



2025 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}

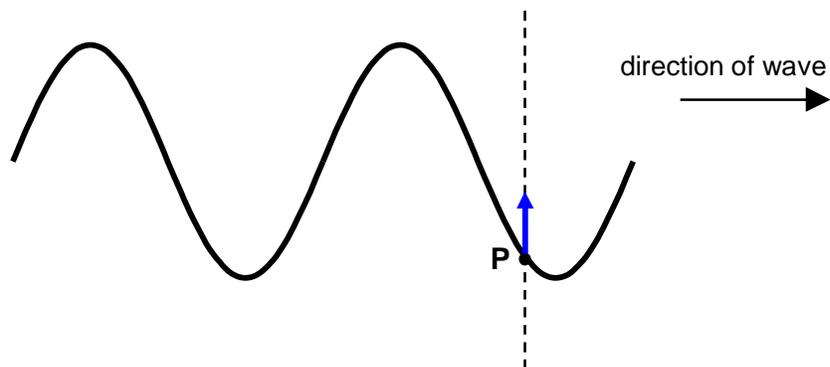
Example 2

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

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

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>

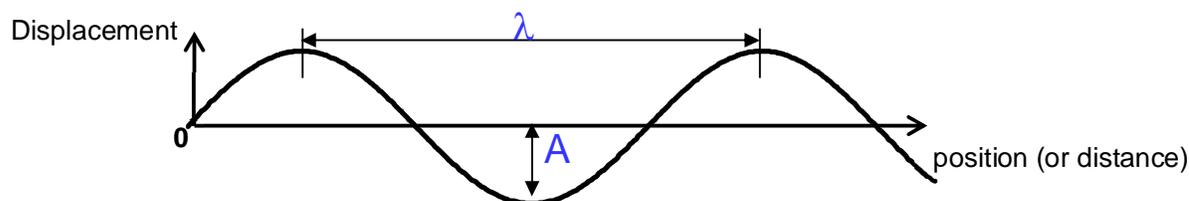
Note: The above simulations are Java applets and may not run on iPads

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?

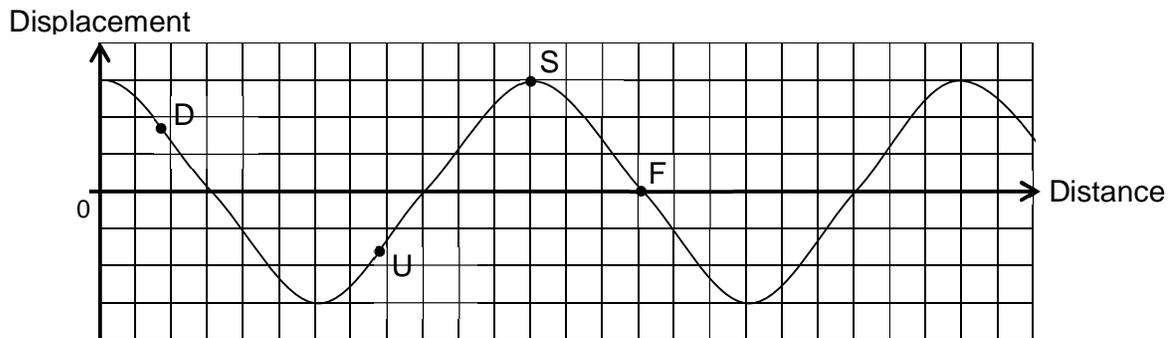
Direction of motion of particles is parallel to the direction of the wave.

- (ii) transverse waves?

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

Example 5

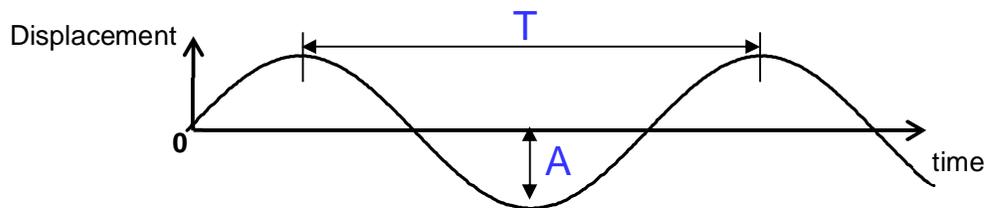
- (a) 5.0 cm
- (b) 20.0 cm

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.

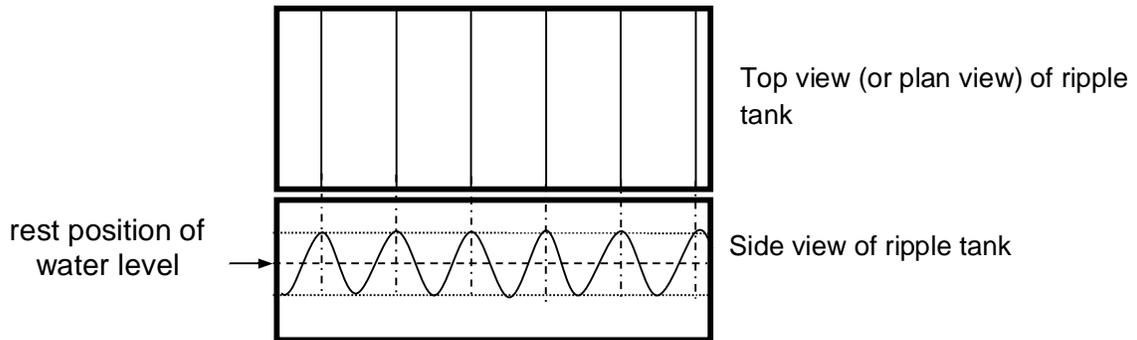
How do the answers above compare to that of the displacement-position graph?

- Same answers

Example 8

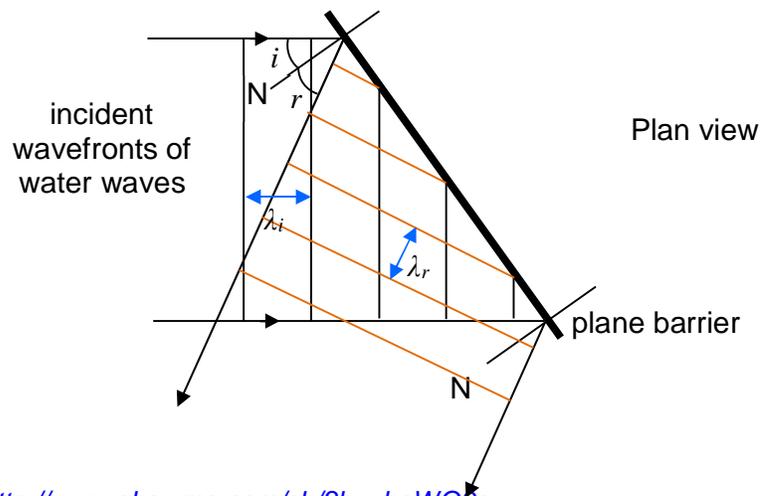
- (i) True
- (ii) False
- (iii) True
- (iv) True

4 Reflection and refraction of plane waves
4.1 Reflection of plane wavefronts



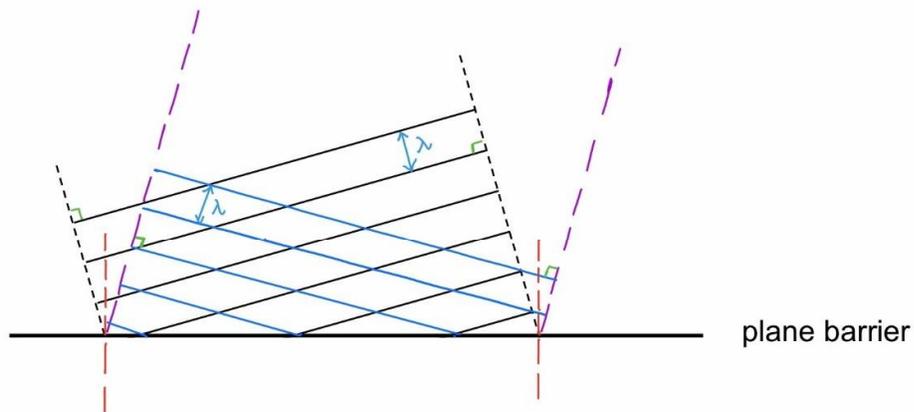
Also see video at <http://www.showme.com/sh/?h=oqBa49o>

- Reflected plane wavefronts**



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

Additional example



angle of incidence = $16^\circ \pm 1^\circ$; angle of reflection = $16^\circ \pm 1^\circ$

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
Wave 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

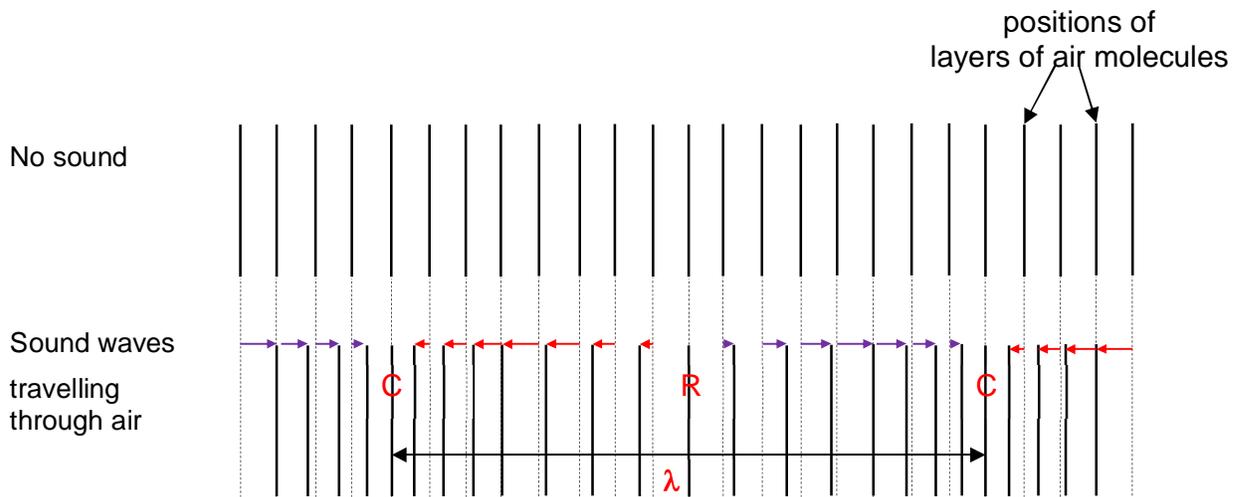
1. True or false? Justify your answer.

- (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

- the middle of compressions (with letter "C") and the middle of rarefactions (with letter "R");
- a wavelength λ between 2 Cs and between 2 Rs.

6.2 Properties of sound waves

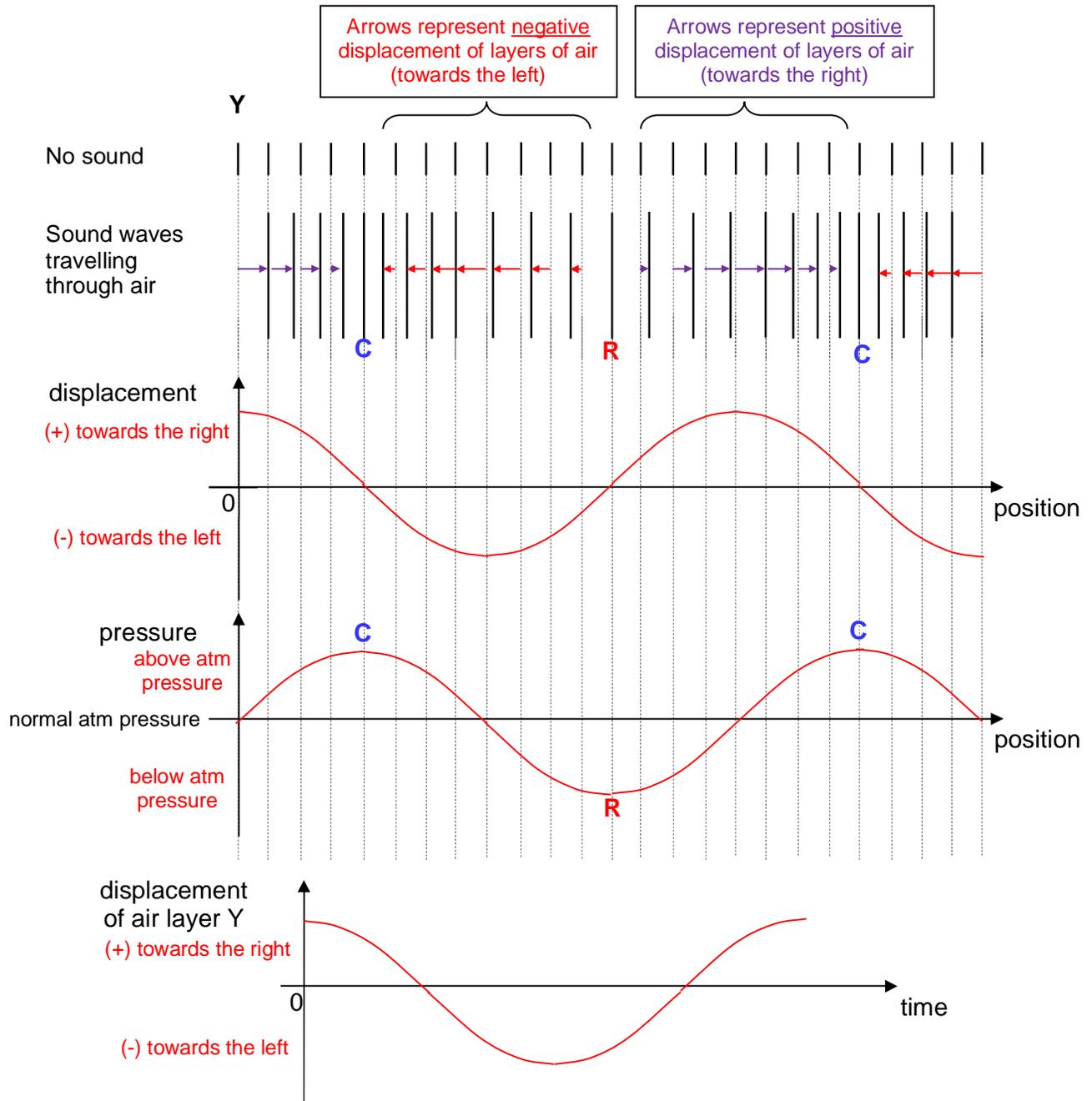
Example 12

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.

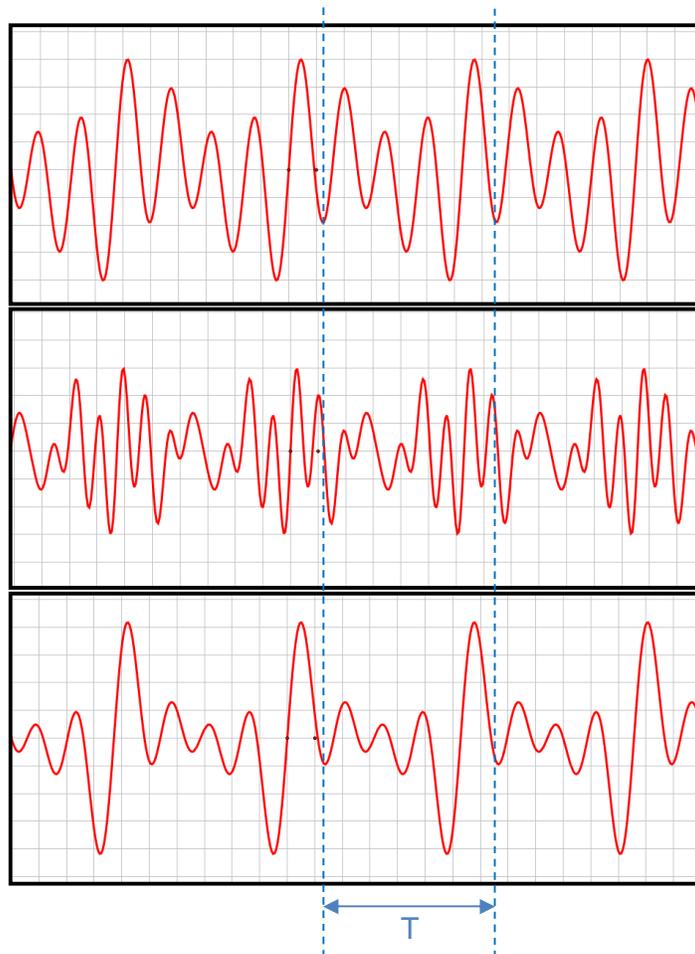


Example 13

$$\lambda = 90 \text{ cm} / 3 = 30 \text{ cm} = 0.30 \text{ m}$$

$$\text{Speed } v = f \times \lambda \quad \rightarrow \quad f = v / \lambda = 330 \text{ m s}^{-1} / 0.30 \text{ m} = 1100 \text{ Hz}$$

- 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	<ul style="list-style-type: none"> • <i>Observer A fires a starting pistol.</i> • <i>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</i> 	<ul style="list-style-type: none"> • Observer A faces a high smooth wall at least 100 m away and claps regularly to coincide with echoes. • Observer B times 50 claps. 	<ul style="list-style-type: none"> • 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	<ol style="list-style-type: none"> 1. <i>distance (d) between A and B</i> 2. <i>time (t) between seeing the flash and hearing the sound</i> 	<ol style="list-style-type: none"> 1. perpendicular distance (d) between A and the wall 2. time (t) between 0th clap and the 15th clap (time interval of 15 claps) 	<ol style="list-style-type: none"> 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	$Speed = \frac{d}{t}$	$Speed = \frac{2d}{(t / 15)}$ $d = 100 \text{ m}$	$Speed = \frac{2d}{t}$
Possible sources of error	<ol style="list-style-type: none"> 1. <i>Wind</i> 2. <i>Human reaction time (in starting & stopping stopwatch)</i> 	<ol style="list-style-type: none"> 1. <i>Wind</i> 2. <i>Human reaction time (in starting & stopping stopwatch)</i> 	<ol style="list-style-type: none"> 1. <i>Error in locating exact positions of the microphone and where the snap sound is produced</i> 2. <i>Noise from surrounding</i>

Example 15

Taking speed of sound, $v = 330 \text{ ms}^{-1}$

Using $v = 2d / t \quad \rightarrow \quad d = vt / 2 = (330 \text{ ms}^{-1} \times 4.0 \text{ s}) / 2 = 660 \text{ m}$

Example 16

$t = 8 \times 10 \text{ ms} = 80 \text{ ms} = 0.080 \text{ s}$

$v = 2d / t \quad \rightarrow \quad d = vt / 2 = (300 \text{ ms}^{-1} \times 0.080 \text{ s}) / 2 = 12 \text{ m}$

8 Ultrasound

- 20 kHz, 20 Hz
- time

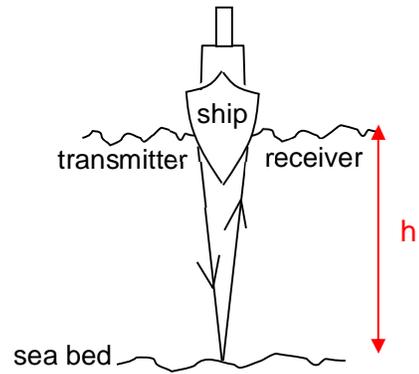
Common applications of ultrasound	*Description of how ultrasound is used
<p>Sonar technologies</p> <ul style="list-style-type: none"> • SONAR (Sound Navigation and Ranging): • To measure distances in air or water 	<ul style="list-style-type: none"> • Commercial fishing boats use sonar, which emits an 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.
<p>For imaging internal organs</p> <ul style="list-style-type: none"> • Medical application • To examine internal tissues, organs of a patient, development of unborn baby (foetus) 	<ul style="list-style-type: none"> • 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.
<p>For breaking up kidney stones & cancer treatment</p> <ul style="list-style-type: none"> • Medical application • Advantage: safe and non-invasive compared to surgery and other methods 	<ul style="list-style-type: none"> • 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.
<p>For quality control in manufacturing</p>	<ul style="list-style-type: none"> • 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.

Example 17: D

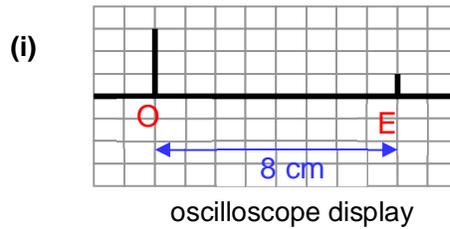
Exercises

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

2 (a) $v = d / t \rightarrow d = v \times t$
 $d = 2 h$
 $\text{depth} = 1500 \text{ m s}^{-1} \times 0.40 \text{ s} = 600 \text{ m}$



(b)



(ii) Assume each division (square) has length of 1 cm
 $\text{time } t = \text{length} \times \text{time base}$
 $\text{time base} = t / \text{length} = 0.8 \text{ s} / 8 \text{ cm} = 0.1 \text{ s / cm}$