following describes the changes in wavelength and speed?

	Wavelength	Speed
A	increases	decreases
B	increases	increases
C	decreases	increases
D	decreases	decreases

[ ]

19 A wave pulse is travelling to the right along a string.



Which of the following best represents the direction of the velocity of the point P?

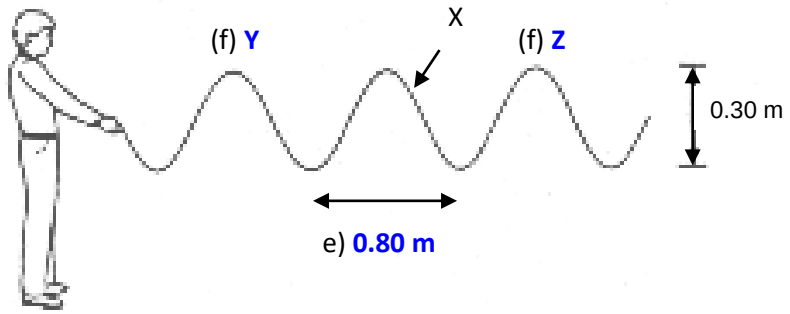
A ↑
B ↓
C →
D ←

1 D 2 B 3 B 4 D 5 D 6 B 7 C 8 D 9 C 10 D 11 A

12 C 13 C 14 B 15 A 16 C 17 A 18 D 19 B

STRUCTURED QUESTIONS

1 The figure below shows a student setting up waves on a long elastic cord. The student's hand makes one complete up-and-down movement in 0.40s, and in each up-and-down movement the hand moves through a height of 0.30 m. The wavelength of the waves on the string is 0.80 m.



For this wave, determine

a Amplitude = 0.15 m

b Period = 0.40 s

c Frequency = 2.5 Hz

d Speed = 2.0 ms^{-1} [6]

e Using a line with arrows on both ends, label the wavelength of the waves in the diagram above. [1]

f Label 2 points **Y** and **Z** on the line which is in phase with point X. [2]

g Sketch the shape of the waves in real life. [2]

Graph with decreasing amplitude. (A common mistake is to draw the wavelength getting shorter as amplitude decreases. The wavelength should be relatively constant. Can you think of a reason?)
Explanation: Energy losses as the waves propagates.

2 Transverse waves are produced in a long rope by securing one end of the rope to a wall and then moving the other end from side to side by hand. The frequency of the waves is 2 Hz.

a How are “transverse waves” different from “longitudinal waves”?

Transverse waves travel (or propagate) in a direction perpendicular to the direction of vibrations;

longitudinal waves travel in a direction parallel to the direction of vibrations.

b Explain the meaning of the expression "the frequency is 2 Hz".

The waves produce two complete vibrations in one second.

[1]

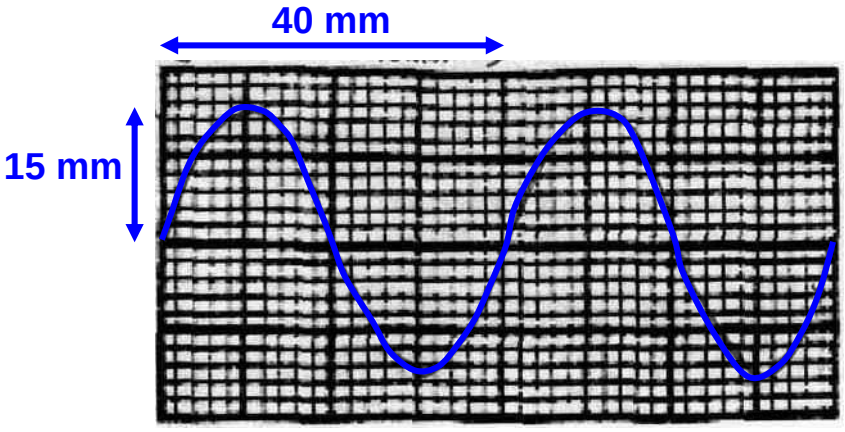
c What determines the amplitude of the waves produced?

The amplitude of the oscillating hand determines the amplitude of the waves.

(The larger the hand swing, the larger the amplitude of the wave) [1]

3 Transverse waves of wavelength 40 mm and amplitude 15 mm travel across a liquid surface.

a On the grid (2mm) below draw a **full-scale** diagram showing a side view of the liquid surface at a particular instant. [2]



b If the frequency of vibrations of the waves is 12 Hz, calculate the speed at which they travel across the liquid surface.

$v = f\lambda = 12 \times (40/1000) = 0.48\ ms^{-1}$ (2 sf)

Speed = …….. mm s^{-1} [2]

4 a Figure 4.1 shows the graph of the variation of the displacement of a wave with distance along the wave at a particular time.

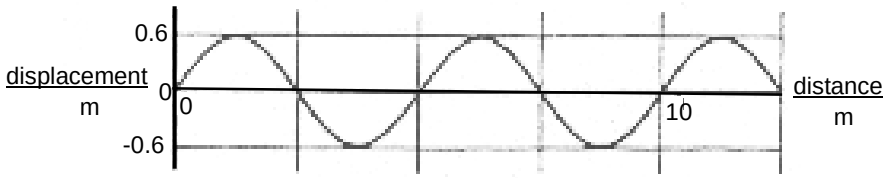


Figure 4.1

State the values for

(i) the amplitude of the wave: 0.6 m [1]

(ii) the wavelength of the wave: 5 m [1]

b Figure 4.2 shows the graph of the variation of the displacement of the same wave with time at a particular point along the wave.

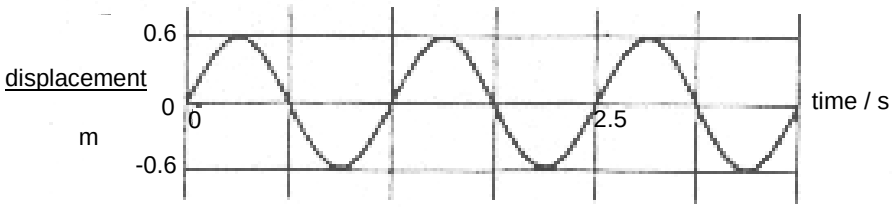


Figure 4.2

State values for

(i) Time for one cycle = 1.25 s [1]

(ii) Frequency of the wave = 0.800 Hz [1]

c Calculate the speed of the wave drawn in Figures 4.1 and 4.2.

$v = f\lambda = 0.800 \times 5 = 4\ ms^{-1}$

Speed of wave = ... ms^{-1} [2]

5 A progressive wave moves past two points P and Q, separated by a distance of 0.90 m. Figure 5.1 shows the displacement y at point P varies with time *t*. Figure 5.2 shows the graph of the displacement of the wave at time *t* = 0 over some distance from point P.

Figure 5.1

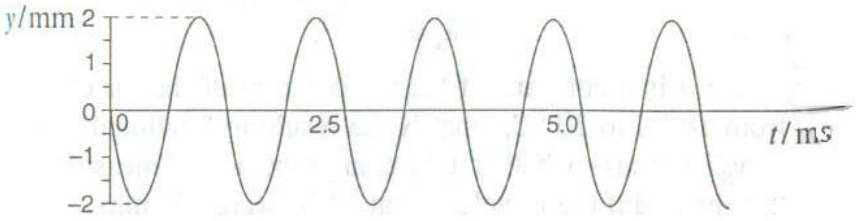
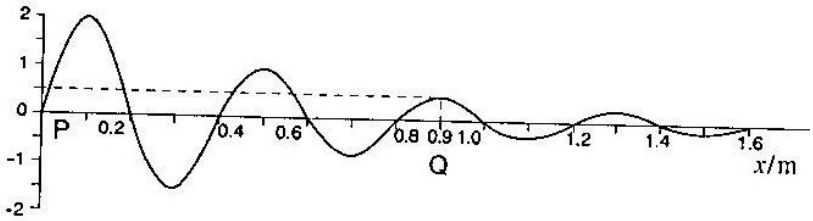


Figure 5.2



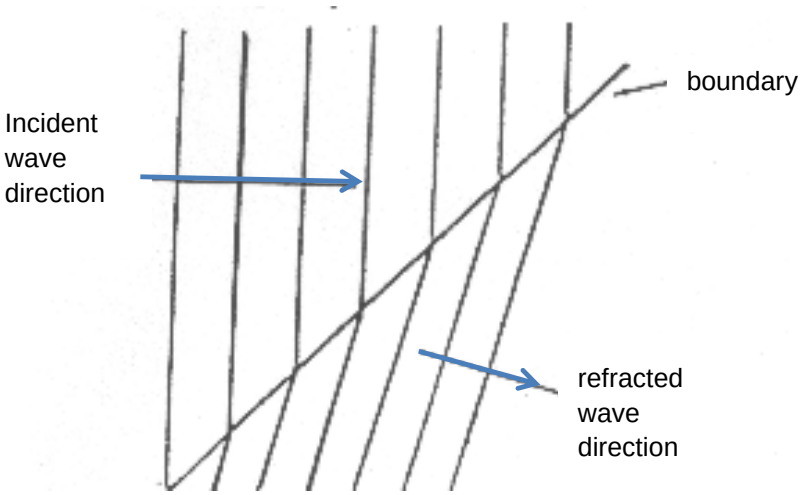
Using the data from the graphs, deduce for this wave the

a wavelength = 0.4 m [1]

b frequency = 800 Hz [1]

c speed of wave = 320 ms^{-1} [1]

6 In the full scale diagram, the unlabelled line represents successive wave crests. Refraction of plane waves is occurring as they cross a boundary. The frequency of the incident waves is 6.0 Hz.



By making suitable measurement, calculate

a the wavelength of the incident waves,

λ_1 = 4.1 / 6 (measure the length of 6 wavelengths and average it)
= 0.68 cm (2 sf)

wavelength = …….. cm [2]

b the speed of the incident waves,

v_1 = 6.0 x 0.68
= 4.1 cm s^{-1} (2 sf)

speed = …….. cm s^{-1} [2]

c the frequency of the refracted waves,

f_2 = 6.0 Hz (no change) (2 sf)

frequency = …….. Hz [1]

d the wavelength of the refracted waves,

λ_2 = 2.4 / 5
= 0.48 cm (2 sf)

wavelength = …….. cm [1]

e the speed of the refracted waves,

v_2 = 6.0 x 0.48

= 2.9 cm s^{-1} (2 sf)

speed = …….. cm s^{-1} [2]

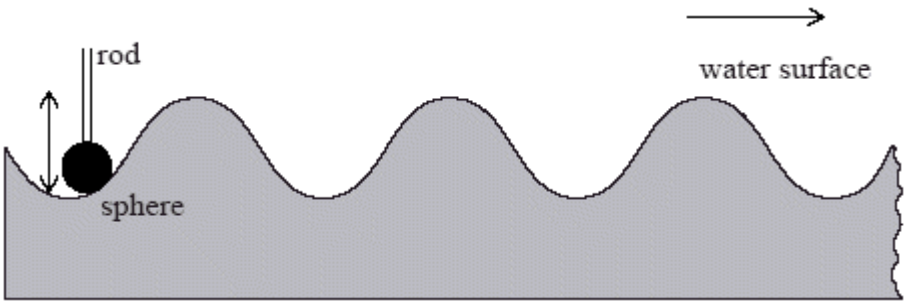
f refractive index of the boundary.

n = v_1 / v_2
= 4.1 / 2.9
= 1.4 (2 sf)

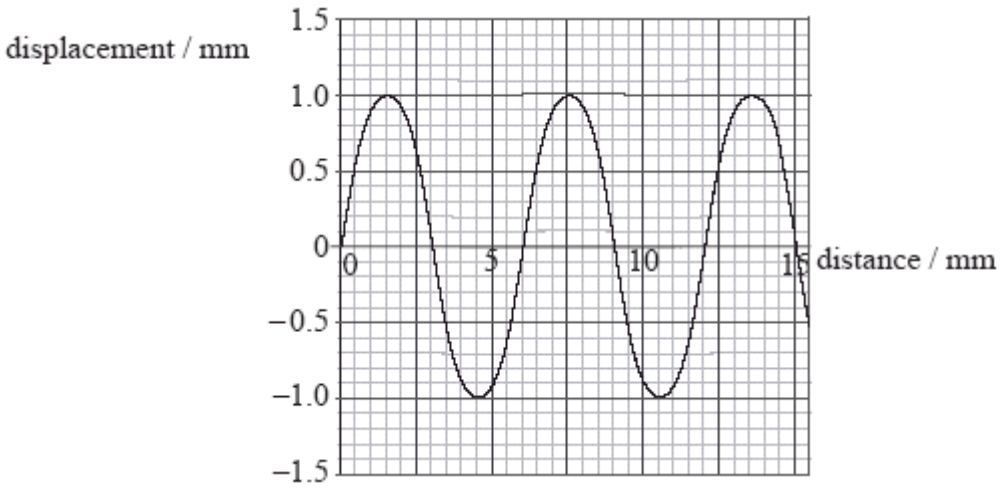
Refractive index = …… [2]

7 This question is about water wave motion.

A small sphere, mounted at the end of a vertical rod, dips below the surface of shallow water in a tray. The sphere is driven vertically up and down by a motor attached to the rod. The oscillations of the sphere produce travelling waves on the surface of the water.



a The diagram shows how the displacement of the water surface at a particular instant in time varies with distance from the sphere. The period of oscillation of the sphere is 0.027 s.



Use the diagram to calculate, for the wave,

(i) the amplitude.

1.0 mm;

Amplitude = …….. mm [1]

(ii) the wavelength.

6.0 mm;

wavelength = …….…….. mm [1]

(iii) the frequency.

37 Hz;

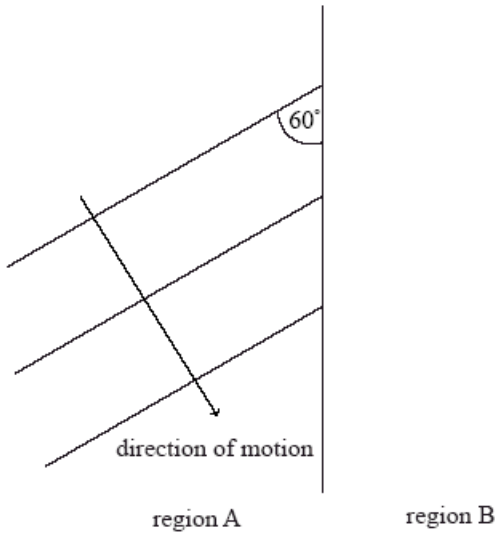
Frequency = …… Hz [1]

(iv) the speed.

0.22 m s^{-1};

Speed = …… mm s^{-1} [1]

b The wave moves from region A into a region B of shallower water. The waves move more slowly in region B. The diagram (not to scale) shows some of the wavefronts in region A.



(i) With reference to a wave, distinguish between a ray and a wavefront.

ray: direction in which energy travels;
wavefront: line connecting points with same phase/displacement;

(ii) The angle between the wavefronts and the interface in region A is 60°. The refractive index ${}_{A}n_{B}$ is 1.4.

Determine the angle between the wavefronts and the interface in region B.

$\sin r = \frac{\sin 60}{1.4}$;

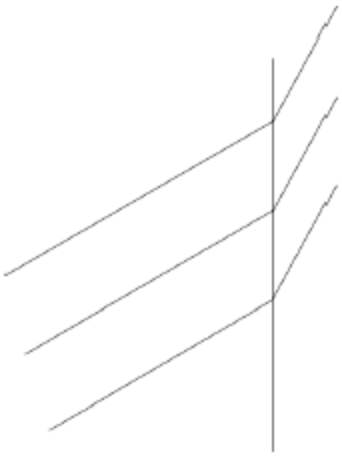
$r = 38°$;

The incident angle is measured between the ray and the normal to the interface. Not from the wave-front to the normal.

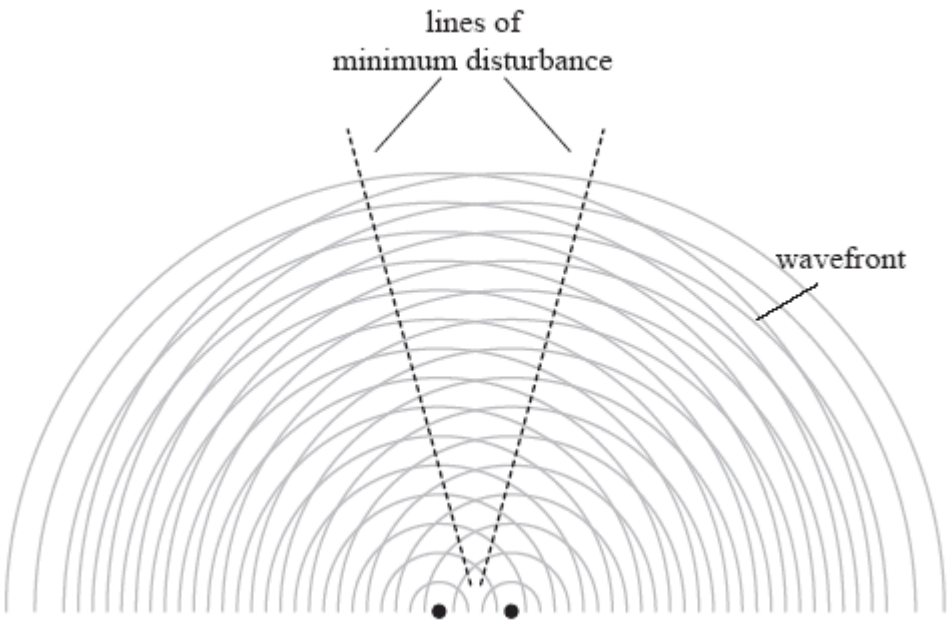
Angle = ... [2]

(iii) On the diagram above, construct **three** lines to show the position of three wavefronts in region B. [2]

wavefronts continuous at boundary and parallel;
wavefronts closer together and equally spaced by eye and in the correct direction;



c Another sphere is dipped into the water. The spheres oscillate in phase. The diagram shows some lines in region A along which the disturbance of the water surface is a minimum.



(i) Outline how the regions of minimum disturbance occur on the surface.

reference to superposition/interference;

waves (almost) cancel to give zero/small displacement;

where waves arrive out of phase/180° out/π out;

(for the last point: out of phase means that the effect of 1 wave is exactly opposite the other, i.e. one wave causes the particle to move up with a certain force, the other wave will force the particle to move down with the same force.)

(ii) The frequency of oscillation of the spheres is increased.

State **and** explain how this will affect the positions of minimum disturbance.

position of any one minimum closer to centre / minima closer together;

frequency increased so wavelength decreased / correct explanation in terms of double-slit equation;

(for the last point, the equation for double slit is taught in A level)

[2]