

1

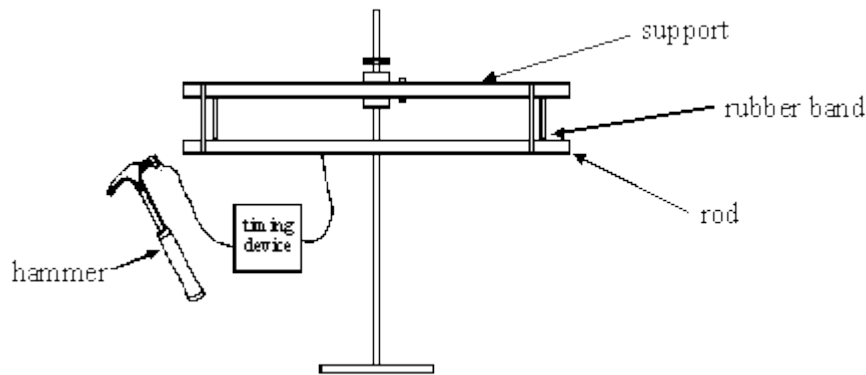
Two points on a progressive wave are one-eighth of a wavelength apart. The distance between them is 0.5 m, and the frequency of the oscillation is 10 Hz. What is the minimum speed of the wave?

- A** 0.2 m s⁻¹ ☐
- B** 10 m s⁻¹ ☐
- C** 20 m s⁻¹ ☐
- D** 40 m s⁻¹ ☐

(Total 1 mark)

2

The diagram below shows a hammer being struck against the end of a horizontal metal rod. A pulse of sound travels along the rod from where the hammer strikes it to the far end and back again. The sound pulse throws the hammer and rod apart when it returns. An electrical timing device measures the time for which the hammer and the rod are in contact.



- (a) Circle the word below that describes the type of wave that travels along the rod.

transverse

longitudinal

(1)

- (b) State the name of the effect that causes the sound pulse to return to the hammer.

(1)

- (c) The rod is 0.45 m long and the time for which the hammer is in contact with the rod is 1.6×10^{-4} s. Calculate the speed of sound in the rod.

Speed of sound _____

(3)

(Total 5 marks)

3

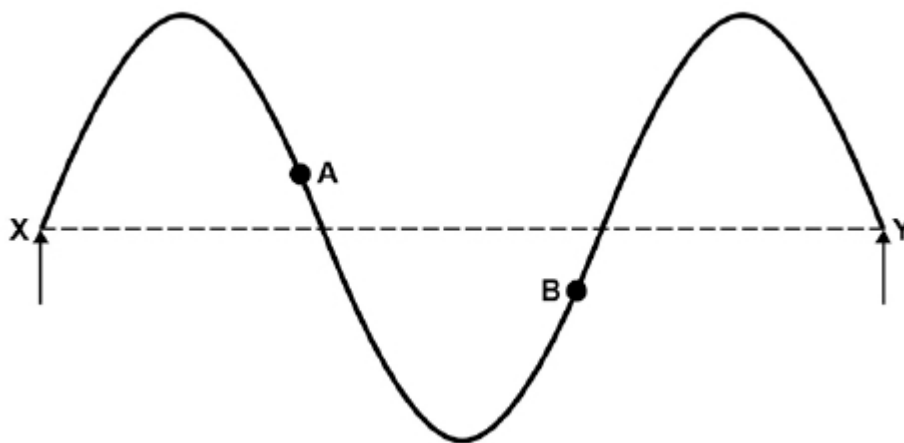
The audible range of a girl's hearing is 30 Hz to 16 500 Hz. If the speed of sound in air is 330 m s^{-1} , what is the shortest wavelength of sound in air which the girl can hear?

- A $\frac{30}{330} \text{ m}$
- B $\frac{16500}{330} \text{ m}$
- C $\frac{330}{16500} \text{ m}$
- D $\frac{330}{30} \text{ m}$

(Total 1 mark)

4

The diagram below shows one position of a guitar string stretched between points X and Y. The string vibrates at a frequency of 330 Hz.



- (a) State the phase relationship between points A and B on the string.

(1)

- (b) Points **X** and **Y** are 0.66 m apart.

Calculate the speed of the wave along the string.

speed = _____ m s⁻¹

(2)

- (c) The total mass of the string is 3.1 g and the total length of the string is 0.91 m.

Show that the tension in the string when it is sounding the harmonic shown in the diagram above is about 70 N.

(3)

- (d) The string is fixed at one end and wrapped around a tuning peg of radius 3.0 mm at the other. The tuning peg needs to be turned through 3 complete rotations to increase the tension in the string from 0 to 70 N in part **(c)**.

Discuss, by estimating the energy stored in the string, whether there is a significant risk to the guitar player when the string breaks.

(3)

(Total 9 marks)

5

The speed of sound in water is 1500 m s^{-1} . For a sound wave in water having frequency 2500 Hz, what is the minimum distance between two points at which the vibrations are $\frac{\pi}{3}$ rad out of phase?

- A 0.05 m
- B 0.10 m
- C 0.15 m
- D 0.20 m

(Total 1 mark)

6

A wave motion has period T , frequency f , wavelength λ and speed v . Which one of the following equations is **incorrect**?

- A $1 = Tf$
- B $T = \frac{v}{\lambda}$
- C $\lambda = \frac{v}{f}$
- D $Tv = \lambda$

(Total 1 mark)

7

A progressive wave in a stretched string has a speed of 20 m s^{-1} and a frequency of 100 Hz. What is the phase difference between two points 25 mm apart?

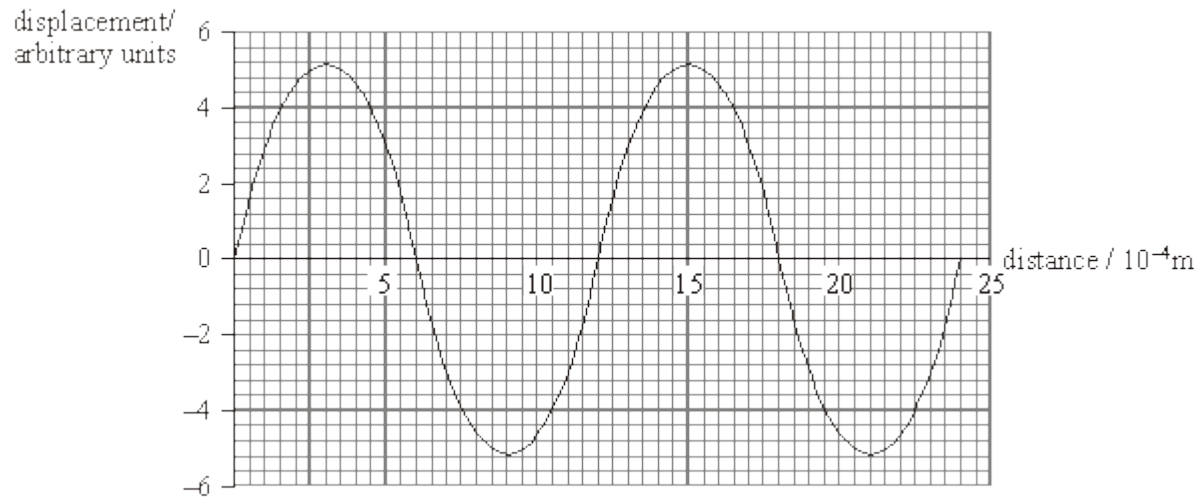
- A zero
- B $\frac{\pi}{4}$ rad
- C $\frac{\pi}{2}$ rad
- D π rad

(Total 1 mark)

8

Figure 1 shows the displacement of particles in an ultrasound wave at different distances from the source at a particular time. The wave travels at 3200 m s^{-1} .

Figure 1



- (a) (i) Use the graph to find the wavelength of the wave in **Figure 1**.

wavelength _____

- (ii) Calculate the frequency of the ultrasound wave.

frequency _____

(3)

- (b) One industrial use for ultrasound waves is to detect flaws inside a metal block. **Figure 2a** shows the arrangement in which the waves are fired downwards in short pulses from a transmitter. **Figure 2b** shows the amplitudes of the initial pulse and the reflected signals recorded by the receiver. You may assume that there is no reflected pulse received from the upper surface of the block.

Figure 2a

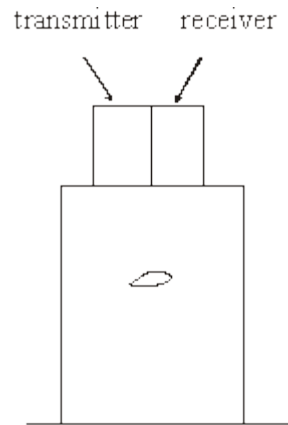
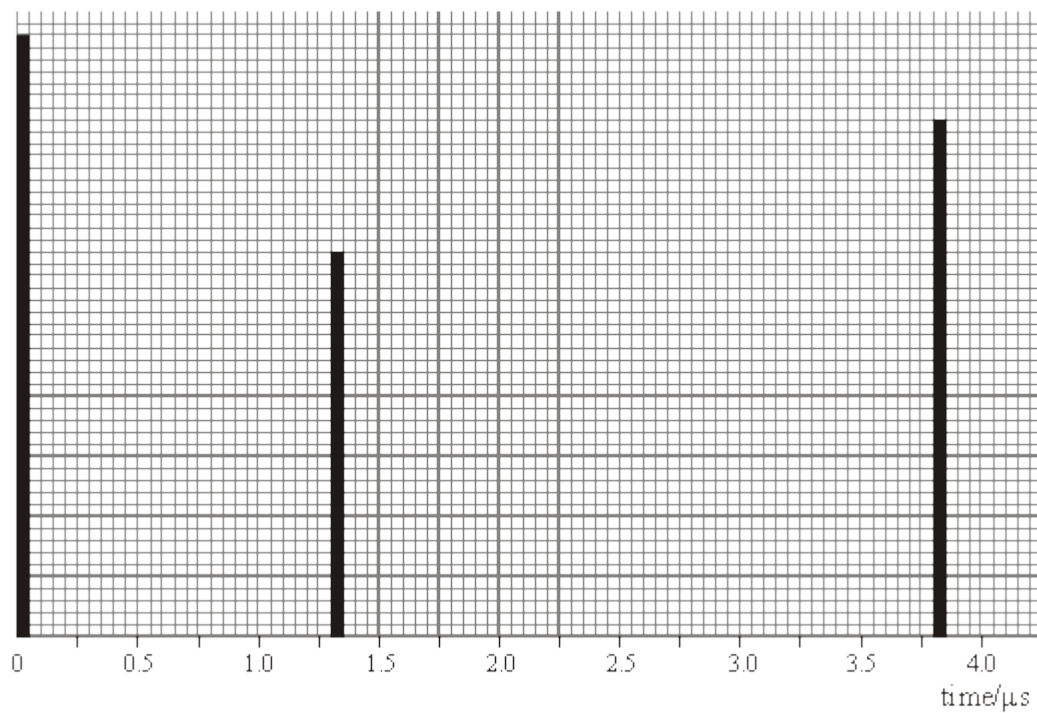


Figure 2b

amplitude/arbitrary units



The ultrasound wave travels at 3200 m s^{-1} . Use data from **Figure 2b** to calculate the distance of the flaw below the top of the block.

distance _____

(3)

(Total 6 marks)

9

Which of the following waves **cannot** be polarised?

A radio ☐

B ultrasonic ☐

C microwave ☐

D ultraviolet ☐

(Total 1 mark)

10

(a) Define the amplitude of a wave.

(1)

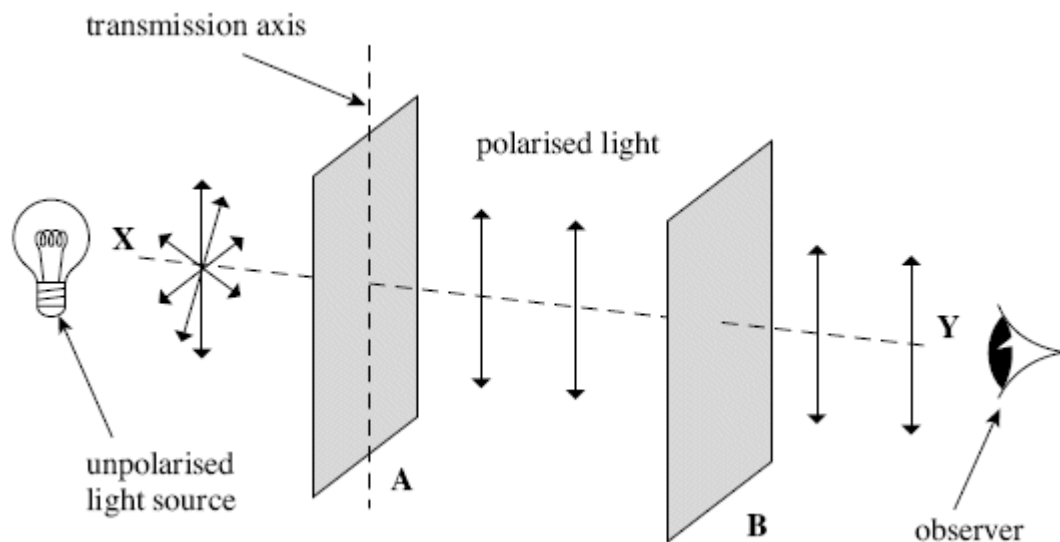
(b) (i) Other than electromagnetic radiation, give **one** example of a wave that is transverse.

(1)

(ii) State **one** difference between a transverse wave and a longitudinal wave.

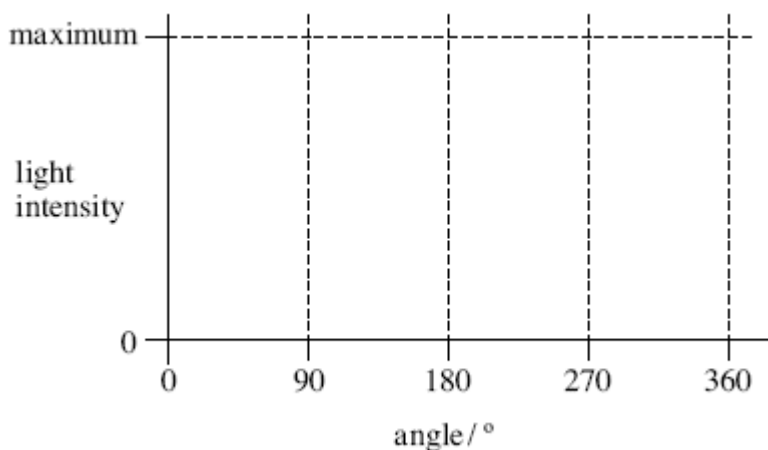
(1)

- (c) The figure below shows two identical polarising filters, **A** and **B**, and an unpolarised light source. The arrows indicate the plane in which the electric field of the wave oscillates.
- (i) If polarised light is reaching the observer, draw the direction of the transmission axis on filter **B** in the figure below.



(1)

- (ii) The polarising filter **B** is rotated clockwise through 360° about line **XY** from the position shown in the figure above. On the axes below, sketch how the light intensity reaching the observer varies as this is done.



(2)

- (d) State **one** application, other than in education, of a polarising filter and give a reason for its use.

(2)

11

Complete the first column in the table to show which of the waves listed are transverse and which are longitudinal.

Complete the second column to show which waves can be polarised.

type of wave	transverse or longitudinal	can be polarised (answer yes or no)
light		
microwaves		
ultrasound		

(Total 3 marks)

12

Which one of the following properties of light waves do polarising sunglasses depend on for their action?

Light waves may

- A interfere constructively.
- B interfere destructively.
- C be polarised when reflected from a surface.
- D be polarised by the lens in the eye.

(Total 1 mark)

13

(a) State the characteristic features of

(i) longitudinal waves,

(ii) transverse waves.

(3)

- (b) Daylight passes horizontally through a fixed polarising filter **P**. An observer views the light emerging through a second polarising filter **Q**, which may be rotated in a vertical plane about point **X** as shown in **Figure 1**.

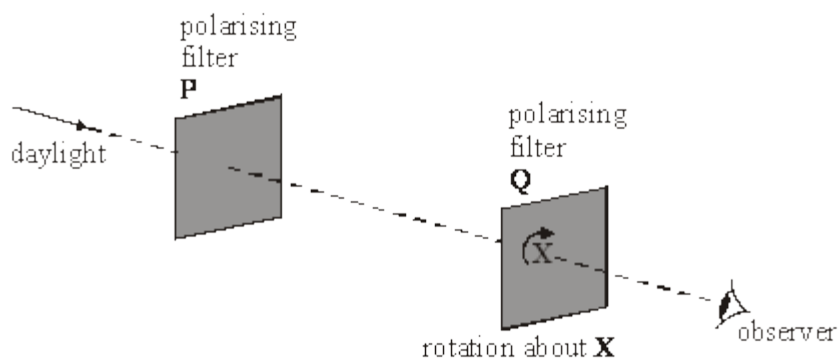


Figure 1

Describe what the observer would see as **Q** is rotated slowly through 360° .

You may be awarded marks for the quality of written communication provided in your answer.

(2)

(Total 5 marks)

14

Which one of the following types of wave **cannot** be polarised?

- A** radio
- B** ultraviolet
- C** microwave
- D** ultrasonic

(Total 1 mark)

15

Which one of the following types of wave **cannot** be polarised?

- A radio
- B ultrasonic
- C microwave
- D ultraviolet

(Total 1 mark)

16

Polarization is a property of one type of wave.

(a) Circle below the type of wave that can be polarized.

transverse

longitudinal

(1)

(b) Give **one** example of the type of wave that can be polarized.

(1)

(c) Explain why some waves can be polarized but others cannot. Space is provided for sketches should you wish to include them in your answer.

(3)

(Total 5 marks)

17

(a) (i) State the difference between a longitudinal wave and a transverse wave.

(2)

(ii) State an example of a transverse wave.

(1)

(iii) State an example of a longitudinal wave.

(1)

(b) Sound with a frequency of 560 Hz travels through steel with a speed of 4800 m s^{-1} . Calculate the wavelength of the sound wave.

(2)

(Total 6 marks)

18

Explain briefly how transmission of energy by a transverse wave differs from transmission by a longitudinal wave.

(Total 2 marks)

1	D		[1]
2	(a) longitudinal	B1	
	(b) reflection	B1	
	(c) use of speed = distance/time $\frac{(0.45 \text{ or } 0.9)}{1.6} \times 10^{-4}$ or $0.45 / 0.8 \times 10^{-4}$ = 5.6 km s ⁻¹ [5.625]	C1 A1	[5]
3	C		[1]
4	(a) π / 180° out of phase ✓ <i>Do not allow "out of phase".</i>		1
	(b) wavelength = 0.44 m ✓ <i>c (= f λ) = 145 (m s⁻¹) ✓</i>		2
	(c) First harmonic frequency = 110 Hz✓ $T = 4 \times 110^2 \times 0.66^2 \times \left(\frac{3.1 \times 10^{-8}}{0.91} \right)$ ✓ 71.8 N✓		3
	(d) Extension of string = 3 × 2π × 3.0 × 10 ⁻³ (= 5.65 cm)✓ energy stored = 0.5 × 71.8 × 0.0565 = 2.03 (J)✓ Compares calculated energy quantitatively to another energy and draws correct inference, e.g. wire would be moving at about 80 mph so a risk / 2 J is the equivalent of 1 kg mass dropped through 0.2 m so a risk✓		

5	B				[1]
6	B				[1]
7	B				[1]
8	(a) (i) wavelength read-off = 1.2 mm	B1			
	(ii) $3200/1.2 \times 10^{-3}$ ecf from (a) (i)	C1	3		
	2.7 MHz	A1			
	(b) read-off correct 1.3 μs	C1			
	factor of two correct	C1	3		
	$= 2.1 \times 10^{-3} \text{ m}$ [2.08] c.a.o.	A1			[6]
9	B				[1]
10	(a) maximum displacement from equilibrium/mean position/mid-point/etc (1)		1		
	(b) (i) any one from: surface of water/water waves/in ripple tank (1) rope (1) slinky clearly qualified as transverse (1) secondary ('s') waves (1)				

(ii) transverse wave: oscillation (of medium) is perpendicular to wave travel

or transverse can be polarised

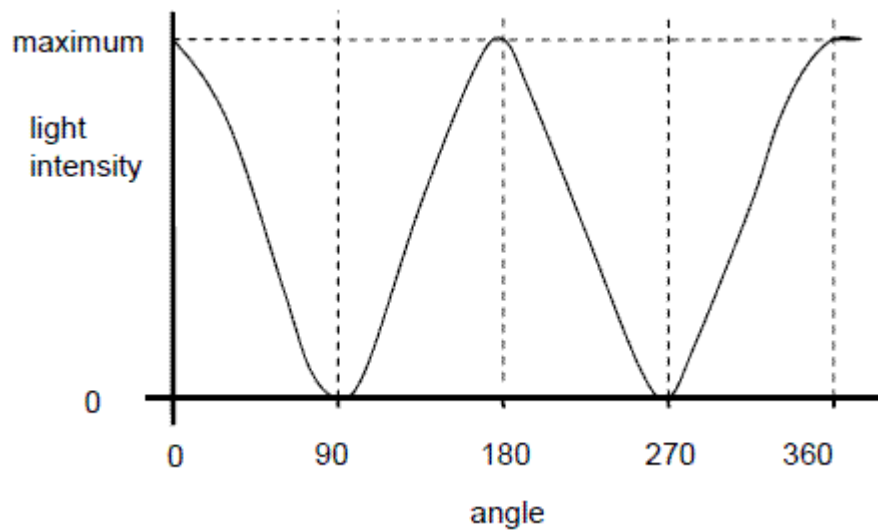
or **all** longitudinal require a medium **(1)**

1

(c) (i) vertical line on $B \pm 5^\circ$ **(1)**

1

(ii)



max 0, 180, 360 + min 90, 270 **(1)**

and line reaches same minimum and maximum every time and reasonable shape **(1)**

2

(d) appropriate use **(1)**

reason for Polaroid filter being used **(1)**

eg

Polaroid glasses/sunglasses/ to reduce glare
windscreens

camera reduce glare/enhance image

(in a) microscope to identify minerals/rocks

polarimeter to analyse chemicals/concentration
or type of sugar

stress analysis reveals areas of high/low stress/
other relevant detail

LCD displays very low power/other relevant
detail

3D glasses enhance viewing experience, etc

2

[8]

11

transverse yes

B1

transverse yes

B1

longitudinal no

B1

[3]

12

C

[1]

13

(a) (i) particle vibration (or disturbance or oscillation) **(1)**
same as (or parallel to) direction of propagation
(or energy transfer) **(1)**

(ii) (particle vibration)
perpendicular to direction of propagation (or energy transfer) **(1)**

3

(b) variation in intensity between max and min (or light and dark) **(1)**
two maxima (or two minima) in 360° rotation **(1)**

2

QWC 1

[5]

14	D				[1]
15	B				[1]
16	(a) Transverse		B1		
	(b) correct example of transverse wave (e.g. light / electromagnetic / radio etc. allow photon b.o.d.)		B1		
	(c) [transverse] displacement vector perpendicular to energy direction [accept 'direction of motion']		B1		
	[longitudinal] vector parallel to energy direction		B1		
	polarisation is restriction of displacement vector to one plane OWTTE				
	[allow any or all marks on clear diagram]		B1		
					[5]
17	(a) (i) loose distinction e.g. one has oscillations parallel to the wave direction and the other has oscillations in the same direction as the wave		C1		
	transverse -vibrations perpendicular to direction of propagation longitudinal -vibrations in same direction as direction of propagation		A1	(2)	
	(ii) any example of transverse wave		B1	(1)	
	(iii) any example of longitudinal wave		B1	(1)	
	(b) $v = f\lambda$		C1		
	8.6 m		A1	(2)	
					[6]

18

disturbance / oscillation / vibration is perpendicular to same directions for transverse and parallel to the direction for longitudinal waves

M1

clear indication of what the direction of reference is eg direction of propagation, transmission of the wave or energy / direction in which the wave is travelling

A1

(2)

[2]