2026 Sec 4 Physics Notes Answers
Chapter 12 General Properties of Waves

1.3 Waves in a ripple tank

Example 1

- Answer: A

2 Wave terms

- distance, crests, troughs
- time
- magnitude, maximum
- distance, per unit time
- number
- line

2.1 Wave equation

- m s^{-1}

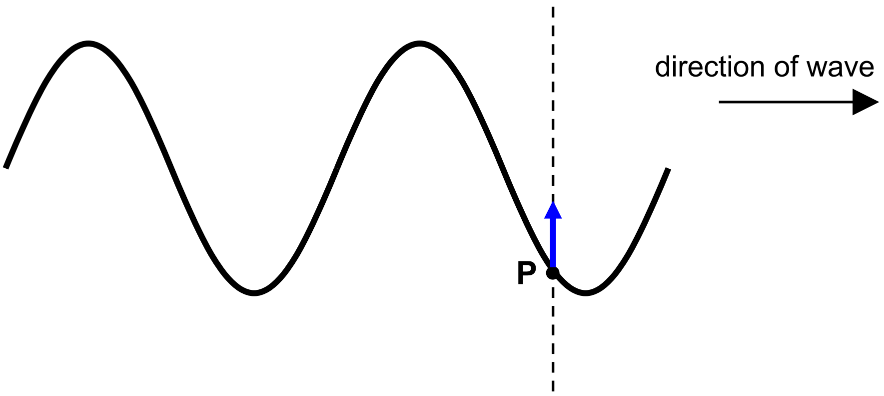
Example 2

(a) $v = f\lambda$
$= (6.0)(0.500)$
$= 3.0$ m s^{-1}

(b) $\lambda = v / f$
$= (3.0) / (2.5)$
$= 1.2$ m

2.2 Motion of waves and particles

Example 3



Also see video at http://www.showme.com/sh/?h=EyApfHs

3 Longitudinal and transverse waves

3.1 Longitudinal waves

- parallel
- Explore the properties of longitudinal waves and corresponding graphs using the simulation at *http://ngsir.netfirms.com/englishhtm/Lwave.htm*

3.2 Transverse waves

- perpendicular
- Explore the properties of transverse waves and corresponding graphs using the simulation at *http://ngsir.netfirms.com/englishhtm/TwaveA.htm*

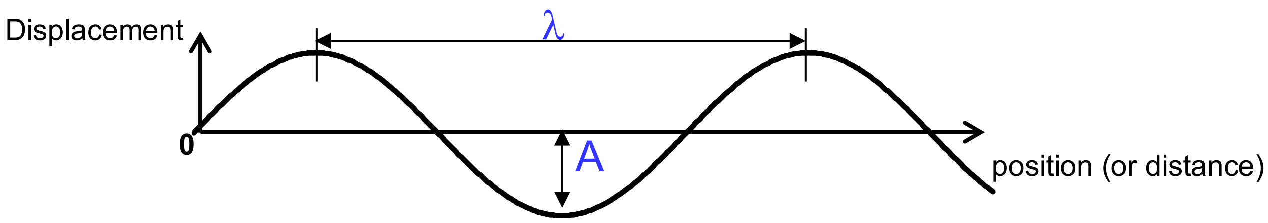
Note: The above simulations are Java applets and may not run on iPads

3.3 Classification of waves

- **Mechanical waves**: medium
- **Electromagnetic waves**: vacuum

3.4 Displacement-position graph

- On the graph below, label clearly the amplitude A and wavelength λ.



Example 4

(a) Based on the displacement-position graph above, is it possible to determine whether it is for a transverse wave or a longitudinal wave? Explain your answer.

No, displacement-position graph is just a representation of the displacement of the particles with their position as the waves pass through them.

(b) What is the direction of motion of the particles in the displacement-position graph for

(i) longitudinal waves?

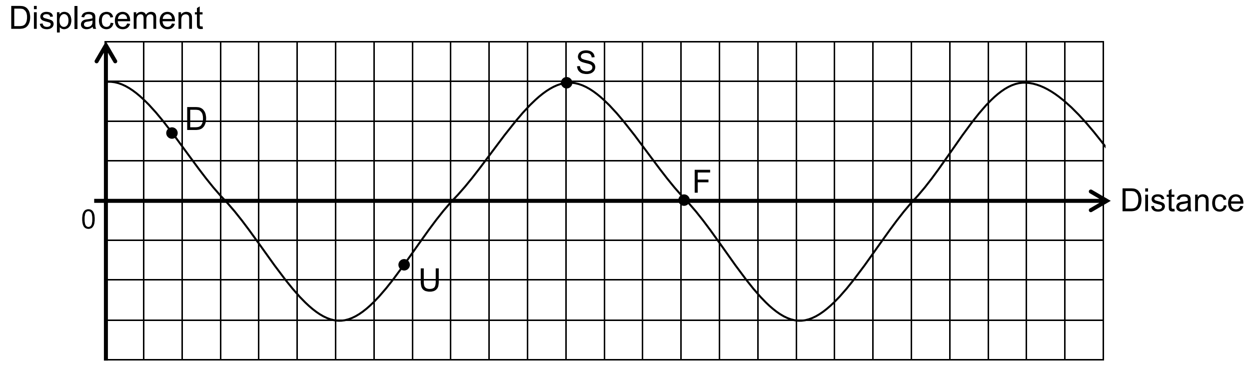
Direction of motion of particles is parallel to the direction of the wave.

(ii) transverse waves?

Direction of motion of particles is perpendicular to the direction of the wave.

Example 5
(a) 5.0 cm
(b) 20.0 cm

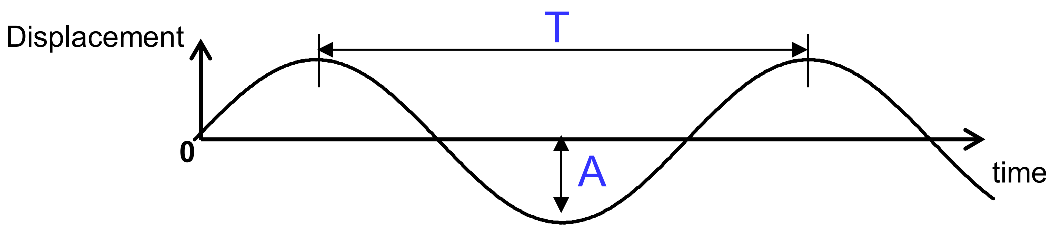
Example 6



Accept other reasonable answers

3.5 Displacement-time graph

- On the graph below, label clearly the amplitude A and period T.



Example 7

(a) longitudinal waves?

Direction of motion of particles is parallel to the direction of the wave.

(b) transverse waves?

Direction of motion of particles is perpendicular to the direction of the wave.

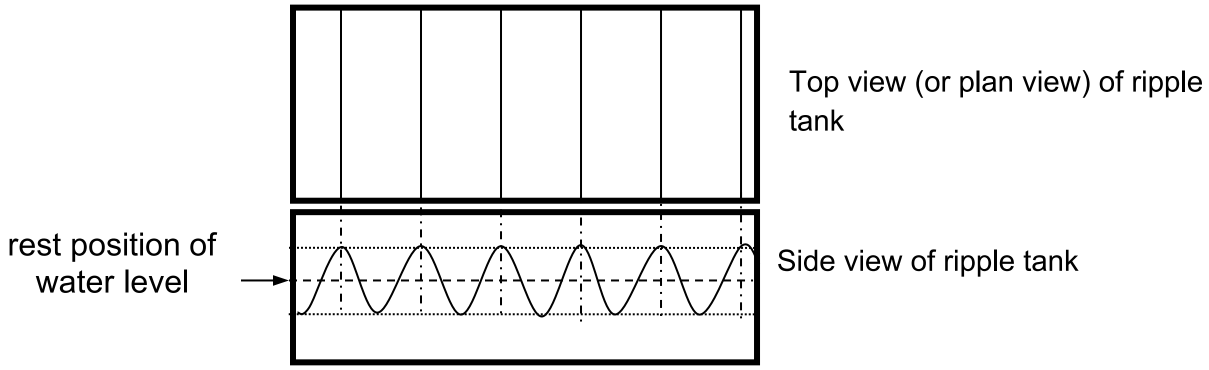
How do the answers above compare to that of the displacement-position graph?

- Same answers

Example 8
(i) True (ii) False (iii) True (iv) True

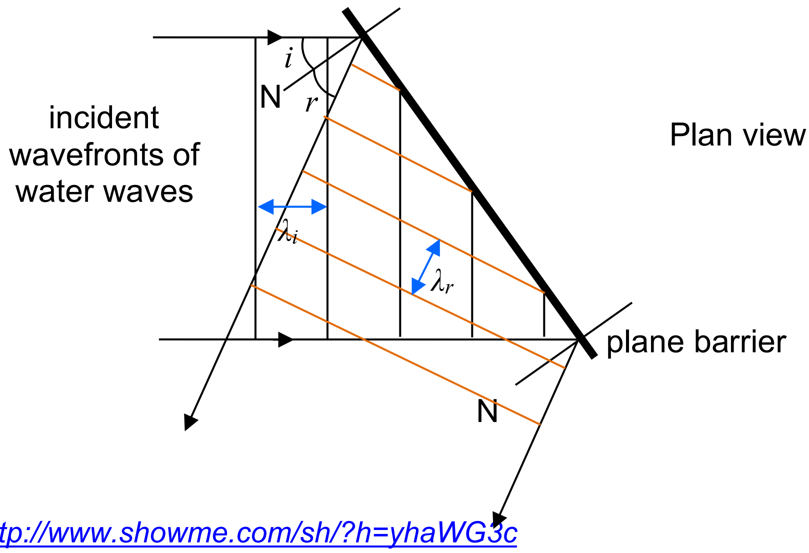
4 Reflection and refraction of plane waves

4.1 Reflection of plane wavefronts



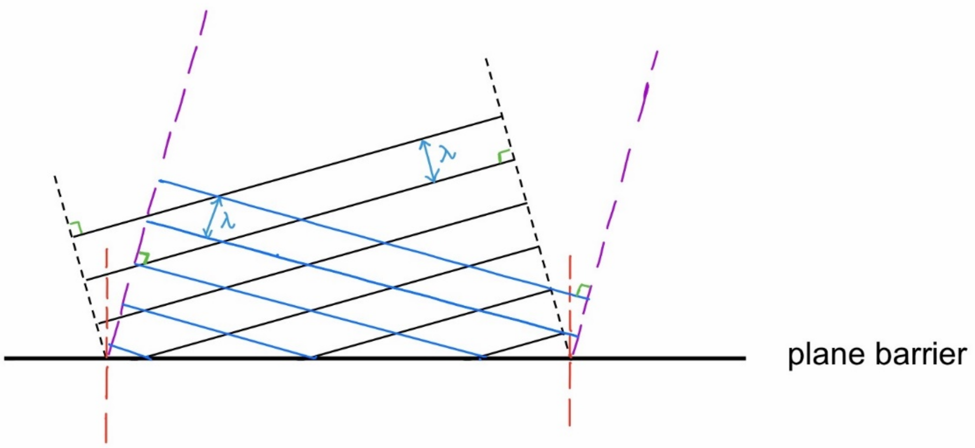
Also see video at http://www.showme.com/sh/?h=oqBa49o

- **Reflected plane wavefronts**



Also see video at http://www.showme.com/sh/?h=yhaWG3c

Additional example



angle of incidence = ...16° ± 1°...; angle of reflection = ...16° ± 1°...

4.2 Refraction of plane wavefronts

	Visible Light	Water Waves	Visible Light	Water Waves
Medium	air → glass (increase in refractive index)	deep → shallow (decrease in depth of water)	glass → air	shallow → deep
change in direction of waves (bending)	towards the normal	towards the normal	away from the normal	away from the normal
W[''ave speed v	decreases	decreases	increases	increases
frequency f	constant	constant	constant	constant
wavelength λ	decreases	decreases	increases	increases

Refracted plane wavefronts

Example 9: C

Also see video at *http://www.showme.com/sh/?h=QeedBrs*

Example 10

(a) 52°

(b) 20°

(c) 1.3 cm

(d) 0.6 cm

(e) 2.2

Discussion

1. True or false? Justify your answer.

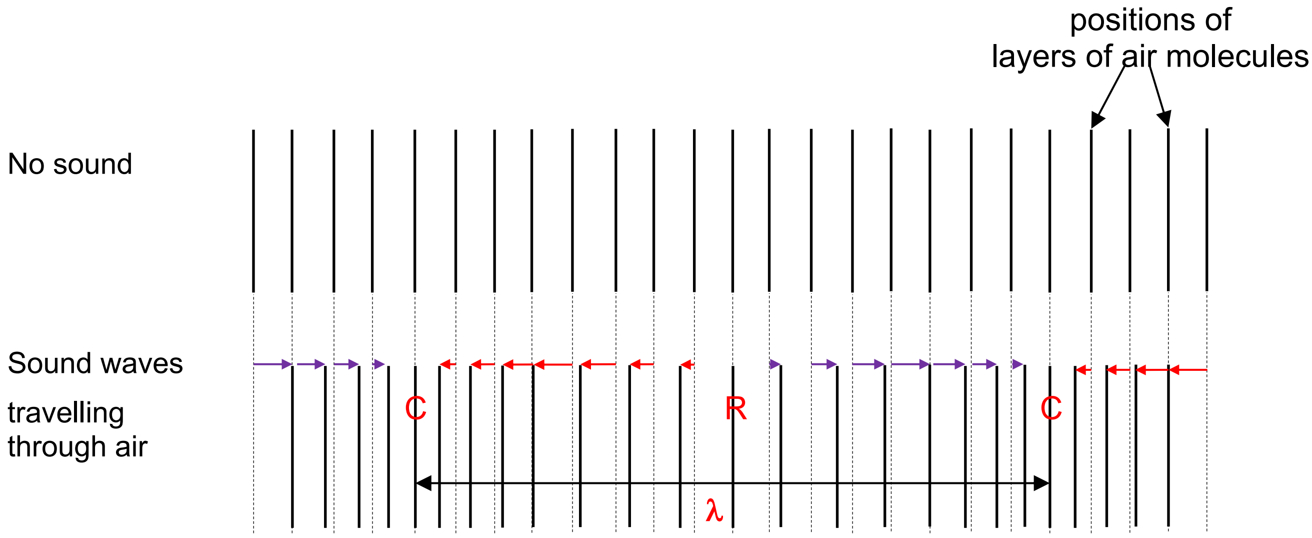
(a) False: $v = f \times \lambda$

(b) False: A slinky spring can be used to produce both transverse & longitudinal waves

6 Sound waves

6.1 Production and transmission of sound waves

- vibration
- longitudinal
- medium, mechanical
- The diagram below shows the positions of layers of air molecules before and after sound waves travel through them from the left towards the right.

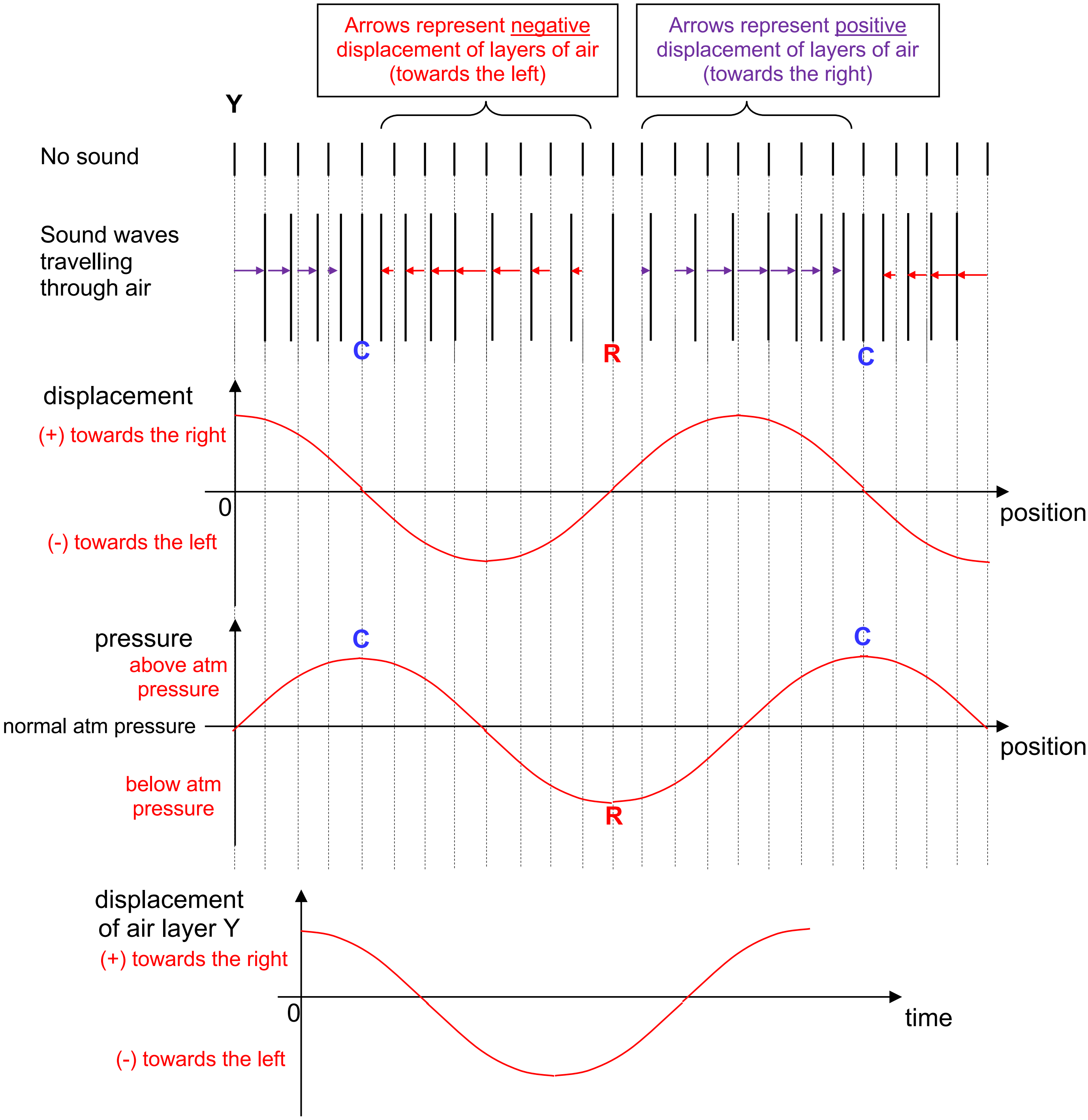


- pressure.
- higher, compression
- lower, rarefaction

Example 11
On the diagram above showing sound waves travelling through air, mark & label
(a) the middle of compressions (with letter "C") and the middle of rarefactions (with letter "R");
(b) a wavelength λ between 2 Cs and between 2 Rs.

6.2 Properties of sound waves

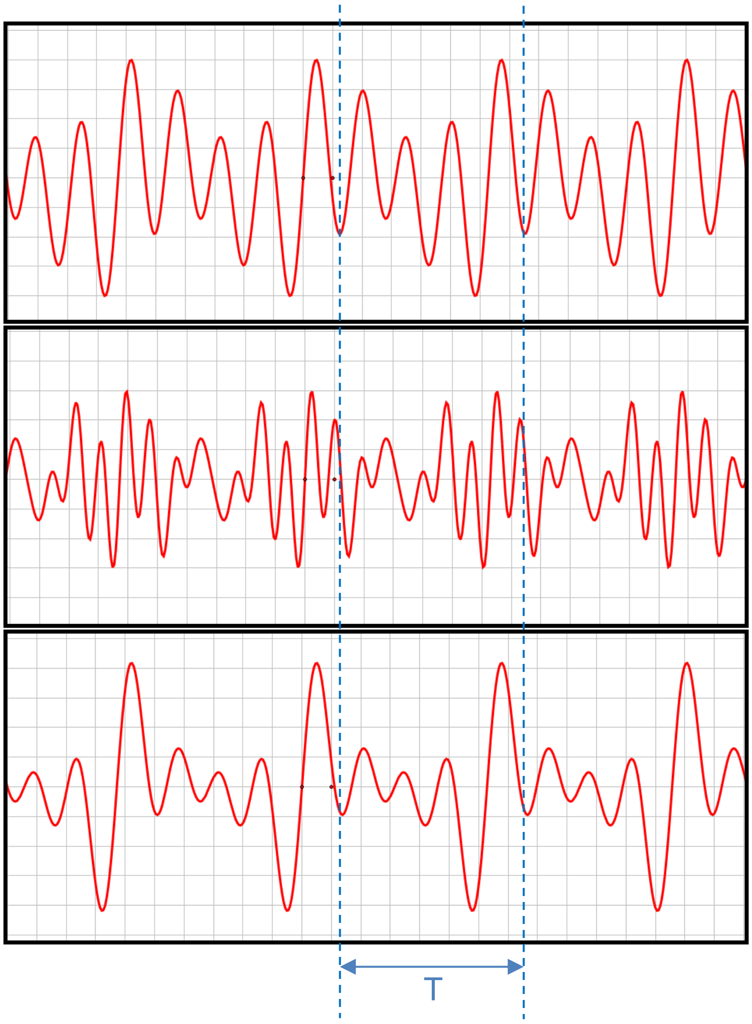
Example 12
Hence, sketch the corresponding
(a) displacement-position graph,
(b) pressure-position graph, and
(c) displacement-time graph of a layer of air, **Y**, starting from the position shown in the diagram.



Example 13

λ = 90 cm / 3 = 30 cm = 0.30 m
Speed v = $f \times \lambda$ ➔ f = v / λ = 330 m s^{-1} / 0.30 m = 1100 Hz

- amplitude, energy
- frequency.
- quality



Example 4
Draw and label the period T on the diagrams above.

7 Speed of sound

- medium

	[Enrichment] *Direct method*	Indirect method	Indirect method
Method	• *Observer A fires a starting pistol.* • *Observer B (at least 200 m away) starts a stopwatch on seeing the flash of the gun and stops the stopwatch on hearing the sound*	• Observer A faces a high smooth wall at least 100 m away and claps regularly to coincide with **echoes**. • Observer B times 50 claps.	• Place a microphone at one end of a long hollow tube and a smooth flat surface at the other end. • Connect the microphone (sound sensor) to a laptop (installed with Addestation software with "Scope" simulator). • Snap your finger next to microphone, and click to capture the image of sound and its echo.
Physical quantities to measure	*1. distance (d) between A and B* *2. time (t) between seeing the flash and hearing the sound*	1. perpendicular distance (d) between A and the wall 2. time (t) between 0^{th} clap and the 15^{th} clap (time interval of 15 claps)	1. distance (d) between microphone and smooth surface = length of tube 2. time (t) between snap sound (incident pulse) and its echo (reflected pulse) - (between 2 peaks on the C.R.O. display)
Formula to use	*Speed =* $\frac{d}{t}$	Speed = $\frac{2d}{(t / 15)}$ d = 100 m	Speed = $\frac{2d}{t}$
Possible sources of error	*1. Wind* *2. Human reaction time (in starting & stopping stopwatch)*	1. Wind 2. Human reaction time (in starting & stopping stopwatch)	1. Error in locating exact positions of the microphone and where the snap sound is produced 2. Noise from surrounding

Example 15

Taking speed of sound, v =330 ms^{-1}
Using v = 2d / t ➔ d = vt / 2 = (330 ms^{-1} x 4.0 s) / 2 = 660 m

Example 16

t = 8 × 10 ms = 80 ms = 0.080 s
v = 2d / t ➔ d = vt / 2 = (300 ms^{-1} × 0.080 s) / 2 = 12 m

8 Ultrasound

- 20 kHz, 20 Hz
- time

<table>
<tr><th>Common applications of ultrasound</th><th>*Description of how ultrasound is used</th></tr>
<tr><td>Sonar technologies
SONAR (Sound Navigation and Ranging):
To measure distances in air or water</td><td>Commercial fishing boats use sonar, which emits an ultrasound pulse into the water and listens for the reflected pulse. The reflected pulses may be reflected from a shoal of fish and the sea floor.
The strength of the reflected pulses will differ according to distance and characteristics of the reflecting objects. The reflected signals are processed by a computer and the location is shown on the screen.</td></tr>
<tr><td>For imaging internal organs
Medical application
To examine internal tissues, organs of a patient, development of unborn baby (foetus)</td><td>By detecting the strength, direction and timing of reflected pulses of ultrasound, a computer can process the data very quickly to generate an image of the internal organs.
Ultrasound is commonly used in prenatal scanning, where pulses of ultrasound are sent into the womb of a pregnant woman via a transmitter. A computer processes the data quickly to form an image of the unborn baby.</td></tr>
<tr><td>For breaking up kidney stones & cancer treatment
Medical application
Advantage: safe and non-invasive compared to surgery and other methods</td><td>When focused onto a kidney stone, high intensity vibrations of ultrasound can break the stone into smaller pieces so that they can be naturally expelled through urination.
High intensity focused ultrasound can also be used to kill cancer or tumour cells.</td></tr>
<tr><td>For quality control in manufacturing</td><td>Detector monitors the strength of the ultrasonic signals passing through a product. Flaws or inconsistency in the product will affect the strength of the signals.</td></tr>
</table>

Example 17: D

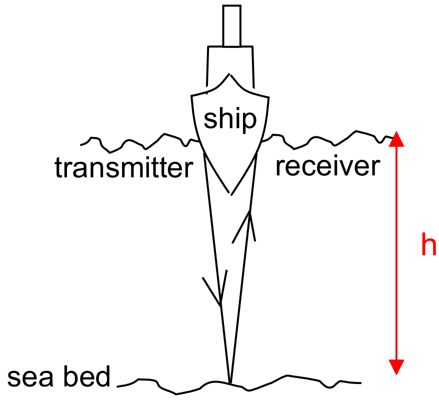
Exercises

1 $v = f \times \lambda$ ➔ $f = v / \lambda$ (λ in metres)

2 (a) $v = d / t$ ➔ $d = v \times t$

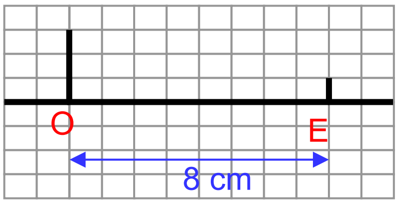
$d = 2h$

depth = 1500 m s^{-1} × 0.40 s = 600 m



(b)

(i)



oscilloscope display

(ii) Assume each division (square) has length of 1 cm

time t = length x time base

time base = t / length = 0.8 s / 8 cm = 0.1 s / cm