StudyPacks

STUDY.

KS4

SCIENCE

Wave Basics

Wave speed = Frequency x Wavelength

This Study Pack aims to cover:

1. Describing Waves using keywords – wavelength, amplitude & frequency
2. How to calculate Wave speed, Wavelength and frequency using The Wave speed Equation.

SP9

Student Name

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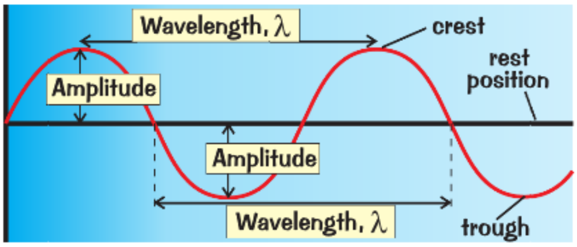
Wave Basics

Waves transfer energy from one place to another without transferring any matter (stuff).

Waves Have Amplitude, Wavelength and Frequency

1) The amplitude is the displacement from the rest position to the crest (NOT from a trough to a crest).
2) The wavelength is the length of a full cycle of the wave, e.g. from crest to crest.
3) Frequency is the number of complete waves passing a certain point per second OR the number of waves produced by a source each second. Frequency is measured in hertz (Hz). 1 Hz is 1 wave per second.

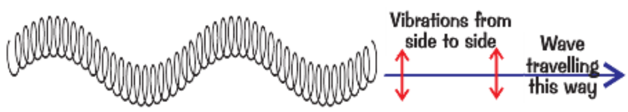


Transverse Waves Have Sideways Vibrations

Most waves are transverse:

1) Light and all other EM waves.
2) Ripples on water.
3) Waves on strings.
4) A slinky spring wiggled up and down.

In TRANSVERSE waves the vibrations are PERPENDICULAR (at 90°) to the DIRECTION OF ENERGY TRANSFER of the wave.



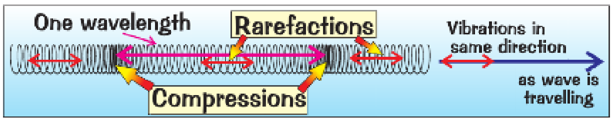
Longitudinal Waves Have Vibrations Along the Same Line

Examples of longitudinal waves are:

1) Sound waves and ultrasound.
2) Shock waves, e.g. seismic waves.
3) A slinky spring when you push the end.

Water waves, shock waves and waves in springs and ropes are all examples of mechanical waves.

In LONGITUDINAL waves the vibrations are PARALLEL to the DIRECTION OF ENERGY TRANSFER of the wave.



Wave Speed = Frequency × Wavelength

The equation below applies to all waves. You need to learn it — and practise using it.

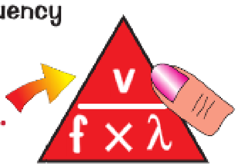
Speed = Frequency × Wavelength
(m/s) (Hz) (m)

OR $v = f \times \lambda$

Speed (v is for velocity)

Frequency

Wavelength (that's the Greek letter 'lambda')



EXAMPLE: A radio wave has a frequency of 92.2×10^6 Hz. Find its wavelength. (The speed of all EM waves is 3×10^8 m/s.)

ANSWER: You're trying to find λ using f and v, so you've got to rearrange the equation. So $\lambda = v \div f = 3 \times 10^8 \div 9.22 \times 10^7 = 3.25$ m.

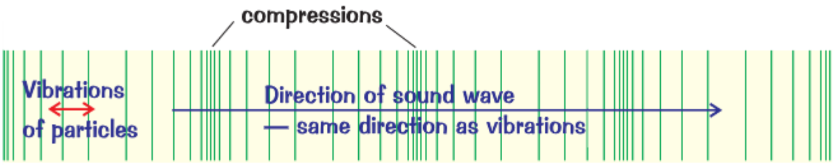
The speed of a wave is usually independent of the frequency or amplitude of the wave.

Sound Waves

We hear sounds when vibrations reach our eardrums. You'll need to know how sound waves work.

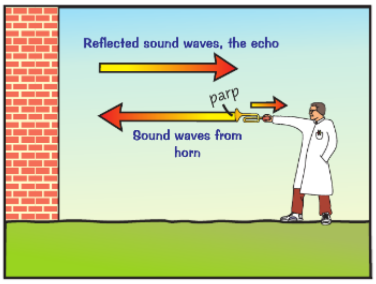
Sound Travels as a Wave

1) Sound waves are caused by vibrating objects. These mechanical vibrations are passed through the surrounding medium as a series of compressions. They're a type of longitudinal wave (see page 34).

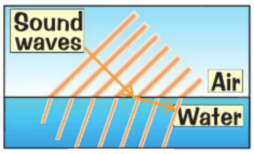


2) Sometimes the sound will eventually travel through someone's inner ear and reach their eardrum, at which point the person might hear it.
3) Sound generally travels faster in solids than in liquids, and faster in liquids than in gases.
4) Sound can't travel in space, because it's mostly a vacuum (there are no particles).

Sound Waves Can Reflect and Refract



1) Sound waves will be reflected by hard flat surfaces.
2) This is very noticeable in an empty room. A big empty room sounds completely different once you've put carpet, curtains and a bit of furniture in it. That's because these things absorb the sound quickly and stop it echoing around the room. Echoes are just reflected sound waves.
3) You hear a delay between the original sound and the echo because the echoed sound waves have to travel further, and so take longer to reach your ears.



4) Sound waves will also refract (change direction) as they enter different media. As they enter denser material, they speed up. (However, since sound waves are always spreading out so much, the change in direction is hard to spot under normal circumstances.)

The Higher the Frequency, the Higher the Pitch

1) High frequency sound waves sound high pitched like a squeaking mouse.
2) Low frequency sound waves sound low pitched like a mooing cow.
3) Frequency is the number of complete vibrations each second — so a wave that has a frequency of 100 Hz vibrates 100 times each second.
4) Common units are kHz (1000 Hz) and MHz (1 000 000 Hz).
5) High frequency (or high pitch) also means shorter wavelength (see p.34).
6) The loudness of a sound depends on the amplitude (p.34) of the sound wave. The bigger the amplitude, the louder the sound.

Longitudinal and transverse waves

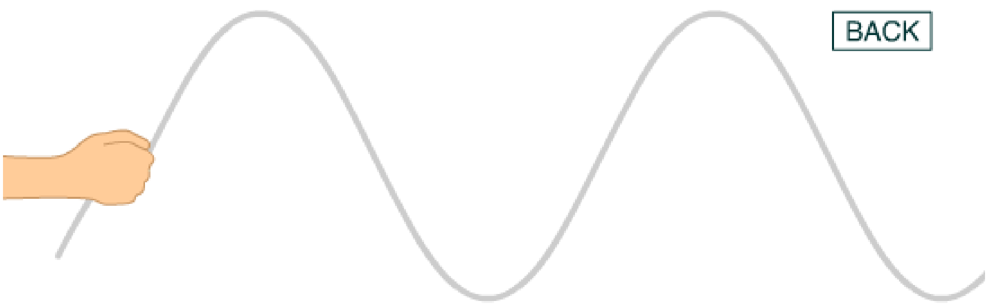
You should be able to describe the characteristics of transverse and longitudinal waves.

Transverse waves

In transverse waves, the oscillations (vibrations) are at **right angles to the direction of travel and energy transfer**

Light and other types of electromagnetic radiation are transverse waves. All types of electromagnetic waves travel at the same speed through a vacuum, such as through space.

Water waves and S waves (a type of seismic wave) are also transverse waves.

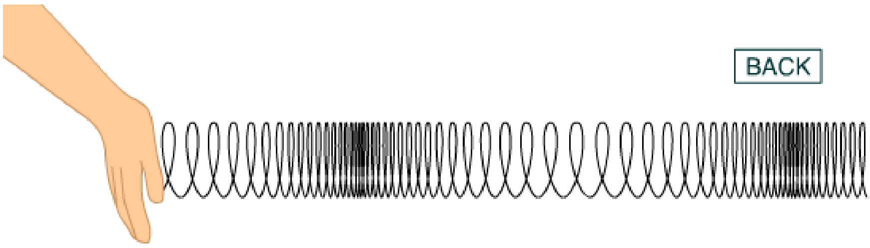


Longitudinal waves

In longitudinal waves, the oscillations are along the **same direction as the direction of travel and energy transfer**.

Sound waves and waves in a stretched spring are longitudinal waves. P waves (relatively fast moving longitudinal seismic waves that travel through liquids and solids) are also longitudinal waves.

Longitudinal waves show area of compression and rarefaction. In the animation, the areas of compression are where the parts of the spring are close together, while the areas of rarefaction are where they are far apart.

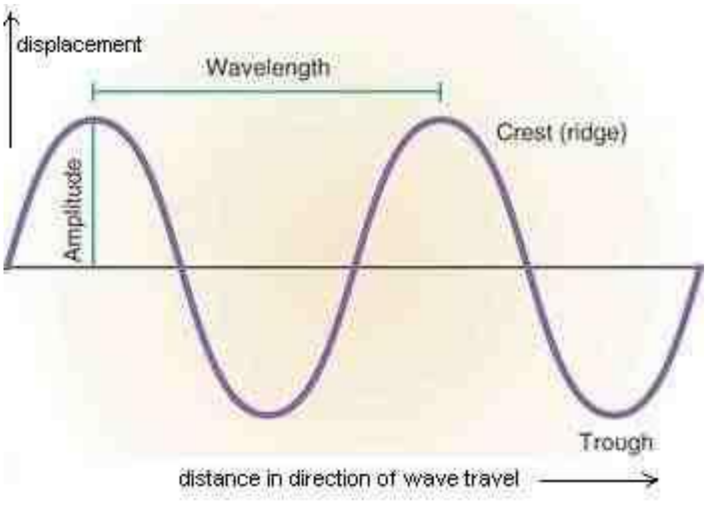


Amplitude, wavelength and frequency

You should understand what is meant by the amplitude, wavelength and frequency of a wave.

Amplitude

As waves travel, they set up patterns of disturbance. The amplitude of a wave is its maximum disturbance from its undisturbed position. Take care: the amplitude is not the distance between the top and bottom of a wave



Wavelength

The wavelength of a wave is the distance between a point on one wave and the same point on the next wave. It is often easiest to measure this from the crest of one wave to the crest of the next wave, but it doesn't matter where as long as it is the same point in each wave.

Frequency

The frequency of a wave is the number of waves produced by a source each second. It is also the number of waves that pass a certain point each second.

The unit of frequency is the hertz (Hz). It is common for kilohertz (kHz), megahertz (MHz) and gigahertz (GHz) to be used when waves have very high frequencies. For example, most people cannot hear a high-pitched sound above 20 kHz, radio stations broadcast *radio waves* with frequencies of about 100 MHz, while most wireless computer networks operate at 2.4 GHz.

Waves

What is the Wave Equation?

The only equation you need for waves is

Velocity or Speed = Frequency x Wavelength $v = f \times \lambda$

This equation is important!

The equation can be rearranged to give

$f = v \div \lambda$ or $\lambda = v \div f$

Q1. A sound wave has a frequency of 3250 Hz and a wavelength of 0·1 m. What is its velocity?

A1. Use $v = f \times \lambda$

$v = 3250 \times 0{\cdot}1$
$= 325$ m/s.

In the diagram, 5 waves pass the sea shore in 1 second, so the frequency is **5 Hz**.

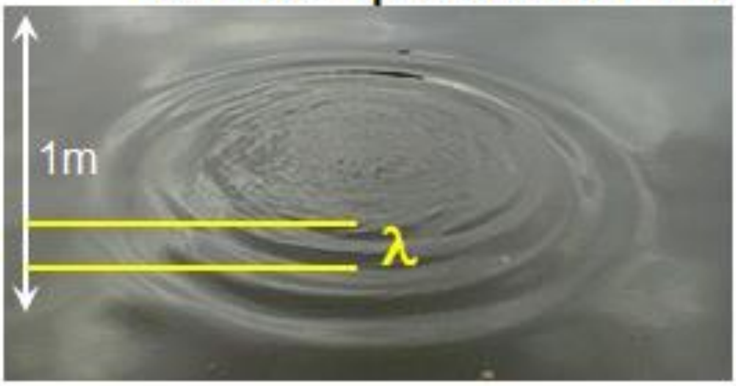
The wavelength (λ) is **2 m**, which means that the waves travel 10 m in 1 s.

The speed is therefore 10 m/s.

So, in this example:

frequency	x	wavelength	=	speed
5 Hz	x	2 m	=	10 m/s

Wave speed formula example



The photograph shows waves travelling across the surface of a pond.

The wavelength is estimated at 0.15m.

If the frequency of the wave is **0.2 Hz**, what is the speed of the wave?

wave speed = frequency x wavelength

wave speed = 0.2 x 0.15

wave speed = 0.03 ms^{-1}

Worked example

A wave has a frequency **600 hertz**

And wavelength of **1600m.** work out the speed?

Wave speed = frequency x wavelength

wave speed = 600 x 1600

= 96000 metres per second.

Wave speed questions

Complete the table:

Wave	F (Hz)	λ (m)	V (ms^{-1})
Water	2	1.5	
Mexican		40	8
Musical note	256		339
Rope	3	0.8	
Ultrasound	35,000		339

Wave calculations

Aim

To practise wave calculations.

1 Calculate and insert the missing values in the table below.

frequency (in hertz, Hz) × wavelength (in metres, m) = speed (in metres/second, m/s)

	Frequency (in hertz, Hz)	**Wavelength (in metres, m)**	**Speed (in metres/second, m/s)**
A	500		1500
B		0.50	1200
C	1000	0.34	
D		0.03	300 million
E	150 million		300 million
F	20 000	0.015	

2 Water waves on a lake pass by a boat which is anchored.

a) A wave crest passes the boat every 4.0 seconds. Calculate the frequency of the waves in hertz.

....

b) The distance from one wave crest to the next wave trough is 5.0 m.

i) Calculate the wavelength of the waves.

....

ii) Calculate the speed of the water waves.

....

....

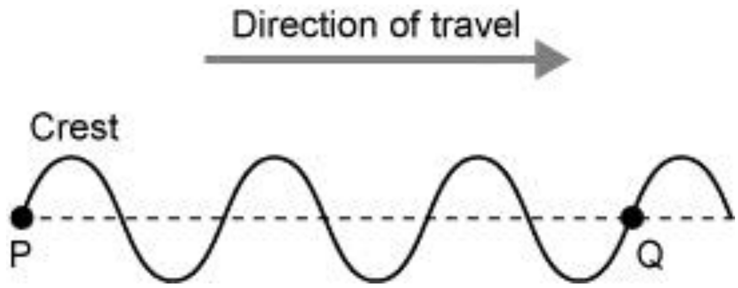
....

Waves – knowing the words is half the battle

Aims

In this worksheet you will practise your understanding of some of the basic terms involved with waves. If you know what the words mean it will help you understand the topic of waves.

The diagram shows a wave on the surface of water at one point in time.



a On the diagram draw an arrow to show:

i the amplitude of the wave. Label the arrow as amplitude.

ii the wavelength of the wave. Label the arrow as wavelength.

b **i** How many waves are there between P and Q? ………………………………….

ii The distance between P and Q is 600 cm. What is the wavelength of the wave?

……………………………………………………………………………………………….

c Water waves are transverse. On the diagram draw an arrow to show how the particles in the water at Q vibrate as the wave passes. Label the arrow “transverse vibration”.

d **i** The top point on a wave is called a crest. What is the name for the bottom point of a wave?

……………………………………………………………………………………………….

ii As the wave moves, what do you see happening to the crests?

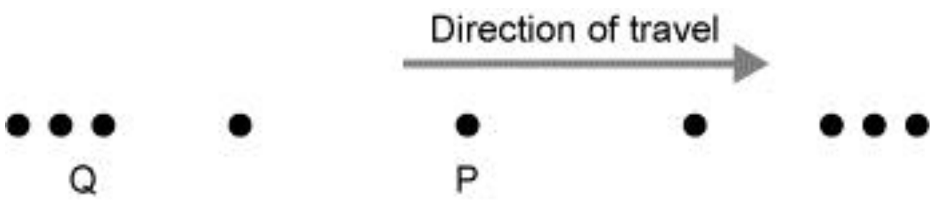
……………………………………………………………………………………………….

iii As the wave moves, what do you see happening to a particle at Q? Complete the sentence:

In a transverse wave a particle vibrates ……………………………………………………………………………………………….

……………………………………………………………………………………………….

The diagram shows molecules of air in a sound wave. These molecules also vibrate. They vibrate as a longitudinal wave. You may have seen a slinky being used to show a longitudinal vibration.



a On the diagram draw an arrow to show how the molecule at P vibrates as the sound wave passes. Label the arrow 'longitudinal vibration'.

b **i** P is a point in the wave called a rarefaction. What is the name of the point Q in the wave?

…………………………………………………………………………………………………….

ii Is the air pressure higher at P or at Q? Explain how you know.

…………………………………………………………………………………………………….

iii In your own words, describe the vibration of a particle at P. Complete the sentence.

In a longitudinal wave a particle vibrates ………………………………………………………

…………………………………………………………………………………………………….

Look at the list of words that are used to describe waves.

frequency	amplitude	wavelength	longitudinal
electromagnetic	seismic (shock)		

Which word in the list describes:

a the distance between one crest and the next crest of a wave?..

b the maximum distance a particle in a wave vibrates from its mean position?...............................

c the number of waves passing a point in one second?...

d a type of wave that is always transverse?.. …….

Waves

1 Draw labelled diagrams to explain what is meant by

a a transverse wave (2)

b a longitudinal wave (2)

2 Match the words in the list with the descriptions **1** to **4** in the table. (4)

A amplitude

B frequency

C wave speed

D wavelength

	Description
1	The distance travelled by a wave crest every second.
2	The distance from one crest to the next.
3	The height of the wave crest from the rest position.
4	The number of crests passing a fixed point every second.

3 Which of the following is a correct description of the image in a plane mirror?

A It is a virtual image

B It can be focused on to a screen

C It is on the surface of the mirror

D It is upside down

.... (1)

4. Give one similarity and one difference between a sound wave and a light wave.

....

.... (2)

5 A sound wave in air has a frequency of 256 Hz. The wavelength of the wave is 1.3 m.

Calculate the speed of sound in air? Write down the equation you use. Show clearly how you work out your answer and give the unit.

....

.... (2)

6 **a** Give **one** example of each of the following from everyday life.

i reflection of light

.... (1)

ii reflection of sound

.... (1)

iii refraction of light

.... (1)

iv diffraction of sound

.... (1)

b We do not normally see diffraction of light in everyday life.

Suggest a reason for this.

.... (2)

7.Electromagnetic waves travel at a speed of 300 000 000 m/s.

BBC Radio 4 is transmitted using a wavelength of 1500 metres.

Calculate the frequency of these waves?

Write down the equation you use. Show clearly how you work out your answer and give the unit.

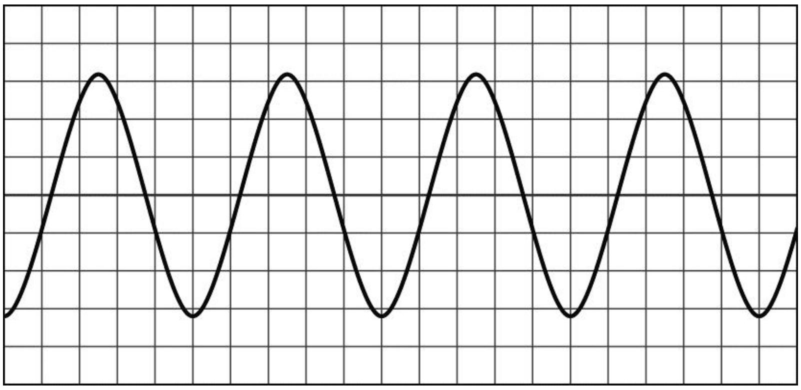
....

....

.... **[H]** (3)

8 *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate*.

The diagram shows an oscilloscope trace of the sound wave produced by a musical instrument.



Explain, in detail, how the wave form would change if the instrument produced a sound which was louder and at a higher pitch.

....

....

....

....

....

....

6 marks

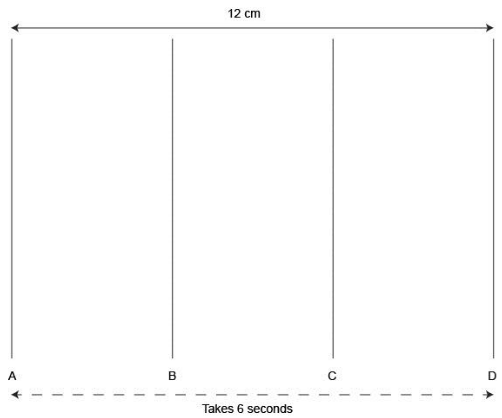
Wave speed formula worksheet

Aims

In this worksheet you will look at a wave diagram to calculate speed and frequency and show your understanding of how sound travels through air.

Questions

1.The diagram shows four wave crests as they move across a ripple tank at a time t = 0.



a What is the wavelength of one wave? …………………………………………………………

b A crest takes 6 seconds to move from A to D.

i How long does a crest take to move from C to D? ………………………………………

ii Use your answer to work out what fraction of a wavelength passes the point D in one second.

....

iii Use the formula $speed = \frac{distance}{time}$ to find the speed of the wave.

....

iv Use the formula *speed* = *frequency* × *wavelength* to find the frequency of the wave.

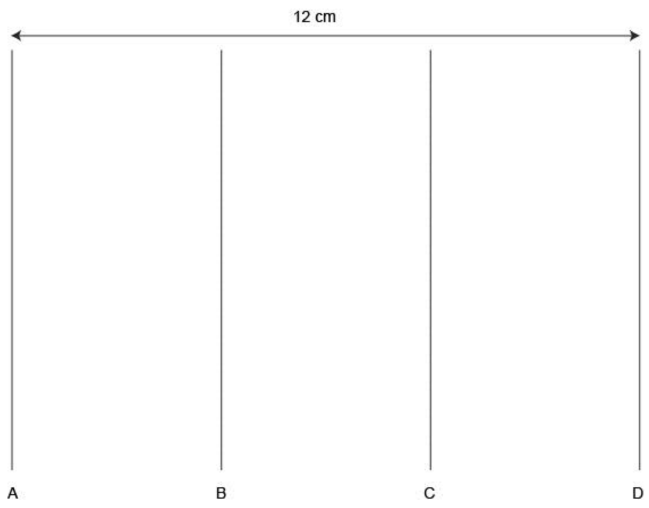
....

....

v Your answer to part **ii** and **iv** should be the same. Why is this?
(Hint – what does frequency mean?)

....

c On the diagram, draw the position of the four crests 3 seconds later.
Use your answers to part **a** and **b** to help you.



Sound travels through the air from a loudspeaker. The diagram shows some of the molecules in the air as the sound passes.

d The sound passes from left to right.

i Describe what happens to the molecules in the air as the sound travels.

....

....

ii On the diagram above, draw an arrow to show how the molecule at P moves.

iii On the diagram above, mark a distance that represents one wavelength.
Label your distance 'wavelength'.

e On the diagram, P is shown at a rarefaction. What is meant by a *rarefaction*?

....

....

f The sound has a frequency of 600 Hz. The speed of sound in air is 300 m/s.
Use the formula *speed = frequency* × *wavelength* to calculate the wavelength of the sound wave.

....

g The pitch of the sound increases.

i What happens to the frequency of the sound?

....

ii What happens to the wavelength of the sound?

……………………………………………………………………………………………………

iii What happens to the movement of the molecule in the air at P?

……………………………………………………………………………………………………

h) Electromagnetic waves travel at a speed of 300 000 000 m/s.

BBC Radio 4 is transmitted using a wavelength of 1500 metres.

Calculate the frequency of these waves?

Write down the equation you use. Show clearly how you work out your answer and give the unit.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… **[H]** (3)

I) Radio waves are received by a house at the bottom of a hill. The waves travel at a speed of 3×10^8 ms^{-1} and have a frequency of 6×10^5 Hz.

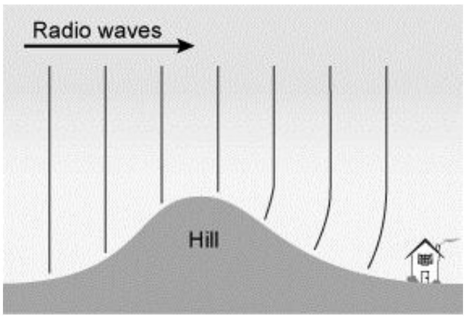
a Rearrange the formula *wave speed = frequency* × *wavelength* to complete the equation below.

wavelength =

b Calculate the wavelength of these waves (Take care. On most calculators you type 3 EXP 8 ÷ 6 EXP 5 =)

……………………………………………………………………………………

……………………………………………………………………………………



c The diagram shows the radio waves moving over the hill.

How have the waves reached the house?

……………………………………………………………………………

d Another radio station emits waves of frequency 6×10^8 Hz.

i Calculate the wavelength of these radio waves. ……………………………………………………………………………

……………………………………………………………………………

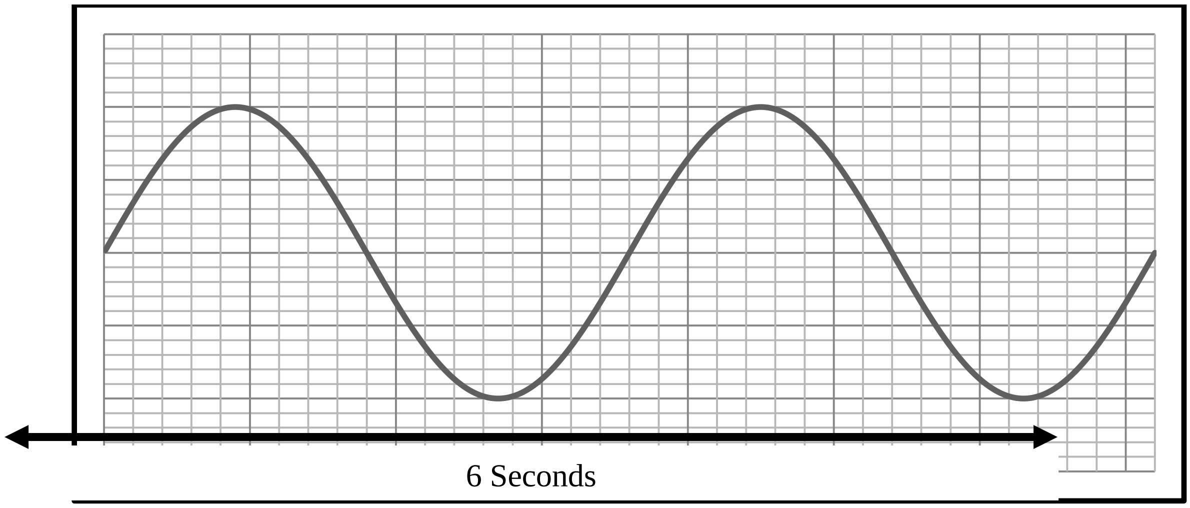
ii Fill in the gaps in the sentence below.

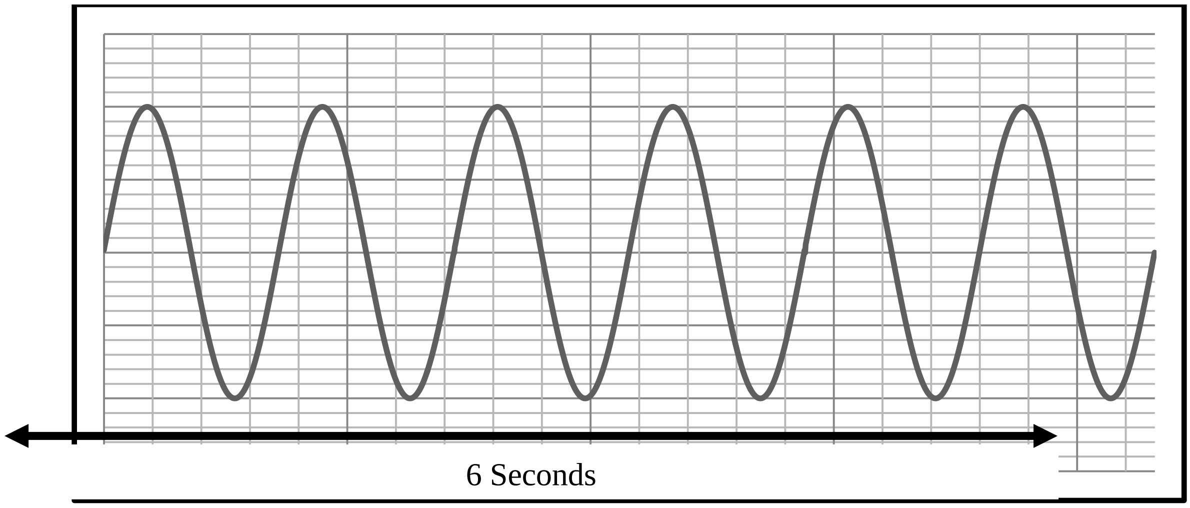
As the frequency of the radio waves decreases, the wavelength ………………………,

while the speed of the waves …………………………………………

Wave Test yourself

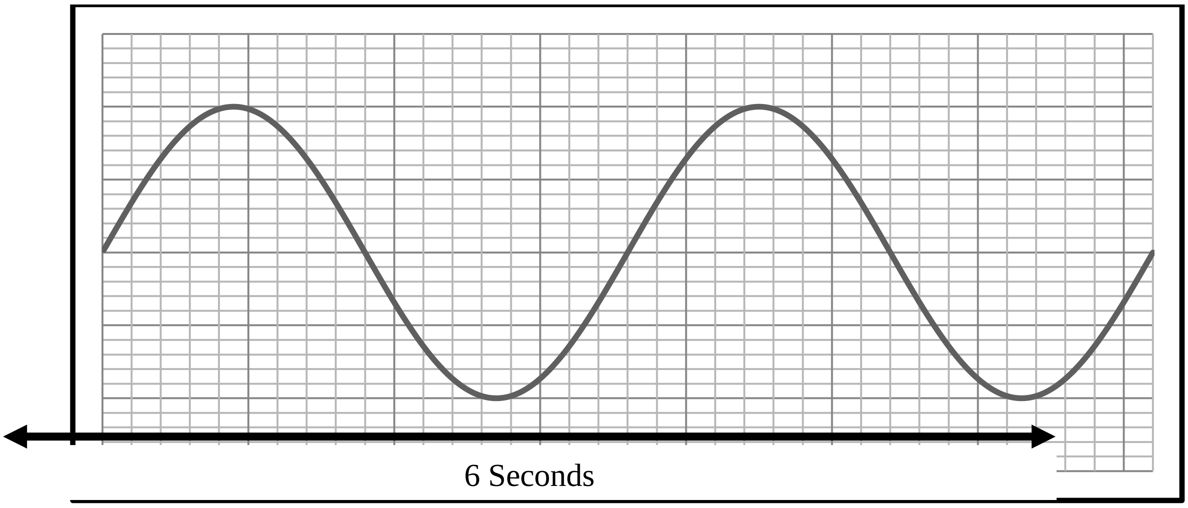
1. Draw on the wavelength and the amplitude of the following waves. (4)

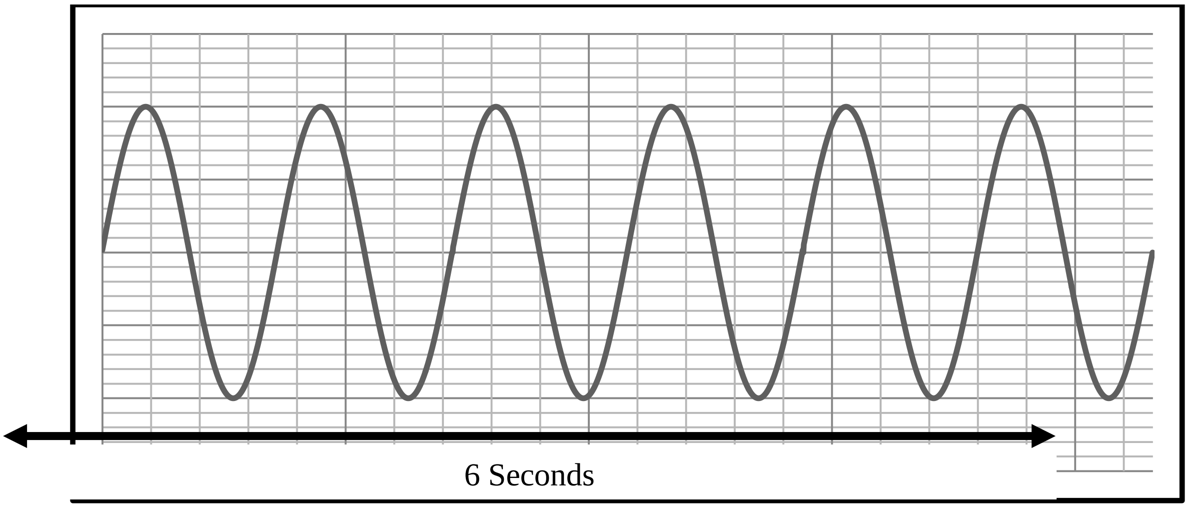




2. Calculate the time period and the frequency of each wave. (4)
3. A wave travelling at 3000 m/s has a wavelength of 1 m.
    a. Calculate the frequency of the wave.
    b. Calculate the time period of the wave.
    c. How many complete wave cycles will occur in:
        i. 1 second?
        ii. 10 seconds?
        iii. 1 minute? (5)
4. A radio wave has a wavelength of 1000 m and a frequency of $3x10^{5}$ Hz. Calculate the wave speed. (1)
5. A gamma wave has a wavelength of $1x10^{-12}$ m and a frequency of $3x10^{20}$ Hz. Calculate the wave speed. (1)

1. Draw on the wavelength and the amplitude of the following waves. (4)

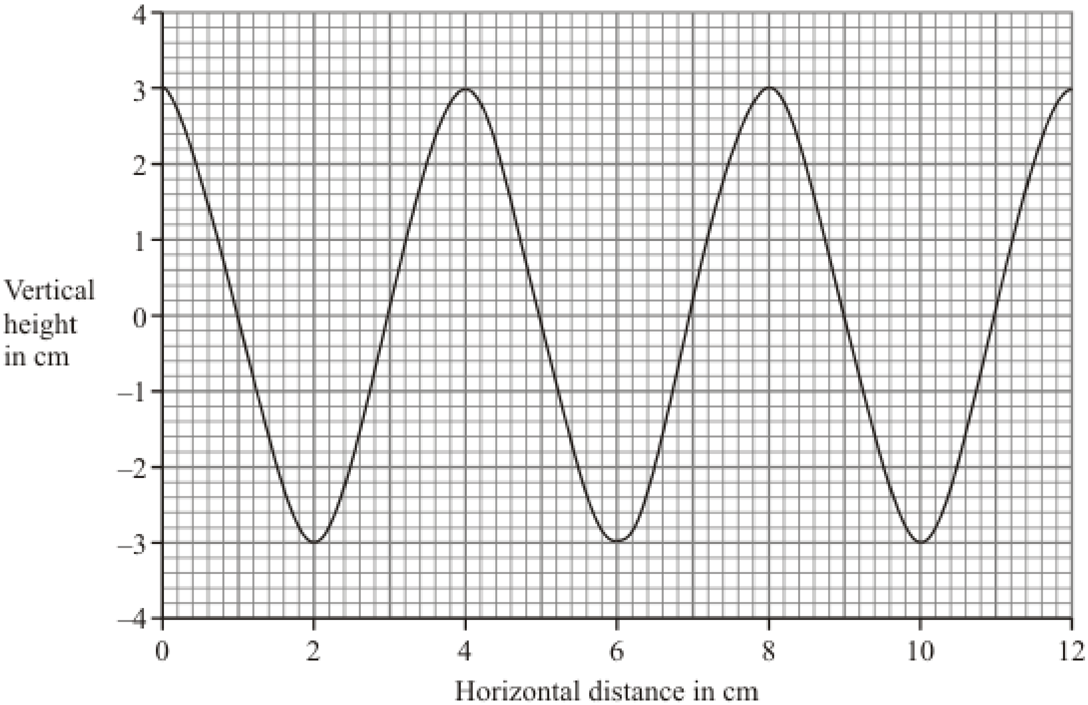




2. Calculate the time period and the frequency of each wave. (4)
3. A wave travelling at 3000 m/s has a wavelength of 1 m.
   a. Calculate the frequency of the wave.
   b. Calculate the time period of the wave.
   c. How many complete wave cycles will occur in:
      i. 1 second?
      ii. 10 seconds?
      iii. 1 minute? (5)
4. A radio wave has a wavelength of 1000 m and a frequency of 3×10^{5} Hz. Calculate the wave speed. (1)
5. A gamma wave has a wavelength of 1×10^{-12} m and a frequency of 3×10^{20} Hz. Calculate the wave speed. (1)

Exam Questions

Q1. The diagram shows a water wave drawn to scale.



(a) What is the wavelength of this water wave? .... cm

(1)

(b) What is the amplitude? .... cm

(1)

(c) Twelve waves pass an observer in four seconds.

What is the frequency of the waves? Show clearly how you work out your answer and give the unit.

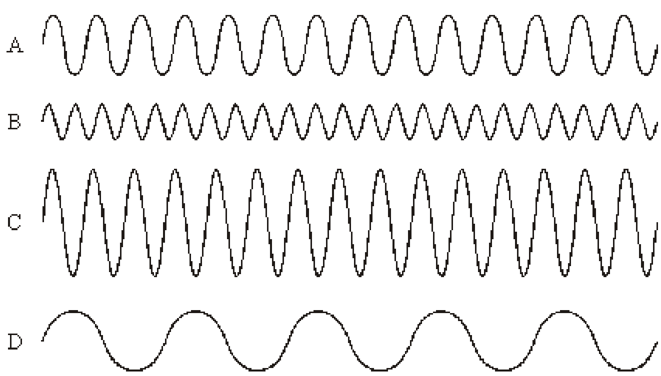
....

....

Frequency = ...

(3)
(Total 5 marks)

Q2. The diagram shows oscilloscope traces of four waves, **A**, **B**, **C** and **D**. All four waves are drawn to the same scale.



Which wave has:

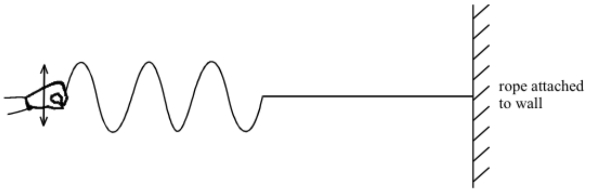
(a) the longest wavelength; ....

(b) the greatest amplitude; ....

(c) the highest frequency? ....

(Total 3 marks)

Q3. The diagram shows some waves travelling along a rope.



(a) Show on the diagram

(i) the wavelength of one of the waves

(2)

(ii) the amplitude of one of the waves

(2)

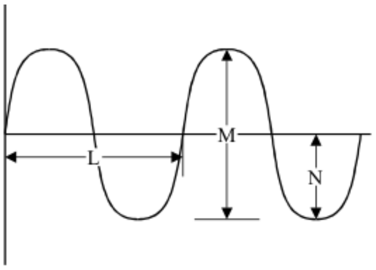
(b) The waves shown on the diagram were produced in two seconds.

What is the frequency of the waves?

....

(2)
(Total 6 marks)

Q4. (a) The diagram shows a wave pattern.



Which letter, **L**, **M** or **N** shows:

(i) the wavelength? ....

(ii) the amplitude? ....

(2)

(c) Describe how you could show that visible light travels in straight lines. You may wish to draw a diagram to help explain your answer.

....

....

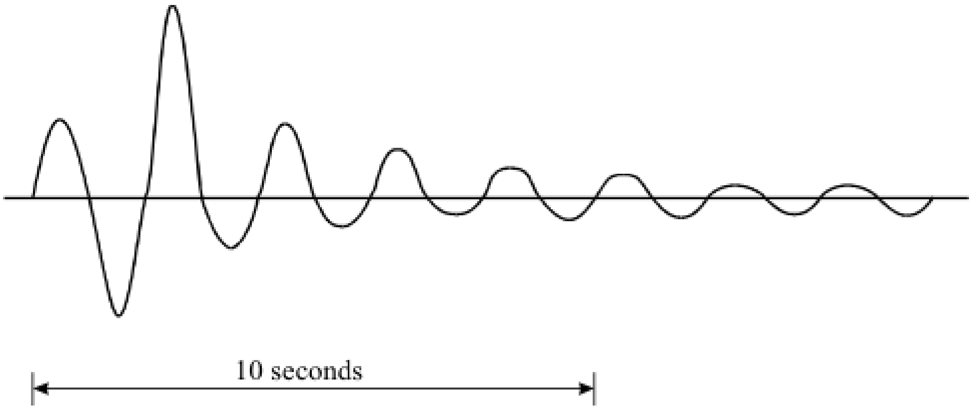
....

....

....

(2)
(Total 4 marks)

Q5. The vibration caused by a P wave travelling at 7.6 km/s has been recorded on a seismic chart.



(i) How many waves are produced in one second?

....

(1)

(ii) Write down the equation which links frequency, wavelength and wave speed.

....

(1)

(iii) Calculate the wavelength of the P wave. Show clearly how you work out your answer and give the unit.

....

....

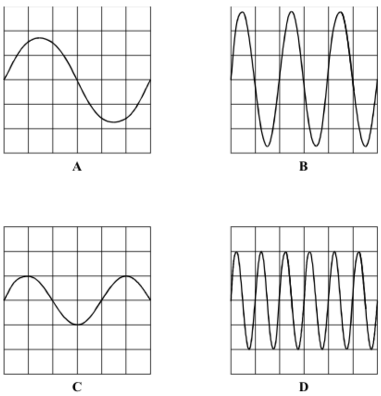
....

Wavelength = ...

(2)

(Total 4 marks)

Q6. The diagram shows four oscilloscope wave traces. The controls of the oscilloscope were the same for each wave trace.



Which **one** of the waves traces, **A**, **B**, **C** or **D**, has:

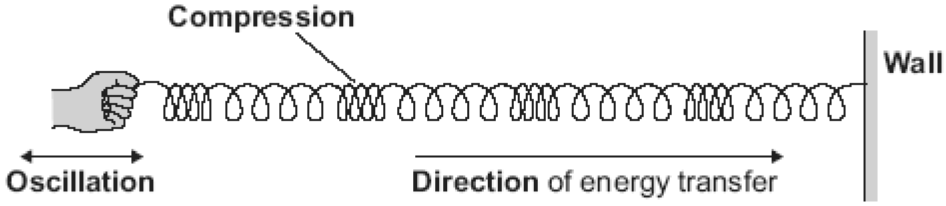
(i) the largest amplitude, ...

(1)

(ii) the lowest frequency? ....

(1)
(Total 2 marks)

Q7. (a) The diagram shows a longitudinal wave being produced in a stretched spring.



(i) Use the bold words from the diagram to complete the following sentence. Put only **one** word in each space.

A longitudinal wave is one in which the .... causing

the wave is parallel to the .... of energy transfer.

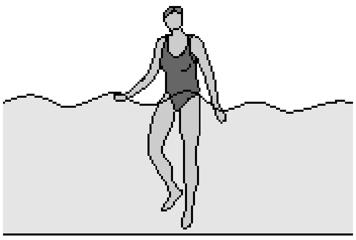
(2)

(ii) Name the type of energy that is transferred by longitudinal waves.

....

(1)

(b) The diagram shows water waves made by a wave machine in a swimming pool.



Every second, two waves go past a person standing in the swimming pool.

The waves have a wavelength of 0.8 metres.

Calculate the speed of the water waves.

Write down the equation you use, and then show clearly how you work out your answer.

....

....

....

....

....

....

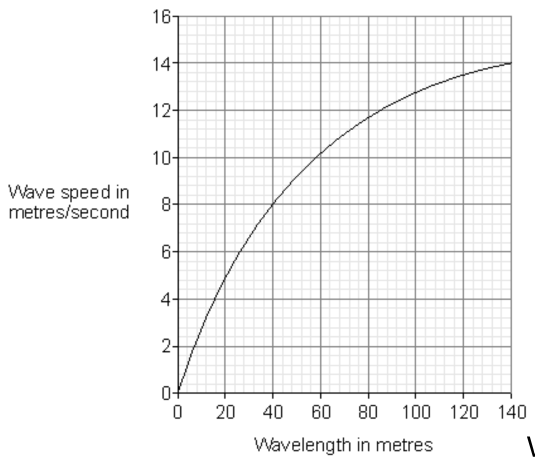
....

....

Wave speed = ... m/s

(2)

(c) The graph shows how the speed of deep ocean waves depends on the wavelength of the waves.



What can you conclude from the graph?

....

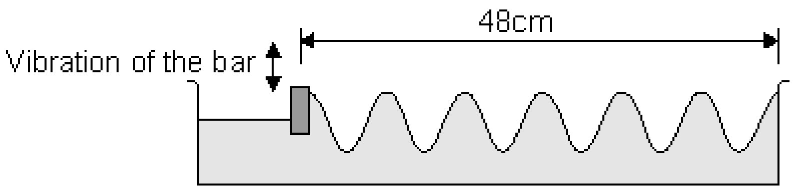
....

....**(2)**

(Total 7 marks)

Q8. Water waves can be made by vibrating a wooden bar up and down in a tray of water.

The bar moves up and down at a frequency of 5 hertz.



(a) Calculate the speed, in cm/s, of the water waves.

Write down the equation you use and then show clearly how you work out your answer.

....

....

....

....

....

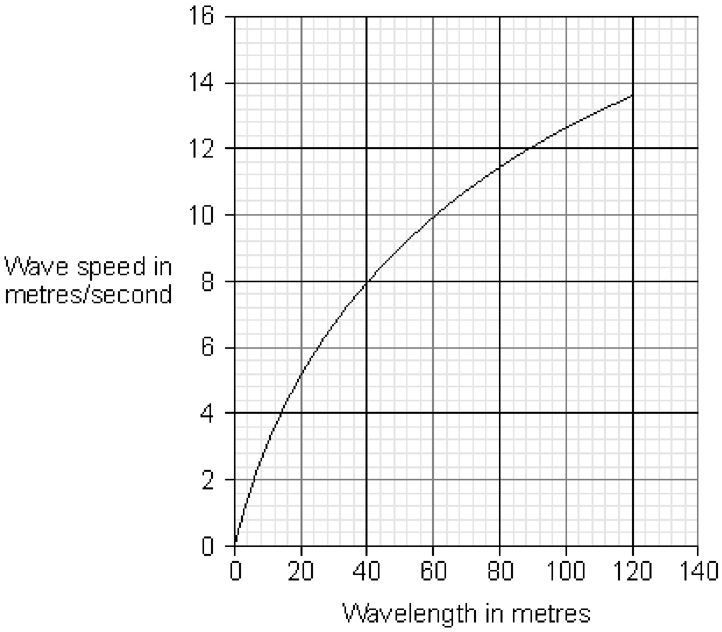
....

....

Wave speed = ... cm/s

(3)

(b) The graph shows how the speed of deep ocean waves depends on the wavelength of the waves.



Use the graph to predict a speed for waves with a wavelength of 140 m.

Show clearly how you have used the graph to work out your answer.

Speed of waves = ... m/s

(2)
(Total 5 marks)

Q9. (a) Microwaves are one type of electromagnetic wave.

(i) Which type of electromagnetic wave has a lower frequency than microwaves?

....

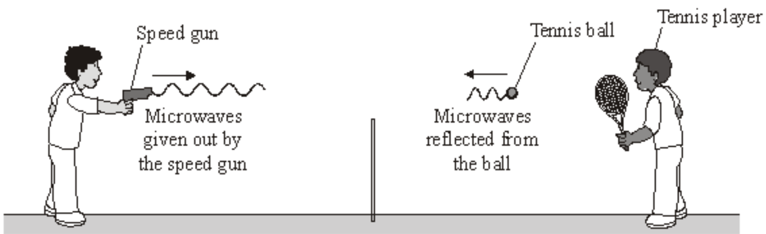
(1)

(ii) What do all types of electromagnetic wave transfer from one place to another?

....

(1)

(b) The picture shows a tennis coach using a speed gun to measure how fast the player serves the ball.



(i) The microwaves transmitted by the speed gun have a frequency of 24 000 000 000 Hz and travel through the air at 300 000 000 m/s.

Use the equation in the box to calculate the wavelength of the microwaves emitted from the speed gun.

wave speed = frequency × wavelength

Show clearly how you work out your answer.

....

....

Wavelength = ... m

(2)

(ii) Some of the microwaves transmitted by the speed gun are absorbed by the ball.

What effect will the absorbed microwaves have on the ball?

....

....

(1)

(iii) Some of the microwaves transmitted by the speed gun are reflected from the moving ball back towards the speed gun.

Describe how the wavelength and frequency of the microwaves change as they are reflected from the moving ball.

....

....

....

....

(2)
(Total 7 marks)

Q10. All radio waves travel at 300 000 000 m/s in air.

(i) Give the equation that links the frequency, speed and wavelength of a wave.

....

(1)

(ii) Calculate the wavelength, in metres, of a radio wave which is broadcast at a frequency of 909 kHz. Show clearly how you work out your answer.

....

....

....

Wavelength = ... metres

(2)
(Total 3 marks)

Q11. Microwaves are used to transmit signals to the satellite. The microwaves have a wavelength of 0.6 metres (m) and travel through space at a speed of 300 000 000 metres per second (m/s).

(i) Write down the equation which links frequency, wavelength and wave speed.

....

(1)

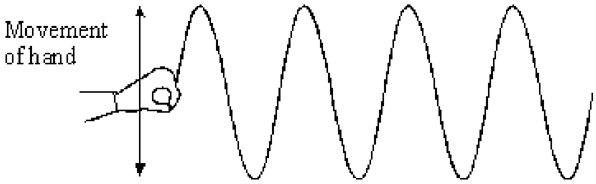
(ii) Calculate the frequency of the microwaves. Show clearly how you work out your answer and give the unit.

....

.... Frequency = ...

(3)

Q12. The diagram shows a wave travelling along a rope.



(a) On the diagram:

(i) show the wavelength and label it **W**;

(ii) show the amplitude and label it **A**.

(2)

(b) The wavelength of the wave is 0. I m. Its frequency is 2 Hz.

Calculate the speed of the wave. Show clearly how you work out your answer and give the unit.

....

....

....

Speed of wave ....

(3)
(Total 5 marks)

Q13. (a) The wavelengths of four different types of electromagnetic wave, including visible light waves, are given in the table.

Type of wave	**Wavelength**
Visible light	0.0005 mm
A	1.1 km
B	100 mm
C	0.18 mm

Which of the waves, **A**, **B** or **C**, is an infra red wave? ....

(1)

(b) A TV station broadcasts at 500 000 kHz. The waves travel through the air at 300 000 000 m/s.

Use the equation in the box to calculate the wavelength of the waves broadcast by this station.

wave speed = frequency × wavelength

Show clearly how you work out your answer.

....

....

Wavelength = ... m

(2)

(c) What happens when a metal aerial absorbs radio waves?

....

....

....

....

(2)

(d) Stars emit all types of electromagnetic waves. Telescopes that monitor X-rays are mounted on satellites in space.

Why would an X-ray telescope based on Earth not be able to detect X-rays emitted from distant stars?

....

....**(1)**

(Total 6 marks)

Q14. Radio waves, ultra-violet, visible light and X-rays are all types of electromagnetic radiation.

(a) Choose wavelengths from the list below to complete the table.

3×10^{-8} m 1×10^{-11} m 5×10^{-7} m 1500 m

TYPE OF RADIATION	WAVELENGTH (m)
Radio waves	
Ultra-violet	
Visible light	
X-rays	

(4)

(b) Microwaves are another type of electromagnetic radiation.

Calculate the frequency of microwaves of wavelength 3 cm.
(The velocity of electromagnetic waves is 3×10^8 m/s.)

....

....

....

....**(4)**

(Total 8 marks)

Mark scheme

M1. (a) 4

1

(b) 3

1

(c) 3

correct answer with no working = 2
allow 1 mark for f = number ÷ time
or correct working i.e., 12 ÷ 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]

M2. (a) **D**

1

(b) **C**

1

(c) **B**

1

[3]

M3. (a) (i) a horizontal distance indicated and labelled

gains 1 mark

but
horizontal distance indicated between identical points on adjacent waves (to within 3-4mm) and labelled

gains 2 marks

2

(ii) peak ↔ trough indicated*

gains 1 mark

but
peak / trough ↔ mean indicated*

(to within 1-2mm either end)*

gains 2 marks
(allow 1 mark if both lines unlabelled or 2 marks if both lines accurately drawn and unlabelled)

2

(b) • 1.5

• hertz / Hz **or** (waves / cycles) per second

for 1 mark each
(do not allow wavelength / hertz per second)

2

[6]

M6. (i) B

1

M4. (a) (i) L

1

(ii) N

1

(c) the answer should be in the form:

***not** inside the eye*

either for **both** marks an arrangement which could demonstrate visibly light travels in straight lines

full credit should be given for answer presented as a diagram **and**
an explanation of how it shows the straightness

or for one mark

named device which uses principle of light travelling in straight lines to work

examples
light (from a street lamp) strikes an object producing a shadow
laser light travelling through (fine) dust shows a straight beam
three pieces of card with central holes need to be lined up to be able to see through the third hole from the first
ray box type experiment using mirrors/prisms, etc
beams on paper or in smoke
torch beams through smoke

example devices:–
–pinhole camera (qualification may get second mark)
–periscope
–optical fibre
*–reflection 'in a **mirror***

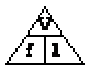
2

[4]

M5. (i) 0.5 1

(ii) wave speed = frequency × wavelength

accept $v = f \times \lambda$
accept s for v
accept m/s = Hz × m
accept



providing subsequent method correct

1

(iii) 15.2 km

both numerical answer and unit are required for both marks
numerical answer and unit must be consistent
*allow **1** mark for 15.2 with incorrect or no unit*
*allow **2** marks for an answer of 1.52 km if the answer to (b)(i) was given as 5*
***r** 1 mark for correct transformation*
***or** 1 mark for correct use of speed = distance/time*

unit on its own gains no credit

2

[4]

M7. (a) (i) oscillation

1

direction

1

correct order only

(ii) A

1

[2]

M8. (a) 40 (cm/s)

correct answer

an answer 0.4 m/s gains full credit

if answer is incorrect

*allow **1** mark for correct wavelength λ = 8 cm*

or

*allow **2** marks for correct substitution into the correct equation, ie. V = 5 × 8*

or

*allow **2** marks for clearly stated wrong wavelength correctly substituted into correct equation and correctly calculated, ie*
λ = 16 cm/s
V = 5 × 16
= 80

3

(b) line extended following pattern

1

14 m/s

accept their numerical value, if not 14, provided the first mark has been awarded

1

[5]

M9. (a) (i) radio(waves)

1

(ii) energy

correct answer only

1

(b) (i) 0.0125 (m)

*allow **1** mark for correct transformation <u>and</u> substitution*

2

(ii) make it hot(ter)

*do **not** accept cook it*
accept (air) particles inside ball will move faster
accept water in the ball gets hotter

1

(iii) wavelength decreases

ignore reference to speed

1

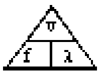
frequency increases

1

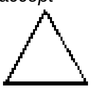
[7]

M11. (i) wave speed = frequency × wavelength

accept correct transformation
***accept** v = f × λ*
accept s for speed
accept m/s = Hz x m

accept 

if subsequent use of


is correct

1

(ii) 500 000 000

*credit for **1** mark correct transformation in words **or** numbers **or** correct substitution*

2

Hertz

***3** marks for 500 000k Hz **or** 500 MHz*

*numerical answer **and** unit must be consistent for full credit*

1

[4]

(ii) sound

1

(b) 1.6

*allow **1** mark for correct substitution into correct equation ie 2 x 0.8*

2

(c) as the wavelength increases so does the wave speed

1

extra information eg wave speed increases faster between
0-40 m than between 100-140 m

or

not in proportion

1

[7]

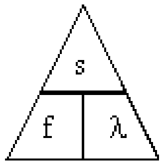
M10. (i) speed = frequency × wavelength

accept the equation rearranged

*accept v **or** s = f × λ*

do not allow w for wavelength

do not accept



unless subsequent calculation correct

1

(ii) 330 (m)

allow 1 mark for

λ =

$$\frac{300\,000\,000}{909\,000}$$

***or** 300 000 000 = 909 000 × λ*

***or** answer of 330000(m) **or** 330033(m)*

2

[3]

M12. (a) any two successive peaks labelled **W**

accept any 2 points on same part of adjacent waves correct by eye

1

half 'height' of wave labelled **A**

correct by eye
N.B. at least one of the answers must be labelled

1

(b) 0.2

correct answer with no working = 2
allow 1 mark for s = f x w or correct working i.e., 2 × 0.1
N.B. correct answer from incorrectly recalled relationship = 0

2

m/s (unit)

*independent mark do **not** allow mps **or** mHz*

1

[5]

M13. (a) C or 0.18 mm

1

(b) 0.6 m

*allow **1** mark for correct transformation and substitution*

*allow **1** mark for changing frequency to Hz*

*answer 600 gains **1** mark*

2

(c) creates an alternating current

accept 'ac' for alternating current

accept alternating voltage

1

with the same frequency as the radio wave

accept signal for radio wave

or it gets hotter

1

(d) X-rays cannot penetrate the atmosphere

accept atmosphere stops X-rays

*do **not** accept atmosphere in the way*

or X-rays are absorbed (by the atmosphere)

before reaching Earth
ignore explanations

1

[6]

M14. (a) radio – 1500
ultra violet 3×10^{-8}
visible – 5×10^{-7}
X-rays – 1×10^{-11}

4

(b) 1×10^{10}Hz 10^{10}HzOK

for 4 marks

else 1×10^{10}

for 3 marks

else $3 \times 10^{8}/0.03$

for 2 marks

else v = frequency × wavelength or $3 \times 10^{8} = 0.03f$
any answer with unit Hz scores 1, 2 or 3

for 1 mark

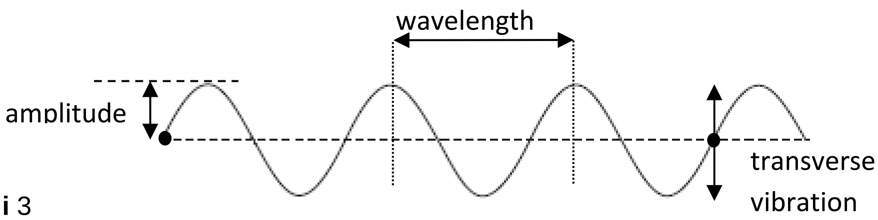
4

[8]

Waves – knowing the words is half the battle

Answers to questions

a and **c** (wavelength can be any complete wave)



b **i** 3

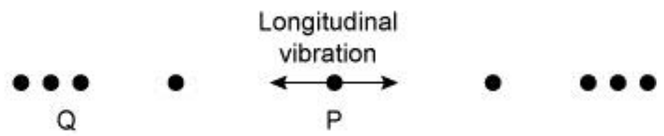
ii 200 cm

d **i** Trough.

ii They move to the right.

iii In a transverse wave a particle vibrates up and down at right angles to the direction of travel of the wave.

a



b **i** Compression.

ii The air pressure is higher at Q. The molecules are closer together.

iii In a longitudinal wave a particle vibrates back and forth along the direction of travel of the wave.

3 a wavelength

b amplitude

c frequency

d electromagnetic

Wave speed worksheet answers

	a	Diagram must show direction of wave travel. Diagram must show direction of vibration perpendicular to direction of wave travel.	2
	b	Diagram must show direction of wave travel. Diagram must show direction of vibration parallel to direction of wave travel.	2
■		**A** amplitude **3** **B** frequency **4** **C** wave speed **1** **D** wavelength **2**	4
■		**A** It is a virtual image.	1
4		**Similarity**: They can both be reflected, refracted, diffracted. **Difference**: Light waves are much faster /sound waves are much slower OR light waves are transverse/sound waves are longitudinal.	2
5		$v = f \times \lambda$ so 256 × 1.3 = 333 m/s	2
6	**a**	**i** Any example using a mirror/water or a shiny smooth surface.	1
		ii Any example of an echo.	1
		iii Any example using a lens, e.g. spectacles, cameras.	1
		iv Any example of hearing a sound around a corner.	1
	b	The wavelength of light is very small, so diffraction only occurs when light passes through a very narrow gap. **OR** The wavelength of light is very small, so the diffraction effect is very small.	2
7		Wave speed = frequency × wavelength Frequency = $\frac{\text{speed}}{\text{wavelength}}$ Frequency = $\frac{300000000\text{m/s}}{1500\text{m}}$ Frequency = 200 000 Hz	3
8		There is a clear, balanced and detailed description of how the wave form would change including increased amplitude and frequency. The answer shows almost faultless spelling, punctuation and grammar. It is coherent and in an organised, logical sequence. It contains a range of appropriate or relevant specialist terms used accurately.	5-6
		There is a description of at least one of the ways in which the wave form would change. There are some errors in spelling, punctuation and grammar. The answer has some structure and organisation. The use of specialist terms has been attempted, but not always accurately.	3-4
		There is a brief description of at least one way in which the wave form would change, which has little clarity and detail. The spelling, punctuation and grammar are very weak. The answer is poorly organised with almost no specialist terms and/or their use demonstrating a general lack of understanding of their meaning.	1-2
		No relevant content.	0

Examples of physics points made in the response:

- louder sound means larger amplitude
- so height of crests increases
- depth of troughs increases
- speed is constant
- higher pitch means higher frequency
- so wavelength becomes smaller
- crests are closer together.

Waves speed formula answers

Answers to questions

a)Three wavelengths is 12 cm, so one wavelength is 4 cm.

b A crest takes 6 seconds to move from A to D.

i 1/3 of 6 seconds = 2 seconds

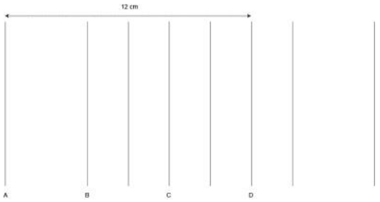
ii half a wave, 0.5

iii 2 cm/s

iv 0.5 Hz

v Frequency is the number of waves that pass a point in one second.

c

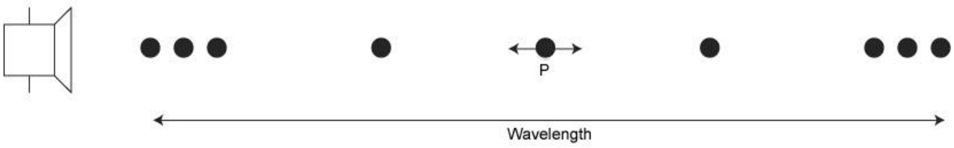


d

i The molecules stay in the same place but vibrate backwards and forwards from left to right.

ii See diagram

iii See diagram



e) A position where the molecules are far apart and where air pressure is the lowest as the wave passes.

f)300 ÷ 600 = 0.5 m

g)

iv frequency increases

ii wavelength decreases

iii The molecule at P vibrates faster from side to side; each complete vibration takes a shorter time.

h)

Wave speed = frequency × wavelength 3

$$\text{Frequency} = \frac{\text{speed}}{\text{wavelength}}$$

$$\text{Frequency} = \frac{300000000\,\text{m/s}}{1500\,\text{m}}$$

Frequency = 200 000 Hz

i).a *wavelength = wave speed / frequency*

b $\lambda = c / f = 3 \times 10^8 / 6 \times 10^5 = 500$ m

c By diffraction over the hill.

d Another radio station emits waves of frequency 6×10^8 Hz.

i $\lambda = c / f = 3 \times 10^8 / 6 \times 10^8 = 0.5$ m

ii Fill in the gaps in the sentence below.

As the frequency of the radio waves decreases, the wavelength **increases**,

while the speed of the waves **remains the same**.

Test yourself Worksheet Answers

1.Wavelengths correctly drawn for both (2) or for one (1)
Amplitudes correctly drawn for both (2) or for one (1)

2.First wave: time period = 6 s/2 = 3 s (1)

Frequency = 1/3 s = 0.3 Hz (1)
Second wave: time period = 6 s/6 = 1 s (1)
Frequency = 1/1 s = 1 Hz (1)

3.A wave travelling at 3000 m/s has a wavelength of 1 m.

a. $f = v/\lambda$ = 3000/1 = 3000 Hz. (1)
b. $T = 1/f$ = 1/3000 = $3.3\text{x}10^{-4}$ s (1)
c. How many complete wave cycles will occur in:
   i. $1/3.3\text{x}10^{-4}$ s = 3000 wave cycles. (1)
   ii. $10/3.3\text{x}10^{-4}$ s = 30000 wave cycles. (1)
   iii. $60/3.3\text{x}10^{-4}$ s = 180 000 wave cycles. (1)

4. $v = \lambda f$ = 1000 x $3\text{x}10^{5}$ = $3\text{x}10^{8}$ m/s (1)

5.$v = \lambda f$ = $1\text{x}10^{-12}$ x $3\text{x}10^{20}$ = $3\text{x}10^{8}$ m/v (1)

Total Marks: 15