



**Waves in air fluids and solids**

Name: \_\_\_\_\_

Class: \_\_\_\_\_

Date: \_\_\_\_\_

---

Time: **319 minutes**

Marks: **318 marks**

Comments:

---



## Mark schemes

- 1** (a) K 1
- (b) Decreases 1
- (c) use a metre rule / 30 cm ruler to measure across 10 (projected) waves  
*accept any practical number of waves number for 10* 1
- and then divide by 10 1
- (d) 1.2 cm = 0.012 m 1
- $18.5 \times 0.012 = 0.22(2)$  (m / s) 1
- allow 0.22(2) with no working shown for 2 marks*
- typical walking speed = 1.5m / s  
*accept any value e.g. in the range 0.7 to 2.0 m / s* 1
- so the water waves are slower (than a typical walking speed)  
*this cannot score on its own* 1
- [8]**
- 2** (a) in a longitudinal wave the oscillations / vibrations are parallel to the direction of energy transfer. 1
- accept wave travel for energy transfer throughout*
- in a transverse wave the oscillations / vibrations are perpendicular to the direction of energy transfer. 1
- (b) accept any sensible suggestion eg a vibrating drum skin does not move the air away to create a vacuum (around the drum) 1

(c) **Level 3 (5–6 marks):**

A detailed explanation linking variations in current to the pressure variations of a sound wave, with a logical sequence.

**Level 2 (3–4 marks):**

A number of relevant points made, but not precisely. A link between the loudspeaker and a sound wave is made.

**Level 1 (1–2 marks):**

Some relevant points but fragmented with no logical structure.

**0 marks:**

No relevant content.

**Indicative content**

the current in the electrical circuit is varying

the current passes through the coil

the coil experiences a force (inwards or outwards)

reversing the current reverses the force

the size of the current affects the size of the force

the varying current causes the coil to vibrate

the (vibrating) coil causes the cone to vibrate

the vibrating cone causes the air molecules to move

the movement of the air molecules produces the pressure variations in the air needed for a sound wave

the air molecules bunch together forming compressions and spread apart forming rarefactions

6

[9]

3

(a) frequency

1

(b) echo(es)

1

(c) 340 (m/s)

*allow 1 mark for correct substitution ie  $25\,000 \times 0.0136$  provided no subsequent step*

*or*

*allow 1 mark for a correct calculation showing an incorrect value from conversion to hertz  $\times 0.0136$*

*an answer of 0.34 gains 1 mark*

2

- (d) (a wave where the) oscillations are parallel to the direction of energy transfer  
*both marking points may appear as labels on a diagram*  
*accept vibrations for oscillations*  
*accept in same direction as for parallel to*  
*allow direction of wave (motion) for direction of energy transfer*  
*allow 1 mark for a correct calculation showing an incorrect value*  
*from conversion to hertz  $\times 0.0136$*

1

- causing (areas of) compression and rarefaction  
*accept correct description in terms of particles*  
*mechanical wave is insufficient*  
*needs a medium to travel through is insufficient*

1

[6]

- 4** (a) X marked in the centre of the sign



*Check position by eye*

1

- (b) concentrated

1

- (c) 0.5 (s)

*allow 1 mark for correct substitution, ie*

$$\frac{1}{2}$$

*provided no subsequent step*

2

- (d) make the cables longer  
*accept pendulum / sign for cables*

1

[5]

- 5** (a) 20 000 Hz

1

(b) 400 (m)

*allow 1 mark for correct  
substitution ie  $1600 \times 0.25$   
provided no subsequent steps shown  
an answer of 200 (m) gains 1 mark*

2

(c) twice

1

(d) From pulse 1 to pulse 3 the distance (to the sea floor) decreased  
*accept the sea got shallower*

**or**

*the submarine went deeper for the distance decreased*

1

then (after pulse 3) the distance (to the sea floor) increased

*accept the sea got deeper*

**or**

*the submarine rose for the distance increased*

*An answer of the distance decreased then increased gains 1 mark*

1

**[6]**

**6**

(a) ultrasound is not ionising

*allow ultrasound does not harm the (unborn) baby*

1

but X-rays are ionising

1

so X-rays increase the health risk to the (unborn) baby

*accept specific examples of health risks, eg cancer, stunted growth,  
impaired brain function etc*

*X-rays are dangerous is insufficient*

1

(b) ultrasound/waves are partially reflected

(when they meet a boundary) (between two different media / substances / tissues)

*must be clear that not all of the wave is reflected*

1

the time taken is measured (and is used to determine distances)

1

(c) 1600 (m/s)

*800 (m/s) gains 2 marks*

*160 000 (m/s) gains 2 marks*

*0.0016 (m/s) gains 2 marks*

*allow 2 marks for*

$$\frac{0.04}{25 \times 10^{-6}}$$

**or**

$$\frac{0.08}{50 \times 10^{-6}}$$

*80 000 (m/s) gains 1 mark*

*0.0008 (m/s) gains 1 mark*

*allow 1 mark for*

$$\frac{0.04}{25}$$

**or**

$$\frac{0.08}{50}$$

*allow 1 mark for evidence of doubling the distance or halving the time*

3

(d) (i) they are absorbed by bone

*allow stopped for absorbed*

*X-rays are reflected negates this mark*

1

they are transmitted by soft tissue

*allow pass through for transmitted*

*allow flesh / muscle / fat*

*accept less (optically) dense material for soft tissue*

1

(the transmitted) X-rays are detected

1

(ii) short

*accept small*

1

[12]

7

(a) high frequency sound (waves)

1

with a frequency above limit of human hearing

**or** with a frequency greater than 20 000 Hz

*above limit of human hearing*

**or** *greater than 20 000 Hz gains maximum 1 mark*

1

(b)  $5(.0) \times 10^{-4}$  (m)

**or**

0.0005 (m)

*1500 =  $3 \times 10^6 \lambda$  gains 2 marks*

*answer of 500 gains 2 marks*

*1500 =  $3.0 \lambda$  gains 1 mark*

3

(c) it will run off the surface of the skin

**or**

water is not a gel

*accept water would evaporate*

1

(d) The width of the coupling agent

1

The width of the water

1

(e) (i) A

1

(ii) E

1



- (f) (i) **K**  
 reflection from skin  
*maximum 5 marks if no mention of reflection* 1
- very little reflection, so small peak 1
- L**  
 reflection from front of kidney 1
- large amount of reflection, so large peak 1
- M**  
 reflection from back of kidney 1
- smaller peak due to absorption of ultrasound in kidney  
**or**  
 smaller peak as further from source  
**or**  
 front of the kidney already reflected a lot, so there is now less to be reflected  
*reflection from a boundary gains 1 mark if no other mark given* 1
- (ii) 0.06 (m)  
**or**  
 $6(.0) \times 10^{-2}$   
*0.12 (m) gains 2 marks*  
*distance =  $1500 \times 8 \times 10^{-5} \times 0.5$  gains 2 marks*  
*distance =  $1500 \times 8 \times 10^{-5}$  gains 1 mark* 3

[19]

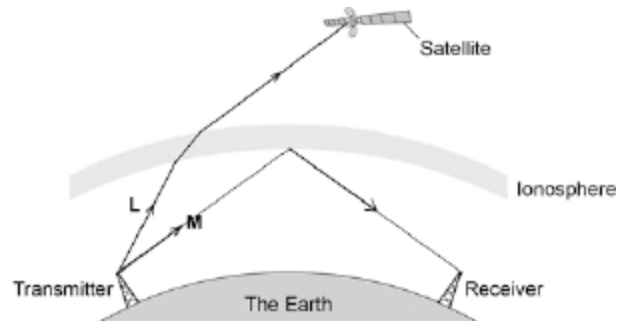
- 8** (a) (i) microwave 1
- (ii) refraction 1

- (b) (i) wave M continues as a straight line to the ionosphere and shown reflected  
*accept reflection at or within the ionosphere*

1

correctly reflected wave shown as a straight line reaching the top of the receiver

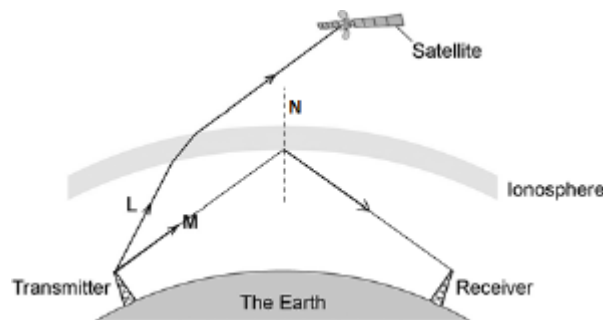
*if more than 2 rays shown 1 mark maximum*



*ignore arrows*

1

- (ii) normal drawn at point where their **M** meets the ionosphere



1

- (c) any **two** from:

- transverse
- same speed (through air)

*accept speed of light or  $3 \times 10^8$  m / s*

- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- transfer energy
- can travel through a vacuum

*an answer travel at the same speed though a vacuum scores 2 marks*

- can be polarised
- show interference.

*travel in straight lines is insufficient*

2

[7]

9

(a) 1.25

*accept 1.3 for 2 marks*

*allow 1 mark for correct substitution*

*ie  $\frac{1}{0.8}$*

*provided no subsequent step shown*

2

(b) (i) increasing the length (of the pendulum) decreases the number of oscillations / swings made (in 20 seconds)

*accept increasing the length (of the pendulum) increases the time (of 1 oscillation / swing)*

*accept increasing the length (of the pendulum) decreases the speed / frequency (of 1 oscillation / swing)*

*answers must refer to the effect of increasing / decreasing length*

*ignore references to time being proportional to length*

1

changing the mass (of the pendulum bob) does not change the number of oscillations / swings made (in 20 seconds)

*accept changing the mass does not change the time / speed / frequency / results*

*accept weight for mass*

1

(ii) any **two** suitable improvements:

- measure (the number of swings) over a wider range of (pendulum) lengths
- measure (the number of swings) over a wider range of (bob) masses
- measure the number of swings made over a greater period of time
- repeat each measurement & calculate mean / average (number of oscillations in 20 seconds)

*accept repeat measurements & discard anomalous measurements*

*repeat measurements is insufficient*

- measure (the total number of swings &) the fraction of swings made
- start the swings at the same height.

*use a computer / datalogger to make measurement (of number of oscillations) is insufficient*

*measuring time period is insufficient*

*using a stop clock with greater resolution is insufficient*

2

[6]

10

(a) pitch

1

loudness

1

- (b) (i) as length (of prongs) decreases frequency / pitch increases  
*accept converse*  
*accept negative correlation*  
*ignore inversely proportional* 1
- (ii) 8.3 (cm)  
*accept  $8.3 \pm 0.1$  cm* 1
- (iii) (8.3 cm is) between 7.8 (cm) and 8.7 (cm)  
*ecf from part (ii)* 1
- (so  $f$  must be) between 384 (Hz) and 480 (Hz) 1
- $410 \text{ (Hz)} \leq f \leq 450 \text{ (Hz)}$   
*if only the estimated frequency given, accept for 1 mark an answer within the range* 1
- (c) (i) electronic 1
- (ii) frequency is (very) high  
*accept frequency above*  
*20 000 (Hz) or audible range* 1
- so tuning fork **or** length of prongs would be very small (1.2 mm) 1
- (d) 285.7 (Hz)  
*accept any correct rounding 286, 290, 300*  
*allow 2 marks for 285*  
*allow 2 marks for correct substitution  $0.0035 = 1 / f$*   
*allow 1 mark for  $T = 0.0035$  s*  
*allow 1 mark for an answer of 2000* 3

[13]

11

- (a) (i) 440 (sound) waves produced in one second  
*accept vibrations / oscillations for waves* 1

(ii) 0.773 (metres)

*allow 2 marks for an answer that rounds to 0.773*

*allow 2 marks for an answer of 0.772*

*allow 2 marks for an answer of 0.772*

*allow 1 mark for correct substitution ie  $340 = 440 \times \lambda$*

3

(b) (sound is) louder

*do **not** accept the converse*

1

as amplitude is larger

*waves are taller is insufficient*

1

higher pitch / frequency

1

as more waves are seen

*reference to wavelengths alone is insufficient*

*waves are closer together is insufficient*

1

**[8]**

12

- (a) (sound waves) which have a frequency higher than the upper limit of hearing for humans  
**or**

a (sound) wave (of frequency) above 20 000 Hz

*sound waves that cannot be heard is insufficient*

*a wave of frequency 20 000 Hz is insufficient*

1

- (b) 640

*an answer of 1280 gains 2 marks*

*allow 2 marks for the correct substitution*

*ie  $1600 \times 0.40$  provided no subsequent step*

*allow 2 marks for the substitution  $\frac{1600 \times 0.80}{2}$*

*provided no subsequent step*

*allow 1 mark for the substitution  $1600 \times 0.80$  provided no subsequent step*

*allow 1 mark for the identification that time (boat to bed) is 0.4*

3

- (c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

*accept heart*

*do **not** allow brain **or** lungs (either of these negates a correct answer)*

- Doppler scanning blood flow

1

- (d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

*clearer / better image is sufficient*

- (scan) produces a slice through the body
- image can be viewed from any direction

*allow images are (always) 3D / 360°*

- an image can be made of any part (inside the body)

*allow whole body can be scanned*

- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are ionising

*allow a description of what ionising is*

- mutate cells **or** cause mutations **or** increase chances of mutations

*allow for cells:*

*DNA / genes / chromosomes / nucleus / tissue*

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells  
*damage cells is insufficient*
- shielding is needed  
*can be dangerous (to human health) unqualified, is insufficient*

1

[7]

13

(a) (i) 20

1

20 000

*either order*

*accept ringed answers in box*

1

(ii) (frequency) above human range  
*accept pitch for frequency*

**or**

(frequency) above 20 000 (Hz)

*do **not** accept outside human range*

*allow ecf from incorrect value in **(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning  
*accept any other appropriate scanning use*  
*do **not** accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle  
*accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation*  
*accept physiotherapy*  
*accept curing prostate cancer or killing prostate cancer cells*
- removing plaque from teeth  
*cleaning teeth is insufficient*

1

(b)  $7.5 \times 10^{-4}$  (m)

$1.5 \times 10^3 = 2.0 \times 10^6 \times \lambda$  *gains 1 mark*

2

- (c) for reflected waves  
*must be clear whether referring to emitted or detected / reflected waves*  
*if not specified assume it refers to reflected wave*

any **two** from:

- frequency decreased
- wavelength increased
- intensity has decreased  
*allow amplitude / energy has decreased*  
*allow the beam is weaker*

2

[8]

14

- (a) the oscillation / vibration (causing the wave)  
*a movement causes the wave is insufficient*

1

for a transverse wave is perpendicular to the direction of energy transfer  
*accept direction of wave travel*

1

and for a longitudinal wave is parallel to the direction of energy transfer  
*accept direction of wave travel*  
*if no marks awarded allow 1 mark for correctly linking perpendicular with transverse and parallel with longitudinal*  
*the marks may be scored by the drawing of two correctly labelled diagrams*

1

- (b) for radio waves:  
*accept converse for each mark*

are transverse

1

travel at speed of light / higher speed

1

have greater frequencies

1

can travel through vacuum

*accept sound waves are not electromagnetic for 1 mark*

1

[7]

15

- (a) (i) perpendicular  
*accept correct description 1*

1



(ii) light off – no / slow rotation

1

light on – fast(er) rotation

*accept starts rotating*

*ignore references to energy transfers*

1

(b) one ray drawn from wrist watch and reflected by mirror

*accept solid or dashed lines*

1

two rays drawn from wrist watch and reflected by mirror with  $i = r$  for both rays

*judge angles by eye*

1

one ray traced back behind mirror

*accept solid or dashed lines*

1

image in correct position

*judged by eye*

*accept image marked where two reflected rays traced back cross behind the mirror*

1

(c) cannot be formed on a screen

*accept image formed behind the mirror*

**or**

rays of light seem to come from it but do not pass through it

1

**[8]**

**16**

(a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the [Marking guidance](#), and apply a 'best-fit' approach to the marking.

**0 marks**

No relevant / correct content.

**Level 1 (1-2 marks)**

There is a basic description of either wave

**OR**

What happens to either wave when they enter the body. However there is little other detail.

**Level 2 (3-4 marks)**

There is either:

A clear description of BOTH waves

**OR**

A clear description as to what happens to BOTH waves inside the body

**OR**

A clear description of ONE of the waves with clear detail as to what happens to either wave inside the body.

**Level 3 (5-6 marks)**

There is a detailed description of BOTH of the waves

**AND**

A detailed description as to what happens to EITHER wave inside the body.

## **Examples of the points made in the response:**

### **Description of an X-ray**

- X-rays are electromagnetic waves / part of the electromagnetic spectrum  
*do **not** allow a description of a property – eg X-rays travel*
- X-rays are (very) high frequency (waves)  
*through a vacuum / at the speed of light*
- X-rays are (very) high energy (waves)
- X-rays have a (very) short wavelength
- Wavelength (of X-rays) is of a similar size to (the diameter of) an atom
- X-rays are a transverse wave  
*correct description acceptable – oscillations / vibrations are perpendicular (at 90°) to direction of energy transfer*
- X-rays are ionising radiation

### **Description of ultrasound**

- ultrasound has a frequency above 20 000 (hertz)  
  
**or**  
  
ultra sound is above 20 000 hertz
- ultrasound is above / beyond the human (upper) limit (of hearing)  
*accept ultrasound cannot be heard by humans*
- ultrasound is a longitudinal wave  
*correct description acceptable – oscillations / vibrations (of particles) are parallel (in same direction) to direction of energy transfer*

### **Statement(s) as to what happens to X-rays inside the human body:**

- X-rays are absorbed by bone
- X-rays travel through / are transmitted by tissue / skin

### **Statement as to what happens to ultrasound inside body:**

- ultrasound is (partially) reflected at / when it meets a boundary between two different media
- travel at different speeds through different media

(b) (because the X-rays) are ionising  
*accept a description of what ionising is*

1

(they will) damage cells  
*instead of cell, any of these words can be used:*  
*DNA / genes / chromosomes / nucleus*

**or**

mutate cells / cause mutations / increase chances of mutations

**or**

turn cells cancerous / produce abnormal growths / produce rapidly growing cells  
*do **not** accept they can be dangerous (to human health)*  
*do **not** accept damage to soft tissue*

**or**

kill cells

1

(c) any **one** from:

- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle  
*accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation*  
*accept physiotherapy*  
*accept curing prostate cancer **or** killing prostate cancer cells*
- removing plaque from teeth  
*cleaning teeth is insufficient*

1

[9]

17

(a) (i) wavelength  
*accept frequency*  
*accept speed*

1

(ii) amplitude  
*accept energy*  
*height is insufficient*

1

(iii) sound

1

(b) 0.12

*allow 1 mark for correct substitution, ie  $8 \times 0.015$  provided no subsequent step shown*

2

metre per second **or** m/s **or** metre/second

*do **not** accept mps*

*units must be consistent with numerical answers*

1

[6]

18

(a) (i) bat(s)

1

(ii) any example in the inclusive range  $5 \leftrightarrow 29$  Hz / hertz  
*appropriate number and unit both required*

1

(b) (i) A, C, D

*all three required and no other*

1

(ii) D, E

*both required and no other*

1

(c) sound cannot travel through a vacuum / (empty) space / free space

*accept there is no medium (for the sound to travel through)*

*do **not** accept there is no air (for the sound to travel through)*

1

(because) there is / are nothing / no particles to vibrate

*accept because there is / are nothing / no particles between them and the source (of the sound)*

1

[6]

19

(a) any **two** from:

- (sound with frequency) above 20 000 hertz / 20 kHz
- frequencies above (human) audible range
- (sound) cannot be heard by humans

2

- (b) **either**  
two appropriate points gain **1** mark each  
*either both pro / con or one of each*

**or**  
one appropriate point (and) appropriate qualification / amplification

*examples*  
*other mammals (sufficiently) similar to humans (1)*  
*so results appropriate (1)*  
*unethical to experiment on humans (1)*  
*so it is better to experiment on mice (1)*  
*knowledge / techniques will benefit humans (1)*  
*and also other animals (1)*  
*experiments were justified because ultrasound has proved useful (1)*

2

- (c) examples  
*allow a wide variety of appropriate responses*

publish / tell doctors / the public (1)  
...their evidence / results / research / data (1)  
*valid point (1)*  
*appropriate example / qualification / expansion / etc (1)*

carry out more research / tests (1)  
...to make sure / check reliability (1)  
*allow just 'stop using them / ultrasonic waves' for 1 mark only*  
*allow using them (only) for industrial purposes for 1 mark only*

2

[6]

20

- (a) (i) **J and L**  
*both required, either order*

1

- (ii) **K**

1

- (iii) **L**

1

highest frequency

*reason does not score if L not chosen*  
*accept most waves (on screen)*  
*do not accept frequency above 20 000(Hz)*  
*do not accept cannot hear it*

1

(b) transmitter

detector

computer

*all three in correct order*

*allow 1 mark for one correct*

2

[6]

21

(a) (i) 3

1

(ii) 30 000 **or** 10 000 × their (a)(i) correctly calculated

1

(iii) any **two** from:

- frequency is above 20 000 (Hz)  
*accept the frequency is 30 000*
- frequency is above the upper limit of audible range
- upper limit of audible range equals 20 000 (Hz)  
*ignore reference to lower limit*
- it is ultrasound/ultrasonic

2

(b) (i) wave (partially) reflected

1

at crack to produce **A** and end of bolt to produce **B**

*accept at both ends of the crack*

1

(ii) 0.075 (m) allow **2** marks for time = 0.0000125

*allow 1 mark for time = 0.000025*

*answers 0.15 **or** 0.015 **or** 0.09 gain 2 marks*

*answers 0.18 **or** 0.03 gain 1 mark*

*the unit is not required but if given must be consistent with numerical answer for the available marks*

3

[9]

22

(a) letter C clearly marking a compression

*accept C at any point in a compression*

*if more than one letter C marked*

*all must be correct*

1

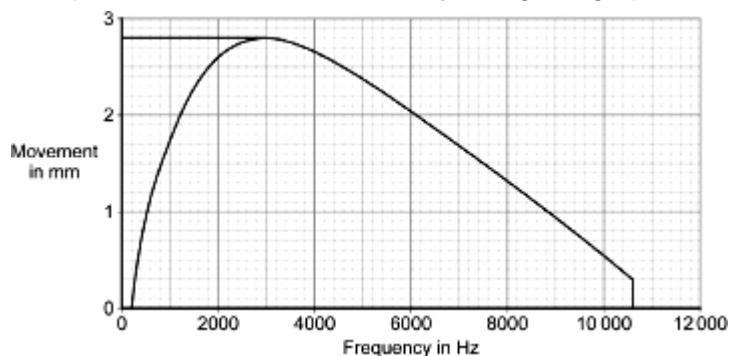
- (b) (i) straight continuous line drawn from loudspeaker to metal to sound sensor  
*judge by eye* 1
- angle I = angle R  
*judge by eye*  
*ignore any arrows on lines* 1
- (ii) less sound reflected  
*accept energy for sound*
- or**
- (some) sound passes through the glass  
*accept (some) sound absorbed by the glass* 1
- (iii) makes the sound louder 1
- (iv)  $v = f \times \lambda$   
340  
*allow 1 mark for correct substitution*  
*ie  $850 \times 0.4$*   
*provided no subsequent step shown* 2
- (c) echo 1
- (d) (i) from 250 Hz to 750 Hz 1
- (ii) curtains reduce (percentage of) sound reflected more (than carpet)  
*accept curtains absorb more sound (than carpet)* 1
- for all frequencies (shown)  
*accept for both marks an answer in terms of walls having a larger (surface) area to reflect sound and curtains reducing the amount of reflected sound more (than carpet)*  
*answers less noisy or walls / curtains have a larger area gain 1 mark only*  
*do **not** accept curtains are cheaper* 1
- (a) 10 600 (Hz)  
*accept 10.6 kHz* 1

[11]



(b) 3000 (Hz)

*allow 1 mark for a line drawn to show greatest movement  
(allow only if frequency is between 2800 and 3200)  
accept other indication of correctly using the graph*



2

(c) (No)

*no marks for just the ticked box  
reasons can score even if yes is ticked*

(human hearing) range is 20 – 20 000 (Hz)

*accept (most) people hear up to 20 000 (Hz) / 20 kHz*

1

any **one** from:

- range on graph is within this range
- range on graph starts after 20 Hz
- range on graph is from to 200 – 10 600 (Hz)
- range on graph finishes before 20 000 Hz

1

(d) reliability

*this answer only*

1

(e) only 1 variable affects dependent variable / size of movement

*accept 'results' for 'size of movement'*

**or**

there is only one independent variable

*fair test is insufficient*

*do **not** accept to control the experiment*

**or**

to be able to compare (effect of different frequencies)

1

[7]

24

(a) vibrate

*allow move more (vigorously) but **not** just move*

1

dirt / muck / grit / rust / dust etc.  
*do not accept bacteria*

1

(b) any **one** medical use eg  
*ignore incorrect biological detail*

- scanning unborn babies
- destroying (kidney) stones

1

(c) (i) 2

1

(ii) C

1

[5]

25

(a) microphone

1

(c) (i) vertical line from any maxima or minima to axis  
*do not penalise minor errors but*  
*do not allow unless intention is clear*

1

(ii) loudness / volume / intensity / energy  
*do not accept noise*

1

(c) 17

*this answer only*

1

(d) the greater the distance, the smaller the amplitude  
*accept volume / intensity / energy / loudness for amplitude*  
**or**  
there is a (strong) negative correlation between distance and amplitude  
**or**  
there is an inverse square relationship between distance and amplitude  
*do not accept distance and amplitude are inversely proportional*

1

(e) 20 Hz

*either order*

1

20,000 Hz

*accept 20 kHz provided unit has been clearly changed*

1

[7]

26

(a) sound / mechanical / longitudinal (wave )

1

any **one** from:

- above 20 000 hertz / 20kHz
- above (human) audible range
- cannot be heard by humans

1

(b) **either**

particles / molecules / fluid vibrate(s) (1)

(and) knock particles of dirt off the jewellery (1)

**or**

by the process of cavitation (1)

*accept 'formation and collapse of tiny bubbles'*

which breaks up / releases dirt from the surface (1)

2

(c) **either both pro**

**or both con**

**or one of each**

**either**

two appropriate points gain **1** mark each

**or**

one appropriate point (and) appropriate qualification / amplification

*examples*

*other mammals (sufficiently) similar to humans (1)*

*so results appropriate (1)*

*unethical to experiment on humans (1)*

*so it is better to experiment on mice (1)*

*knowledge / techniques will benefit humans (1)*

*and also other animals (1)*

*experiments were justified because ultrasound has proved useful (1)*

2

[6]

27

- (a) 20000  
*accept any unambiguous indication* 1
- (b) kilohertz  
*credit misspellings*  
*credit '1000 hertz' or '1000 Hz'*  
*accept 1000 oscillations/beats/waves per second* 1
- (c) (i) cleaning (e.g. something delicate such as a watch)  
*or quality control/flaw detection*  
*credit any appropriate extra Specification response*  
*e.g. sonar* 1
- (ii) pre-natal (scanning)  
*do **not** credit just 'scanning'/medical scanning/ scanning a baby*  
*credit any appropriate extra Specification response*  
*e.g. destruction of (kidney) stones or cleaning teeth* 1
- (d) 8 ( $\mu$ s) 1
- (e) distance (1)  
between the boundary and the detector (1)  
*accept 'between the boundary and the source'*  
*accept any correct use of speed = distance/time* 2
- (f) examples  
publish/tell doctors/the public (1) ... their evidence/results/research/data (1)  
carry out more research/tests (1) ... to make sure/check reliability (1)  
*allow a wide variety of appropriate responses*  
*valid point (1) appropriate example/qualification/expansion/etc. (1)*  
*allow just 'stop using them/ultrasonic waves' (1)*  
*allow using them (only) for industrial purposes (1)* 2

[9]

28

(a) (i)

*correct order essential*

(A =) a microphone

1

(B =) an oscilloscope

*or cathode ray oscilloscope or CRO*

1

(ii) the amplitude

*accept any unambiguous indication*

1

(iii) quieter / softer

*do not accept less (which could refer to the amplitude, frequency or wavelength)*

1

(b) sound cannot travel through a vacuum / (empty) space / free space

*accept there is no medium for the sound to travel through*

1

(because) there is / are nothing / no particles to vibrate

*accept (because) there is / are nothing / no particles between them and the source (of the sound)*

1

[6]

29

(a) (i) same frequency / period / pitch / wavelength

*ignore references to amplitude*

1

(ii) differences in waveform / shape / quality

*accept the diagrams are not identical*

1

(b) (i) 20 000 Hz / hertz

**or** 20 kHz / kilohertz

*in both cases, if the **symbol** rather than the name is used, it must be correct in every detail*

1

(ii) material(s) / substance(s) (through which sound travels)

1

(iii) is absorbed  
*accept (some) sound (energy) is transformed / transferred as heat / thermal energy*

1

is transmitted  
*accept is refracted*  
*accept changes speed*  
*accept changes velocity*  
*do **not** accept is diffracted*  
*do **not** accept is diffused*  
*do **not** accept is dissipated*

1

[6]

30

(a) (i) 25 (%)  
*do **not** accept  $\frac{1}{4}$*

1

(ii) increases

1

(b) tick (✓) in top and bottom box  
*both required*

1

(c) SHINY surfaces are good reflectors of infra-red radiation  
*accept white for shiny*

**or** black surfaces are POOR reflectors of infra-red radiation  
*accept bad for poor*  
*accept insertion of 'not' before 'good' in statement*

**or** black surfaces are good EMITTERS of infra-red radiation

**or** black surfaces are good ABSORBERS of infra red radiation

1

[4]

31

(a) (mechanical) vibration(s)  
***not** just 'particles knocking into each other'*  
*not reference to 'sound particles'*

1

(b) K

1

(c) (i) reflected by the material from loudspeaker to microphone X

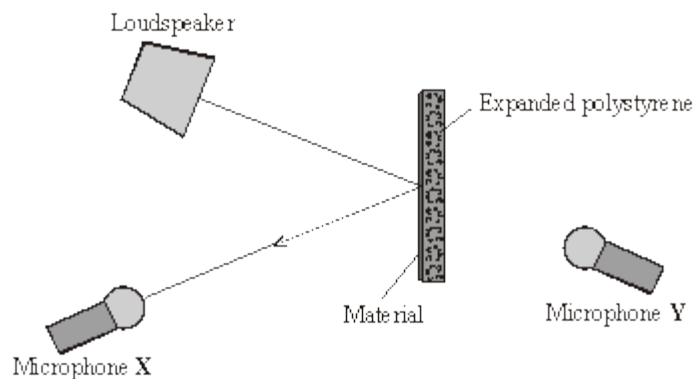
1

shown by straight lines with angle of incidence = angle of reflection  
(by eye) **and** at least one arrow in the correct direction

*do not credit if the direction is contradicted by any incorrect arrow /  
may be shown by waves / wavefronts in the direction of straight  
lines*

*ignore any sound to Y or which 'misses' the material*

*example*



1

(ii) any **one** from:

- so (the student) can compare results
- so only one (independent) variable
- to get reliable / accurate results
- because (the expanded) polystyrene absorbs some of the sound  
*do not credit just 'so it's a fair test'*

1

(iii) **[A]** wood

1

**[B]** either 0.25 or 1/4 or 25 % or 15/60 or 1: 3

*do not credit 1 : 4*

1

- (d) practical suggestion 1
- appropriate reason / explanation
- example** line / panel the walls with wood / plasterboard / increase the thickness of the plaster (on the walls) (1)  
 (this) will absorb / reflect (back) (most / some of) the sound (1)  
 credit legal suggestions for attempting to limit the noise made by the neighbours  
**example** ask the neighbours to make less noise (1)  
 by limiting the time(s) music played (1)  
 do **not** credit reference to 'sound particles' for second mark 1

[9]

32

- (a) (i) **A, C and D**  
 any order but all three required and no others 1
- (ii) **D and E**  
 either order but both required and no others 1
- (b) (i) 20000 (Hz) to 20 (Hz)  
 accept '19980 (Hz)'  
 or vice-versa 1
- (ii) frequency (of dog whistle) too high (for humans to hear) / frequency above 20000 Hz  
 accept 'it is ultrasound'  
 accept 'sound from the whistle is ultrasonic' 1
- (c) (i) substance 1
- reflection  
 correct order essential 1
- (ii) detector 1

[7]



33

(a) any **two** points:

*do not credit features which are true of sound in general eg longitudinal waves*

- humans cannot hear ultrasound
- it has a very high frequency / pitch  
*do not credit just 'has a high frequency / pitch'*
- above the (upper) limit for humans / above 20 000 Hz

2

(b) (i) ultrasound / waves are reflected

*...are bounced is insufficient, but*

*...echo is acceptable*

1

Pulse **A** indicates / is the crack

Pulse **B** indicates / is the back (of the block or crack)

*need to mention both A and B to get this mark*

1

(ii) 90 (mm)

*accept any answer in the range 88 – 92 (mm)*

1

[5]

34

(i) (partly) reflected when they hit a (boundary between two) different media or substance or tissue

*accept named substances*

*do not accept bounce back*

1

time taken for reflected wave (to return) is used to produce the image

1

(ii) any **one** from:

cleaning a delicate mechanism / jewellery

*do not accept cleaning*

welding plastics

cutting textiles

mixing emulsion paints

sonar

motion sensors (in burglar alarms)

*do not accept burglar alarms*

removing dental plaque

industrial quality control

breaking up kidney stones

treating injuries

1

[3]

35

(a) sound with a frequency above audible

*do not accept answer in terms of  $\lambda$*

*do not accept sound which cannot be heard unless obvious from context*

*accept above 20 kHz*

1

(b) (i) to show detail **or** to give a clear image/picture

*accept the generators **or** transducers can be small*

*accept so the beam does not spread out/beam in focus*

***not** 'good picture'*

1

(ii) (much) smaller wavelength

*allow higher frequency/pitch*

1

(iii) no damage to living cells (provided low power)

*accept the converse*

*accept no damage to baby **or** not dangerous to baby*

1

(iv) any **two** forms

sex

stage of development

*or specific examples*

abnormalities

general health

potential problems (at birth)

*accept specific examples e.g. umbilical cord around neck*

size of head

*accept multiple births*

2

[6]

36

(a) stop

*accept any indication*

cannot travel

2

(b) middle box ticked

*accept a tick next to the statement even if not in the box  
do **not** accept two ticks*

1

(c) (i) B

highest frequency

*accept most waves (in box)  
accept 'squashed together'  
do **not** accept 'squashed'  
accept 'close (together)'  
accept shortest wavelength*

2

(ii) D

largest amplitude

*accept tallest **or** highest wave  
do **not** accept biggest wave  
do **not** accept 'high' wave*

2

[7]

37

(a) glass

1

air

*must be in correct order*

1

closer the particles faster the speed

*answer must show a comparison*

**or**

particles in glass closest in air furthest apart

*accept the denser the material the faster the sound travels*

**or**

sound travels faster in solids than gases

*incorrect explanation negates credit*

1

- (b) (i) grasshopper  
(ii) ultrasound  
*accept ultrasonic* 1
- (c) all of reflected pulse closer than given in original diagram  
*accept a cluster of pulses ignore a reflected pulse in original position any pulse drawn to right of original negates credit* 1
- reflected pulse smaller than emitted but greater than 1 square high  
*accept cluster of pulses provided one part fulfils height criteria* 2

[7]

38

- (a) number of complete vibrations per second  
*for 1 mark* 1
- (b) (i) correct trace (more waves), *ignore amplitude*  
*for 1 mark* 1
- (ii) correct trace (higher amplitude), *ignore frequency*  
*for 1 mark* 1
- (c) (i) higher  
*for 1 mark* 1
- (ii) quieter  
*for 1 mark* 1

[5]

39

- (a) vibrates (owtte)  
*for one mark* 1
- (b) (i) higher  
*for one mark* 1
- (ii) louder  
*for one mark* 1
- (c) (i) ultrasonic (ultrasound)  
*for one mark* 1

(ii) different frequency / wavelength / pitch  
*gains 1 mark*

**but**

high frequency / pitch, higher frequency /pitch (lower frequency / pitch *wrong*)  
*gains 2 marks*

2

**[6]**

**40**

(a) 4

1

(b) 3

1

(c) 3

*correct answer with no working = 2*  
*allow 1 mark for  $f = \text{number} \div \text{time}$*   
*or correct working i.e.,  $12 \div 4$*   
*N.B. correct answer from incorrectly*  
*recalled relationship / substitution = 0*

2

Hz / hertz

*accept HZ, hz, hZ*  
*allow waves / cycles per second*  
*allow wps, w/s, cps, c/s*

1

**[5]**

**41**

(a) Quality of written communication:  
Correct use of 2 of the words, angle, critical, normal and reflection

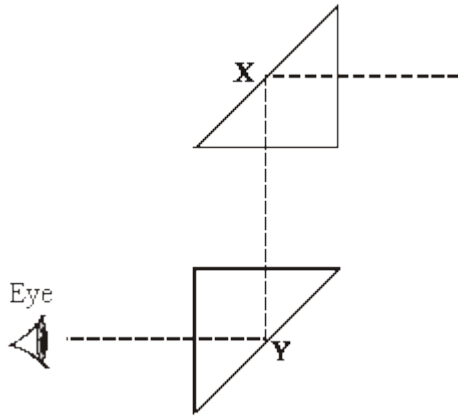
1

any **two** from

- light is reflected / bounces off
- if angle between ray and normal angle of incidence
- is greater than critical angle
- idea that no refraction bending if ray at  $90^\circ$

2

(b)



1 mark for reflection at **X** if ray would reach the lower prism  
1 mark for subsequent reflection at **Y**  
1 mark for subsequent ray emerging from prism in direction of front of eye  
accept dotted **or** dashed lines  
ignore any arrows

3

[6]

42

(a) (ultrasound) waves reflected  
accept 'bounce off'

1

at boundary / from muscle

1

(b) (i) time

1

(ii) speed of (ultrasound) waves

1

[4]

43

(a) (i) cat

1

(ii) tuna

1

(b) (i) ultrasound  
allow ultrasonic

1

(ii) cleaning / quality control / flaw detection / medical scanning /  
animal scaring / sonar

1

[4]

44

**Quality of written communication**

correct use of **three** scientific terms from speed / velocity, reflection, density, time, boundary

1

any **three** from:

different tissues have different densities

ultrasound travels at different speeds / velocities in different tissues

reflection

*accept bouncing back*

from tissue boundaries

time taken to return

3

[4]

45

(a) changes the sound wave(s)

to a varying **or** changing (electric) potential difference **or** p.d. **or** voltage **or** current **or** to an irregular alternating current or a.c. **or** transfers sound energy to electrical energy (1) mark is vibrations **or** pulses **or** of sound **or** in air become electrical waves

*do not credit just 'to electricity' or 'to a.c'*

2

(b) (i) decrease **or** reduce the amplitude

*accept less amplitude nothing else added*

1

(ii) increase the frequency **or** decrease wavelength

*accept higher frequency nothing else added*

1

[4]

46

- idea that (in words or on diagram)
- sound reflects / bounces off cliff
- returns the way it came / produces an echo

*each for 1 mark*

[2]

47

D

*gains 1 mark*

**but** E ( $D + E = 1$ )

*gains 2 marks*

[2]