ASPIRE HUB

EDUCATION

Secondary 3 Physics

General Properties of Waves
Worksheet 2

NAME:

DATE:

Learning Outcomes:

(i) Describe what is meant by wave motion as illustrated by vibrations in ropes and springs and by waves in a ripple tank (including use of the term wavefront).

(ii) Show an understanding that waves transfer energy without transferring matter.

(iii) Define and use the terms speed, frequency, wavelength, period and amplitude, including graphical representation.

(iv) Recall and apply the relationship speed of wave = frequency × wavelength to new situations or to solve related problems.

(v) Compare transverse and longitudinal waves and give suitable examples of each.

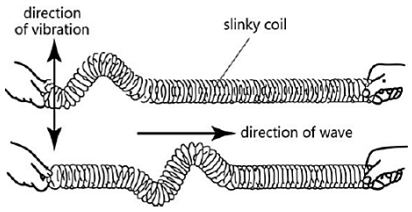
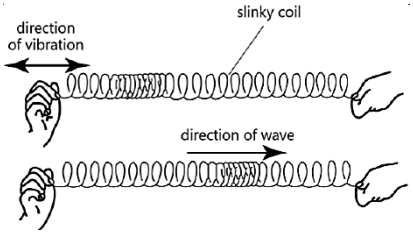
Waves

A wave is a disturbance that propagates through space, transferring energy with it but not matter.

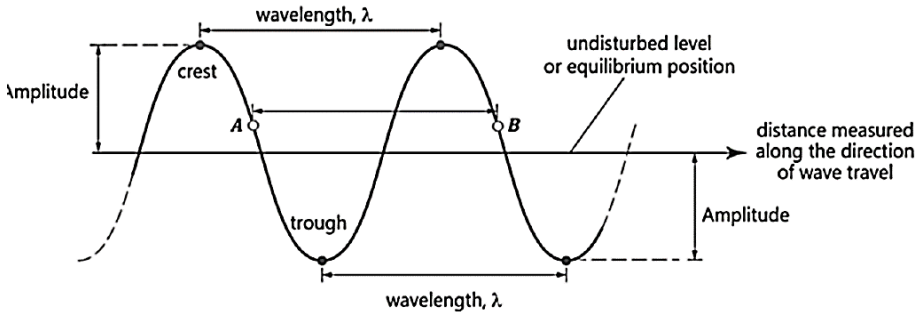
Hence, a **wave motion** transfers energy from one point to another through the vibrations of the medium particles, without transferring the material medium itself.

1. Types of Waves

There are 2 types of waves – **transverse** and **longitudinal**.

Transverse Waves	Longitudinal Waves
Waves where the direction of vibration is perpendicular to the direction of the wave travel.	Waves where the direction of vibration is parallel to the direction of the wave travel. [A series of compressions and rarefactions is created]
	
Examples: • Water waves • Rope waves • Electromagnetic waves (radio waves, microwaves, infrared waves, visible light, ultraviolet, x-rays and gamma rays)	**Examples:** • Sound waves • Waves in a slinky coil (coil vibrates in-line)

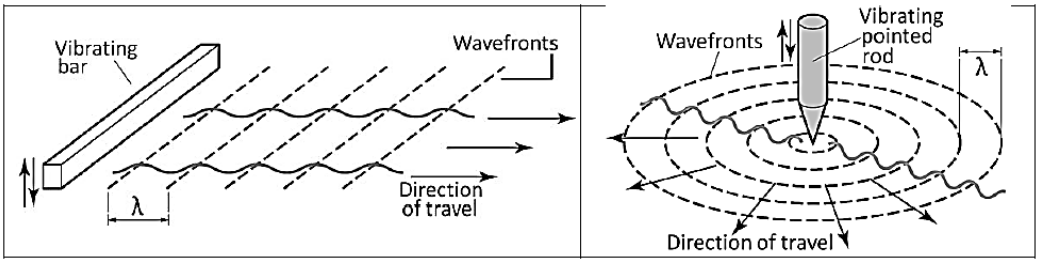
2. Wave Terminology



Definitions	Units
Crest (or **peak**) is the highest point on a transverse wave.	
Trough is the lowest point on a transverse wave.	
Wavefront is an imaginary line joining all adjacent points that are in phase. • i.e. Wavefront can be drawn by joining all the crests of a wave. • Direction of wave motion is always perpendicular to the wavefront	
Amplitude is the maximum displacement from the equilibrium position.	**m**
Wavelength (λ) is the shortest distance between two points of the same phase.	**m**
Frequency (f) is the number of oscillations completed per unit time.	**Hz or s^{-1}**
Period (T) is the time taken to complete one oscillation.	s
Speed of a wave is the distance travelled per unit time.	**ms^{-1}**
Two points are said to be **in phase** if they have the same velocity (i.e. same speed and direction) and have the same displacement from rest position. • Crests/troughs are in the same phase.	

[] Distance between two adjacent wavefronts is wavelength.

[] Wavefronts can be linear or circular depending on the source of the wave:



3. Wave Equations

$f = \frac{1}{T}$, f = frequency [**Hz**]

T = period [s]

$v = f\lambda$, v = speed of wave [**ms-1**]

f = frequency [Hz]

λ = wavelength [m]

Derived from:

$v = \frac{d}{t} = \frac{\lambda}{T} = f\lambda$

[] speed of a wave depends on the <u>medium</u> the wave is in

[] frequency of the wave depends on the <u>source</u> i.e. how fast the vibrating bar is moving

[] wavelength usually changes according to the equation v = f λ

4. Examples – Calculation and Description

4.1 Example (Calculation)

Q. A large ripple tank with a vibrator working at a frequency of 30 Hz produces 25 complete waves in a distance of 50 cm. Determine the wavelength and speed of the wave.

A. $\lambda = 50/25 = 2$ cm = 0.02 m

$v = f\lambda = 30 \times 0.02 =$ 0.6 m/s

4.2 Example (Description)

Q. Describe the motion of a particle as one complete wave moves past it.

A. The particle will move to maximum positive displacement, and to maximum negative displacement, and back to its original position.

Q. Explain how a dipper produces a transverse water wave.

A. As the dipper moves up and down, it pushes the water particles up and down too. The water particles oscillate vertically and perpendicular to the direction of the wave motion. Energy is transferred from one point to another without transferring the water particles.

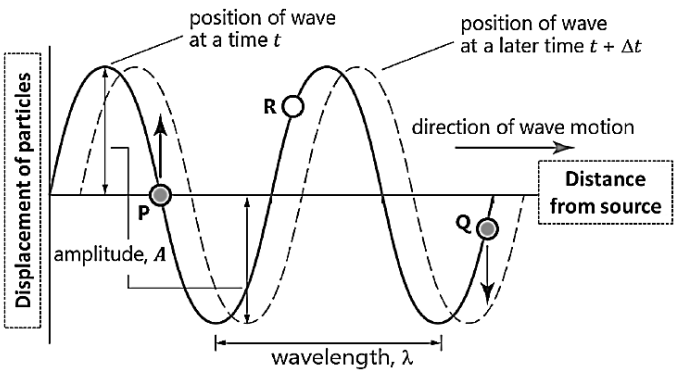
Q. Explain how a sound wave from a speaker propagates through air.

(note: sound wave is longitudinal)

A. As the cone of the speaker moves inwards and outwards continuously, the air particles are pushed inwards and outwards too. They oscillate parallel to the direction of the wave motion and transfer energy from one point to another through a series of compressions and rarefactions.

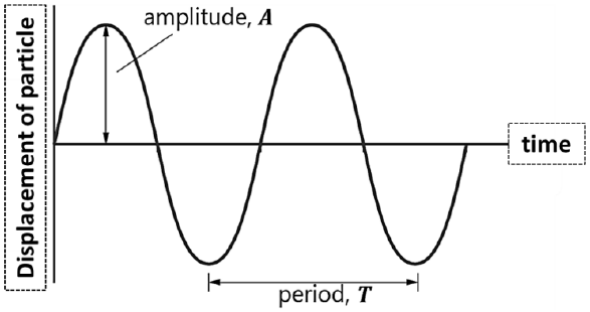
5. Graphical Representation

Displacement-distance Graph



- Displacements of the **particles** at every point on the wave at a **specific time t**.
- Able to determine amplitude and wavelength from graph.

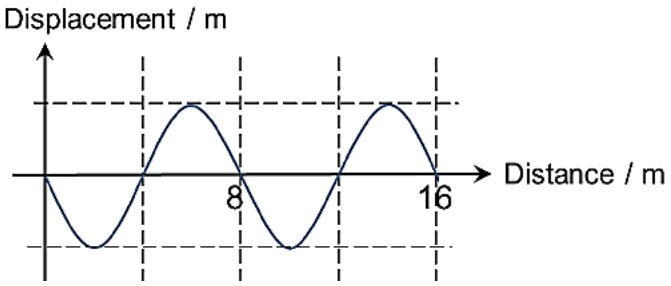
Displacement-time Graph



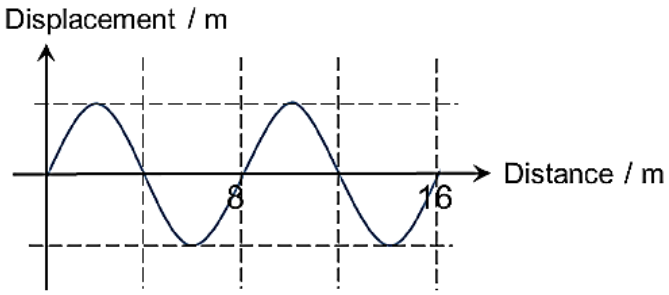
- Displacement of **a particle with respect to time**.
- Able to determine amplitude and period from graph.

5.1 Example

Q. Given the displacement-distance graph of a wave below, deduce how the displacement-distance graph will look like after half a period.



A.



Multiple Choice Questions

1. The fundamental difference between transverse and longitudinal waves is a difference in _____.

   A. amplitude

   B. direction of vibration

   C. medium through which they travel

   D. wavelength

( )

2. Which of the following are the examples of a transverse wave and a longitudinal wave?

	Transverse	Longitudinal
A	Ultrasound	Light
B	Light	Water ripples
C	Water ripples	Ultrasound
D	Ultrasound	Water ripples

( )

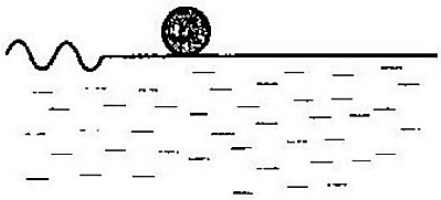
3. One end of a spring is moved backwards and forwards to produce a model of a wave.

What is this type of wave called, and what is an example of it?

	Type of wave	Example
A	Longitudinal	Radio Wave
B	Longitudinal	Infrasound Wave
C	Transverse	Radio Wave
D	Transverse	Infrasound Wave

( )

4. A wave moves across the water surface as shown below. A ball is in the middle of the water.



What would happen to the ball when the wave passes?

A. It moves together with the wave

B. It moves back-and-forth

C. It moves up-and-down

D. It moves in a circular pattern

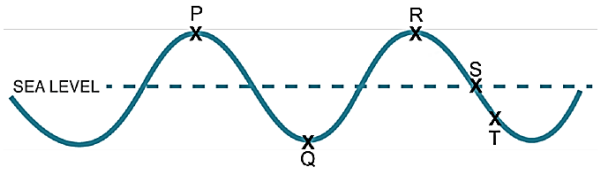
( )

5. Which of the combinations will produce a wave with a period of $\frac{1}{6}$ S?

	Speed / m s^{-1}	Wavelength / m
A	18	3
B	2	3
C	3	2
D	1	6

( )

6. The diagram shows waves travelling on the sea. The wavelength of the wave is 7.5 m.



Which two points could be 10 m apart?

A. P and S

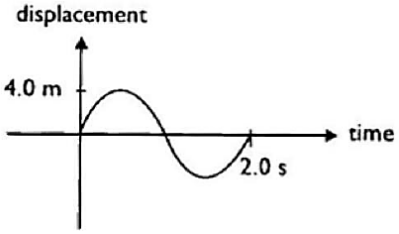
B. P and T

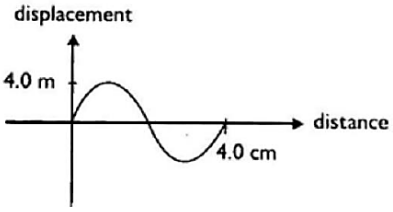
C. Q and S

D. Q and T

( )

7. The graph on the left shows how the displacement of a point in a wave varies with time. The graph of the right shows how the displacement of points in a wave varies with distance.





Using the information from the graphs, what is the distance moved by the wave in 2 s?

A. 0.005 m

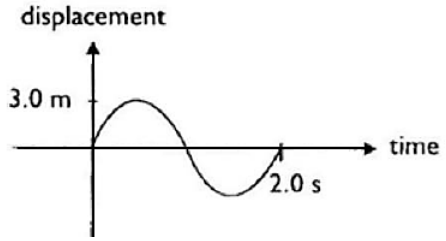
B. 0.02 m

C. 0.04 m

D. 0.08 m

( )

8. Study the graph shown below.

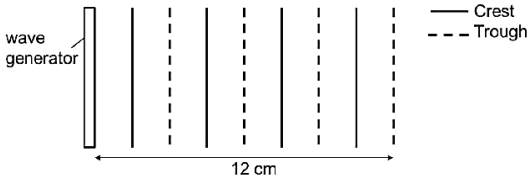


Which of the following quantities cannot be determined from the graph?

A. Frequency
B. Period
C. Wavelength
D. Amplitude

( )

9. A wave generator which makes 5 oscillations per second is used to produce waves in a ripple tank.

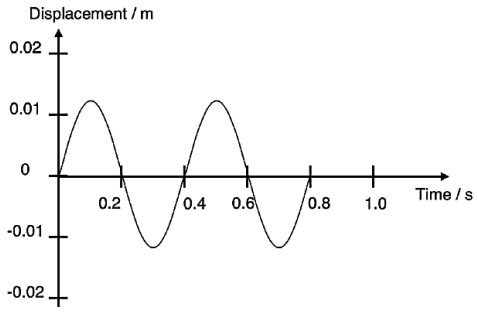


Which of these is correct for the waves produced?

	Frequency / Hz	Wavelength / m	Speed / m s^{-1}
A	0.5	12	6
B	5	3	15
C	0.2	3	0.6
D	5	12	240

( )

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



What is the number of complete wavelengths produced in one second?

A. 0.2 B. 0.4

C. 1.25 D. 2.5

( )

11. A radio station that broadcasts at a frequency of 90.5 MHz is known as 90.5 FM. Given that the speed of radio is waves is 3.00×10^2 Mm s^{-1}, what is the radio station that broadcasts radio waves with a wavelength of 3.33 m?

A. 90.0 Hz B. 90.1 Hz

C. 90.0 MHz D. 90.1 MHz

( )

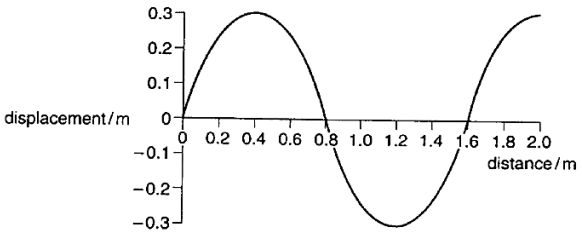
12. A source of disturbance produces waves at a frequency of 50 Hz. What is the time taken to complete 2 wavelengths?

A. 0.02 s B. 0.04 s

C. 25 s D. 50 s

( )

13. 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.



What is the distance travelled by one particle in one complete oscillation?

A. 0.30 m
B. 0.60 m
C. 1.20 m
D. 1.60 m

( )

14. Initially, a water wave has a frequency of 2 Hz and a wavelength of 10 cm. If the depth of the water increases over time, what could be a possible speed after 5 seconds?

A. 25 cm/s
B. 20 cm/s
C. 5.0 cm/s
D. 0.20 cm/s

( )

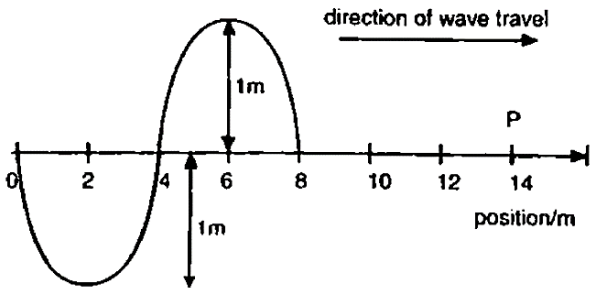
15. What would happen to the wavelength of a wave when the period is increased?

Assume that the wave is in the same medium.

A. Remain the same
B. Increase
C. Decrease
D. Increase then decrease

( )

16. The graph represents a wave pulse travelling along a rope at 2 m s^{-1} in the direction shown by the arrow.



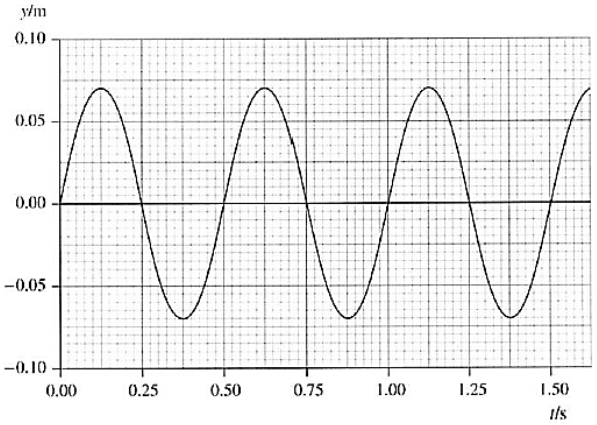
From the moment shown, what is the shortest time before point P on the rope has a displacement of 1.0 m?

A. 2.0 s
B. 4.0 s
C. 6.0 s
D. 8.0 s

( )

Structured Questions

1. The diagram below shows the displacement-time graph of a wave. The speed of the wave is 11 m s^{-1}.



(a) State the period T of the wave.

_____

(b) State the amplitude A of the wave.

_____

(c) Calculate the wavelength of the wave.

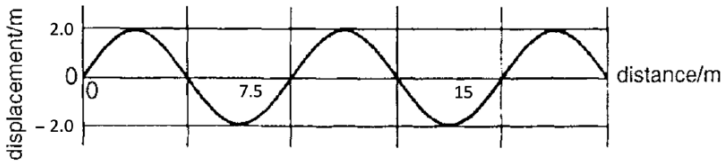
_____

(d) Sketch the displacement-distance graph of the wave in the space provided below.

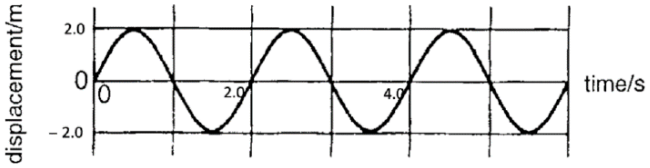
_____

_____

2. The graph below shows the variation of the displacement of a wave along the wave at a particular time.



The graph below shows the variation of the displacement of a particular point in the same wave with time.



(a) Calculate the frequency of the wave.

_____

(b) State the distance travelled by a particle of the wave in 2.0 s.

_____

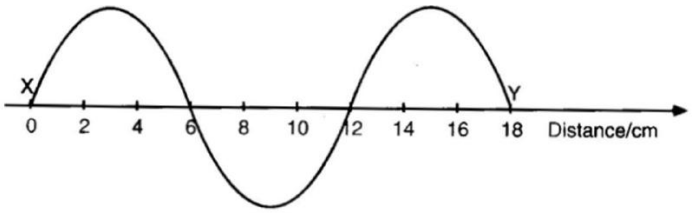
(c) Calculate the speed of the wave.

_____

(d) Hence, state the speed of the wave if the frequency of the wave is doubled.

_____

3. The figure below shows the variation of the displacement of a wave with distance along the wave at a particular time.



If the time taken for the wave to move from X to Y is 0.30 s, determine the

(a) wavelength,

_____

(b) velocity, and

_____

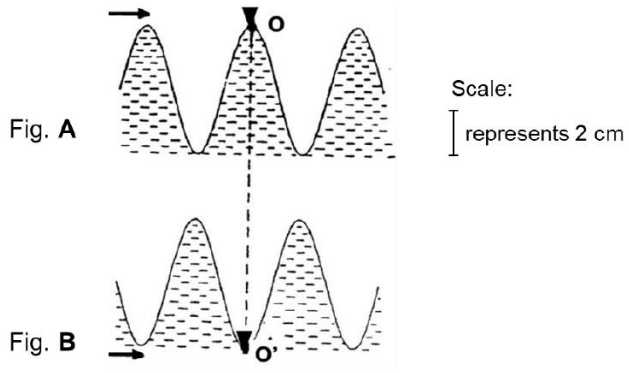
(c) period of the wave

_____

(d) Draw, on the figure above, the wave after 0.25 s.

_____

4. Fig. A and Fig. B represent the scaled diagrams of the cross-section of water waves produced by a plane wave vibrator in a ripple tank. A small fishing boat float is floating on the water surface at O in Fig. A. It is shown, 0.1 s later, in position O' in Fig. B.



(a) State the type of wave and estimate the amplitude of the wave.

_____

(b) Calculate the frequency of the plane wave vibrator.

_____

(c) If the waves travel across the water at 20 cm/s, what is its wavelength?

_____

(d) If the water becomes shallower, how will the speed and wavelength of the wave change? Explain your answer.

_____
_____
_____

(e) Would the float rise to O again? Explain your answer.

_____
_____

5. Fig. A below shows a sectional view of a beach. Two boats are located at positions P and Q as shown, where PQ = 20 m. Straight water waves travel towards the beach. The waves take 4.0 s to travel from P to Q.

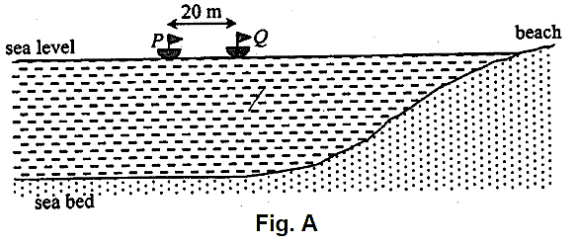


Fig. A

(a) Find the average speed of the waves between P and Q.

_____

(b) Fig. B below shows the view of the beach from above. On Fig. B, draw the wave pattern observed when the waves travel towards the beach.

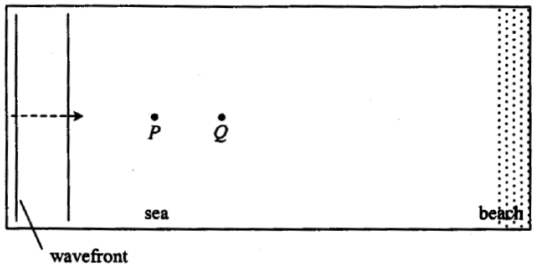


Fig. B

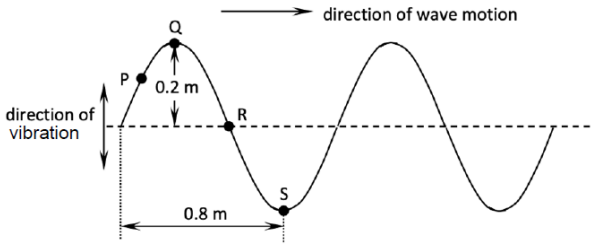
_____

_____

_____

_____

6. The figure below shows the water waves produced by a vibrator. The frequency of the vibrator is 2 Hz.



(a) State the kind of wave motion produced.

_____

(b) With reference to your answer in (a), explain what a wave motion is.

_____

_____

_____

(c) Find the period and speed of the wave.

_____

_____

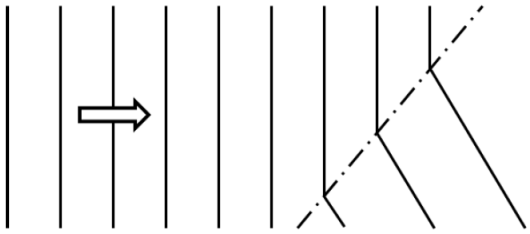
(d) Which of the particles, P, Q, R and S, is / are moving upwards?

_____

(e) On the figure, sketch the waveform after 0.125 s.

(f) In the space provided below, sketch the displacement-time graph of particle Q during a time interval of 0.25 s starting from the instant shown in the figure above.

7. The real size diagram below shows some straight water wavefronts entering a region with a different depth of water.



(a) Explain what is a wavefront.

_____

_____

(b) From the diagram, determine the wavelength of the water wave before it enters the second region.

_____

(c) Is the second region of water deeper or shallower than the first region?

_____

_____

(d) Describe the changes in the frequency and speed, if any, for the water wave entering the second region.

_____

8. A rope was attached to the wall at one end. A student wants to illustrate a transverse wave by moving the rope up-and-down consistently. The frequency of the waves produced in the rope is 10 Hz.

(a) Explain briefly the meaning of 10 Hz.

_____

(b) What is a transverse wave?

_____

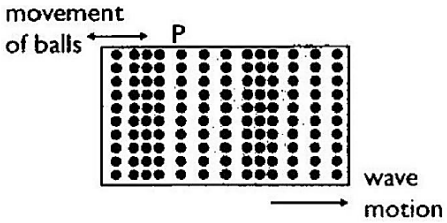
_____

(c) After some time, the student feels the rope 'tugging' at him. Suggest what has happened.

_____

_____

9. An unknown energy source causes the disturbance amongst the balls in a container as shown. The container is in the upright position.



(a)(i) Based on the observation, state the type of wave produced.

_____

(ii) Give the reason for your answer in (a)(i).

_____

_____

(b) If P is the starting point of a wavelength, mark the position on the diagram with a letter Q to show the complete wavelength of PQ.

(c) Give an example of this type of wave.

_____