S3 Physics

Name:

Class:

Teacher:

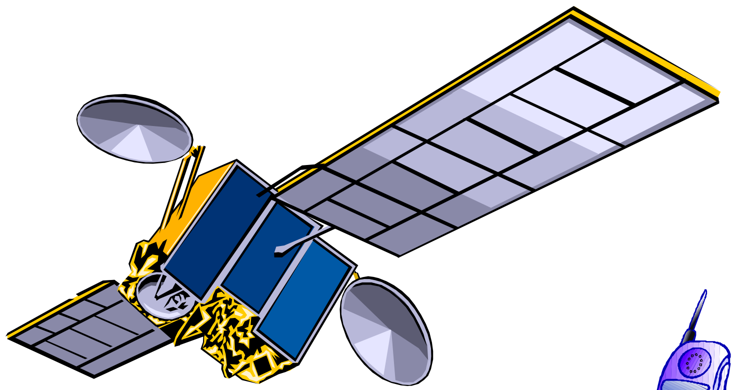
Paisley Grammar School

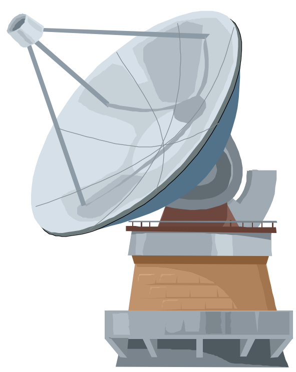
Physics Department

UNIT 1

Signals

PUPIL PACK





Study Guides
Summary Notes
Questions
Homework Sheets

S3 Physics: Signals
Study Guide

Section 1 – Communication Using Waves

Since the earliest times, humans have tried to communicate with each other. The ability to communicate effectively is at the heart of civilisation. All of the early attempts at telecommunications relied on two types of waves: light and sound.

In this section, you will find out about communicating using sound and other waves, and you will also find out more about waves themselves.

- ❑ 1. Give an example that shows the speed of sound in air is very much less than the speed of light in air.
- ❑ 2. Describe an experimental method for measuring the speed of sound in air.
- ❑ 3. Carry out calculations involving $speed = \frac{distance}{time}$ in problems on sound.
- ❑ 4. State that waves are one way of carrying signals.
- ❑ 5. Use each of these terms correctly with respect to sound: *wave*; *frequency*; *wavelength*; *speed*; *energy, energy transfer*; *amplitude*.
- ❑ 6. Carry out calculations involving $speed = \frac{distance}{time}$ in problems on water waves.

.

Section 2 – Communication Using Cables

In some modern telecommunications systems, the messages are carried along cables. This could be electrical cables, such as in telegraph and telephone systems, or optical fibres. Optical fibres are lighter, cheaper and less prone to tapping or crossed lines, and so most telecommunications companies are adopting them nowadays.

At the end of this section you should be able to:

- ❑ 1. Describe how a message can be sent using a code – for example, Morse Code.
- ❑ 2. State the function of: *(a)* a transmitter; and *(b)* a receiver.
- ❑ 3. State that the telephone is an example of long range communication between a transmitter and receiver.
- ❑ 4. State the energy changes in: *(a)* a microphone; and *(b)* a loudspeaker.
- ❑ 5. State which device can be found in a telephone's: *(a)* earpiece; and *(b)* mouthpiece.
- ❑ 6. State that electrical signals can be transmitted along wires during a telephone call.
- ❑ 7. State that the speed of a telephone signal is very much greater than the speed of sound.

Section 3 – Radio and Television

Radio communication is used by millions of people for entertainment and for information. Radio is very important to the emergency services, and to the military. Most people use the television a lot, usually for entertainment, and often for news and other information. Television has become such an important part of society that it is often a person's main window on the world.

In this section, you will discover how a radio and a television work.

❑ 1. Name the main parts of a radio receiver.

❑ 2. Identify these parts on a block diagram of a radio receiver.

❑ 3. Describe the function of each of these parts of a radio receiver.

❑ 4. Name the main parts of a television receiver.

❑ 5. Identify these parts on a block diagram of a television receiver.

❑ 6. Describe the function of each of these parts of a television receiver.

❑ 7. Describe how a picture is produced on a television screen in terms of line build-up.

❑ 8. Explain how colour pictures can be produced on a television screen using red, green and blue light.

❍ 9. Describe how a moving picture is seen on a television screen using these terms: *line build-up*; *image retention*; *brightness variation*.

❍ 10. Describe the effects of mixing red, green and/or blue light.

Section 4 – Transmission of Radio Waves

A lot of the modern telecommunications systems use radio waves or microwaves to carry the information between the transmitter and receiver. To understand how these systems work, we have to first understand how the waves that carry the information behave. You will find out about the behaviour of waves in this section.

The first man-made satellite, "Sputnik I", was launched in 1957. Nowadays, several satellites are used to transmit thousands of phone calls and many television channels around the world (and all at the same time!)

In this section you will find out about the use of satellites to enable communication with all parts of the world, and about the aerials used to send and receive signals over long distances.

By the end of this section you should be able to:

❑ 1. State that mobile telephones, radio and television are examples of long range communication which do not need cables between the transmitter and receiver.

❑ 2. State that microwaves, radio and television signals are waves that carry energy.

❑ 3. State that microwaves, television and radio signals travel at very high speeds.

❑ 4. State the speed of microwaves, television and radio signals through air.

❍ 5. Carry out calculations involving the relationship between speed (v), distance (d) and time (t) in problems on microwaves, television and radio waves.

Section 1 - Communication Using Sound

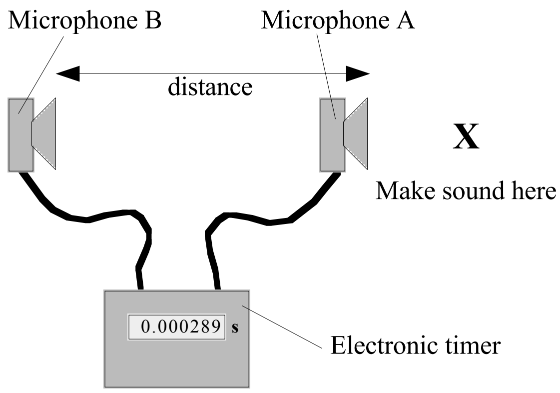
The Speed of Sound

The speed of sound in air is much less than the speed of light.

Speed of sound in air is about 340 m/s
Speed of light in air is 300,000,000 m/s

An example of this is when a flash of lightning (light) is seen before the thunder (sound) is heard, although both were produced at the same time

Measuring the Speed of Sound



Make a loud sound at X.

When the sound reaches microphone A the electronic timer starts and when sound reaches microphone B the timer stops.

Measure the distance between the microphones with a ruler.

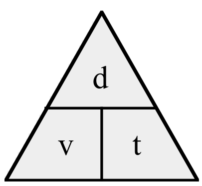
$$\text{Speed of sound} = \frac{\text{distance}}{\text{time}}$$

Speed, Distance and Time
(sound waves)

m

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

m/s s



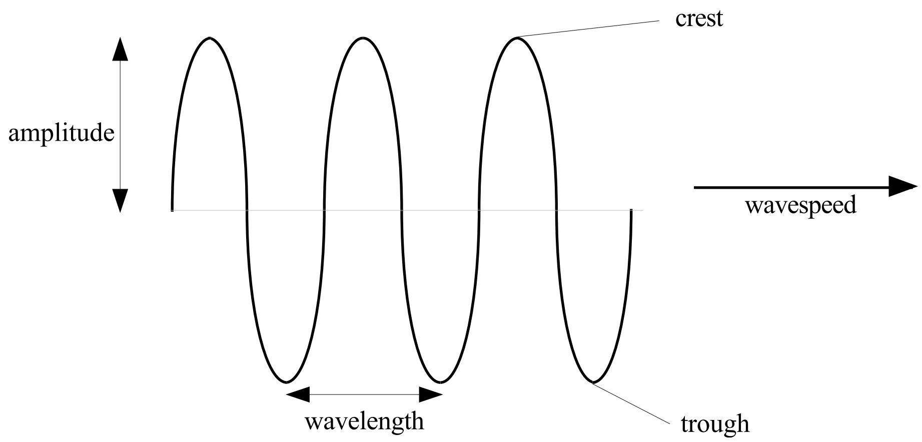
$d = v\,t$

$v = \dfrac{d}{t}$

$t = \dfrac{d}{v}$

Wave Terms

Waves carry **energy** from place to place and therefore they can be used to transmit signals.



Frequency, **f** - Number of waves passing a point each second. Hertz (Hz)

$$\text{frequency} = \frac{\text{number of waves}}{\text{time (in seconds)}}$$

Wavespeed, v - Distance travelled by a wave in one second. metres per second (m/s)

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

Amplitude - Size of maximum disturbance from centre (zero) position. -

Wavelength, λ - Distance from one point on a wave to the same point on the next wave. metres (m)

Period, **T** - Time taken for one wave to pass a point. seconds (s)

Section 2 - Communication Using Cables

Transmitters and Receivers

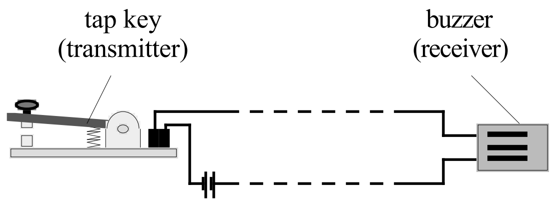
Sound is of limited use as a method of communication since it can only travel short distances and it is difficult to keep the communication private.

Other methods of communication (e.g. the Morse code telegraph and the telephone) permit communication over much longer distances.

In such methods the message is encoded and sent out by a **transmitter** and then picked up by a **receiver**.

Morse Code Telegraph

In the Morse code telegraph electrical signals are transmitted along wires at very high speed (almost 300,000,000 m/s).



Each letter of the alphabet is encoded as a series of long and short pulses ('dashes' and 'dots') of electricity:

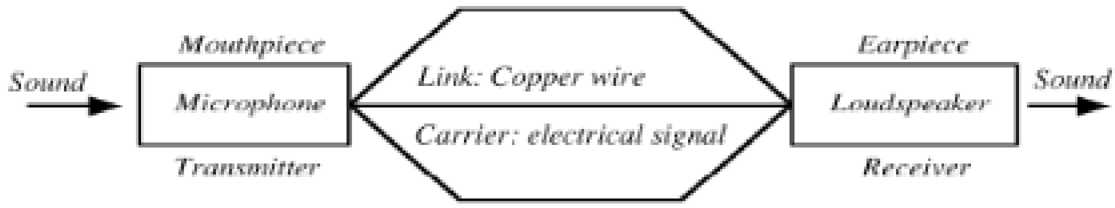
A = • ▬ , B = ▬ • • • , C = ▬ • ▬ •

Telephone

In a telephone, sound is converted directly into an electrical signal at the **mouthpiece** (the transmitter), which is then sent along a wire to an **earpiece** (the receiver) where it is converted back into sound. The electrical signal travels along the wire at almost the speed of light (300,000,000 m/s). Some networks convert the electrical signal into Light which is sent along Fibre optics at 200 000 000m/s, then converted back to an electrical signal

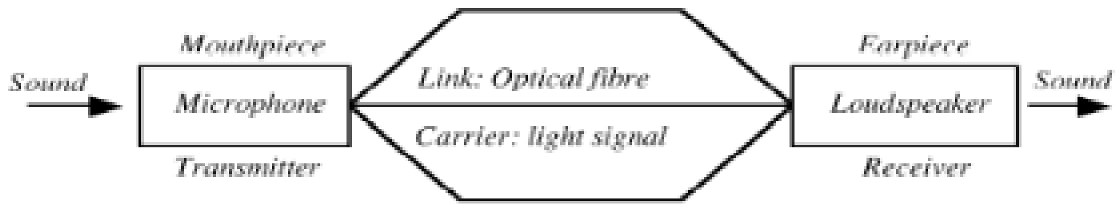
The mouthpiece contains a **microphone** which converts *sound into electrical energy* and the earpiece contains a **loudspeaker** which converts *electrical into sound energy*. The telephone can communicate over long distances, there is no need to know a special code and is is fairly private.

People can speak to each other, over long distances, by telephone. Speech is changed



into an electrical signal and changed back again at the receiver.

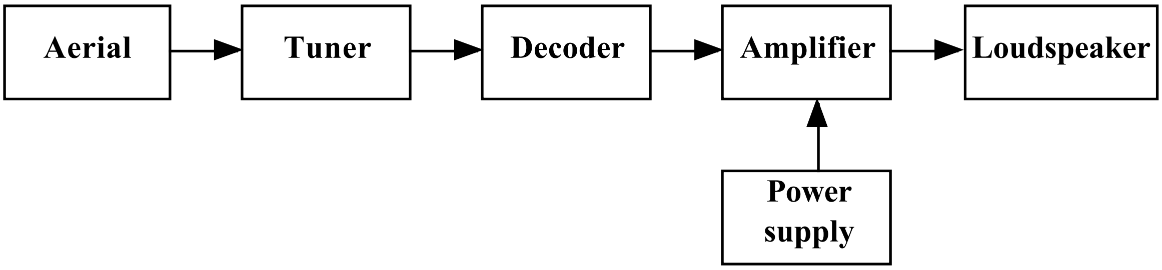
Phones can be connected by copper wire (shown above) or optical fibre (shown below).



Section 3 - Radio and Television

Radio Receiver

The main parts of a radio receiver can be represented in a block diagram :



The **aerial** picks up radio waves of many different frequencies and converts them into electrical signals.

The **tuner** selects one particular frequency from the many received by the aerial.

The **decoder** extracts the audio (sound) signal from the transmitted radio signal.

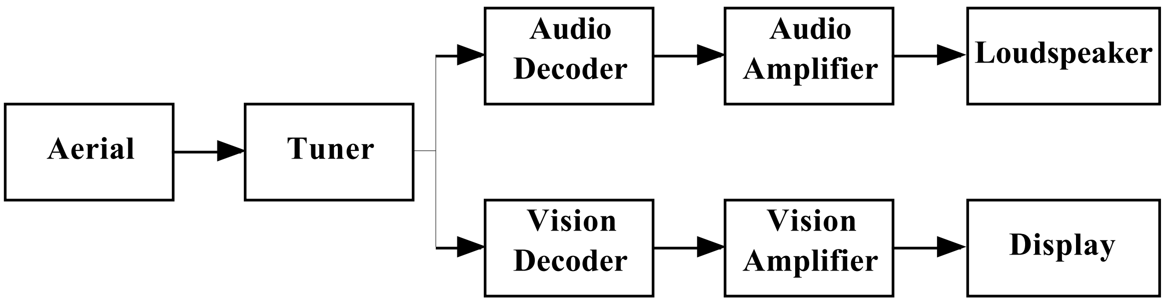
The **amplifier** increases the strength of the electrical signal.

The **loudspeaker** converts the electrical signal into sound.

The **power supply** supplies extra energy for the amplifier.

Television Receiver

The main parts of a television receiver can be represented in a block diagram :



The **aerial** picks up television waves of many different frequencies and converts them into electrical signals.

The **tuner** selects one particular frequency from the many received by the aerial.

The **audio decoder** extracts the audio (sound) signal from the transmitted television signal.

The **audio amplifier** increases the strength of the electrical audio signal.

The **loudspeaker** converts the electrical signal into sound.

The **vision decoder** extracts the vision (picture) signal from the transmitted television signal.

The **vision amplifier** increases the strength of the electrical vision signal.

The **display** converts the electrical signal into light.

There is also a **power supply** to supply extra energy to the amplifiers.

S3 Physics : Signals
Summary Notes

Colour Television

A colour television has three different coloured emitters (LED/Plasma) at each point or PIXEL on the screen. They are lit up with varying brightness. This allows all the colours to be produced by colour mixing.
The three colours of pixels that are used are **red**, **green** and **blue**. These are the **primary colours of light**.

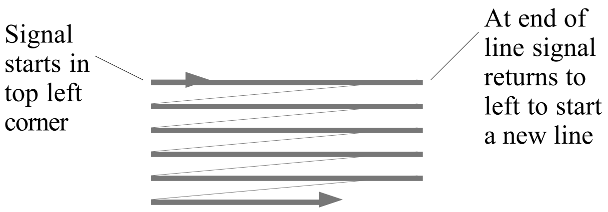
The primary colours can be mixed in equal intensities to produced the **secondary colours** as follows:

red + green = yellow
red + blue = magenta
blue + green = cyan (turquoise)
red + green + blue = white

Other colours can be produced by varying the relative intensities of the primary colours (e.g. yellow is produced by equal intensities of red and green, but if the red light is more intense than the green then orange is seen)

The Display

A picture is built up on the TV screen by in a series of **lines** (there are 625 lines on a UK TV:1080 in HD).



As the signal moves across the screen the **brightness** of each emitter is altered A new picture is produced 25 times each second and because **our eyes retain the image** on the retina of the eye each picture merges into the next. Since each picture is only slightly different from the previous one the picture appears to move.

S3 Physics - Signals

Questions

1. During a thunderstorm there was a time delay of 15 seconds between the lightning flash and the clap of thunder. If the storm was 5km (5000m) away, what value does this give for the speed of sound in air?

2. When the one o'clock gun is fired from Edinburgh Castle, some tourists see the puff of smoke 5 seconds before they hear the bang. How far away are they from the castle?

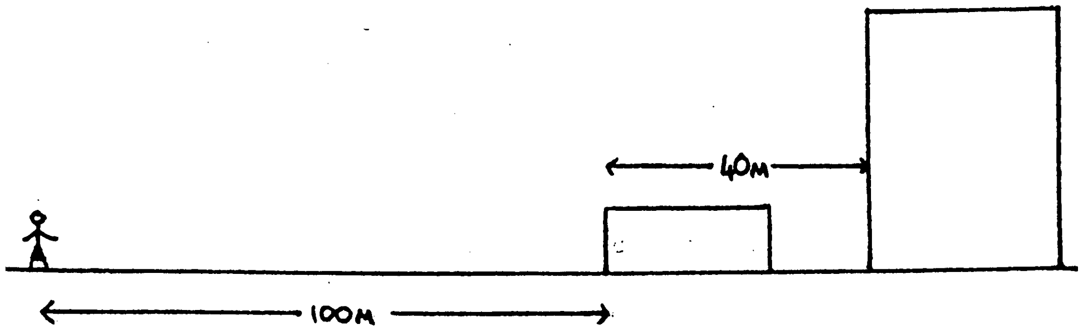
3. How long does it take sound energy to travel 1km through air (answer to the nearest second)?

4. How far will sound (v=340m/s) travel in 1 minute?

5. A lamp and a horn are turned on simultaneously. A person standing 240m away measures a time interval of 0.75s between seeing the flash and hearing the sound.
   (a) What is the speed of sound?
   (b) What assumption have you made in order to do this calculation?

6. An explosion in Dundee could be heard in St. Andrews a minute later, at a distance of 20km away. Use this information to calculate the speed of sound.

7. A girl stands l00m away from a low building which has a taller building 40m behind- it. When she shouts she hears two echoes 0. 25s apart. Use this information to calculate the speed of sound.



8. In important sprint races, the starting blocks are fitted with loudspeakers. Explain why this is necessary for sprints, whereas in longer races the starter just. stands.. beside the track with a starting pistol.

9. During the school sports, the timekeeper in the 80m hurdles stands at the finishing line and starts his stopwatch on hearing the starting pistol. Calculate the error there will be in his time for the race. Assume the speed of sound is 320.m/s . (Ignore the timekeeper's reaction time.)

10. If 10 waves pass a point in 2 seconds, what is the frequency?

11. A boy counts 24 water waves hitting a beach in 4 minutes. What is the frequency?

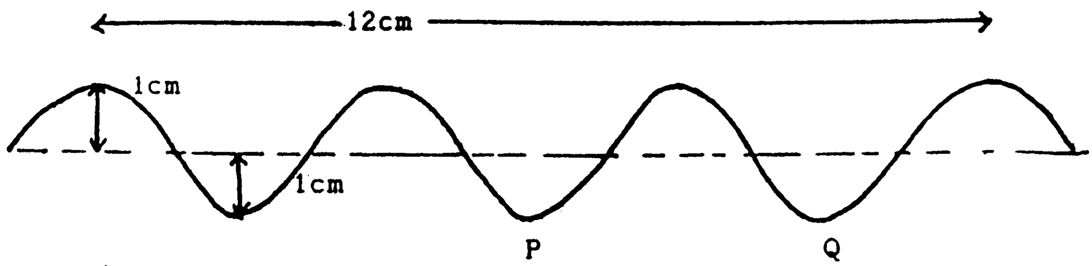
12. What is the frequency if (a) 10 waves pass a point in 2 seconds?
(b) 48 waves pass a point in 4 seconds?
(c) 40 waves pass a point in 5 seconds?

13. A loudspeaker vibrates at a frequency of 256 Hz to produce the note we call "middle C".
(a) How many waves does it produce in 1 second?
(b) How many waves does it produce in 1 minute?

14. When a stone is dropped into a pond the water waves spread out and travel a distance of 4 metres in 2 seconds. What is the speed of these waves?

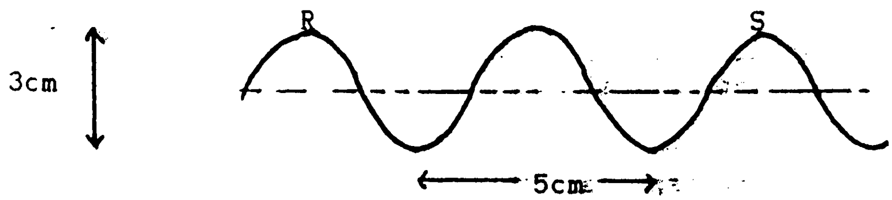
15. How long would it take for one wave to pass a point if
(a) 10 waves pass a point in 2 seconds?
(b) 10 waves pass a point in 50 seconds?
(c) 5 waves pass a point in 3.5 seconds?

16. (a) Find the amplitude and the wavelength of the waves in this diagram:



(b) What is the distance between the points P and Q?

17. Here is a diagram of some water waves:



(a) Find the amplitude of the waves.
(b) What is the distance between the points marked R and S?

18 What is meant by the "frequency" of a wave?

19. Draw three full waves and mark on your diagram:
    (a) the wavelength
    (b) the amplitude

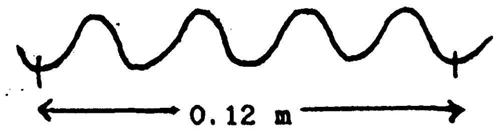
20. Two sound waves are examined using a microphone attached to a signal generator. The traces appear as shown:

Which wave has (a) the bigger amplitude?
(b) the bigger frequency?

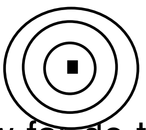
21. Copy and complete the following table by marking in the correct symbols and units.

Quantity	Symbol	Unit	Symbol
time	t	second	s
velocity			
wavelength			
frequency			

22. This diagram represents some water waves. If 80 crests pass a point in 20 seconds, find:
    (a) the frequency
    (b) the wavelength



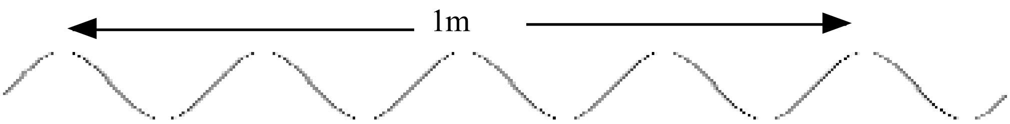
23. A photograph of waves in a pond caused. by a stone looks like this:



The photograph was taken 2 seconds after the stone hit the water and the wavelength of the waves is 40cm

(a) How far do the waves travel in the two seconds?
(b) Calculate the speed of the waves.

24. This diagram represents some water waves which are being made at a rate of 50 per second.



(a)• What is the frequency? . . . . . -
(b) Find the wavelength.

S3 Physics - Signals

Questions

25 How far does light travel through air in 10 seconds?

26 How Far does light travel through an optical fibre in 10 seconds?

27 How long does light take to travel 350 000 000 m through air?

28 How long does light take to travel through an optical fibre cable 1 000 000 000 m long?

29 How long does a signal take to travel along an optical fibre link between two towns which are 400 km (400 000 m) apart?

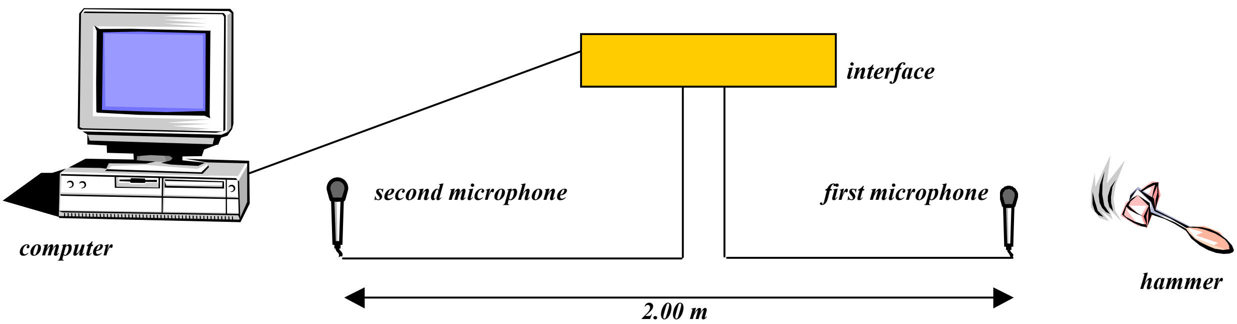
30 A signal takes 3 milliseconds (0.003 seconds) to travel a distance of 600 km (600 000 m) along a certain optical fibre link. At what speed does the light travel along this link?

31 A signal travelling at a speed of 2×10^8 m/s takes 2.5 milliseconds (0.002 5 seconds) to reach the end of a length of optical fibre cable. How long is the cable?

32 Signals travel at a speed of 2×10^8 m/s along a transatlantic optical fibre cable. How long is the cable if it takes 25 milliseconds (0.025 seconds) for the signal to travel along it?

Homework 1.1 - Communication Using Waves I

1. A pupil reads about an experiment that can be carried out to measure the speed of sound in air. When the hammer hits the metal block a sound wave is produced. The computer is used to measure the time it takes for the sound wave to travel from one microphone to the other. The computer will display the time taken for the sound to travel this distance or it can be used to calculate the speed of sound directly.



The pupil carried out the experiment, and the time measured was 0.006 s.

(a) What other information does the computer need to calculate the speed of sound for her? (1)
(b) Find the speed of sound using the pupil's results. (1)
(c) The pupil found that the speed was not calculated properly when the experiment was done close to a wall. Suggest a reason for this. (1)

2. You see a flash of lightning, and then hear the thunder 6 seconds later. How far away (roughly!) is the thunderstorm? Take the speed of sound to be 340 m/s. (1)

3. A person at the mouth of a cave shouts, and hears an echo from the back wall of the cave. Using a stopwatch, she times 1 second between shouting and hearing the echo. Calculate how far away the back wall of the cave is. Take the speed of sound to be 340 m/s. (3)

4. Copy and complete the following table. You **must** show all your working for each answer. (3)

SPEED	DISTANCE	TIME
10 m/s	100 m	
	3000 m	150 s
1.2 m/s		30 s

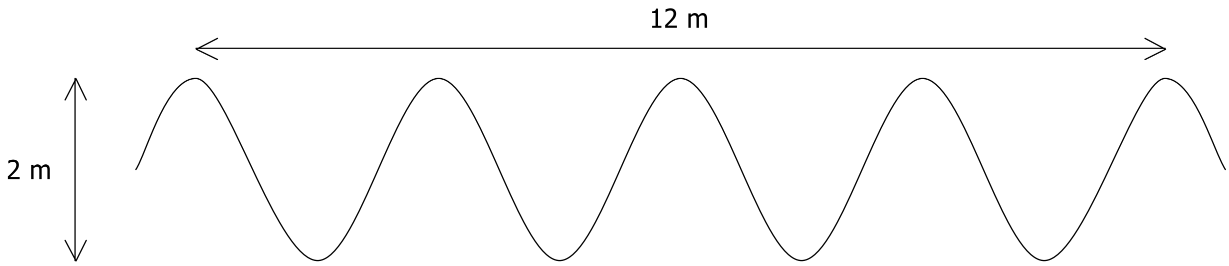
Total 10 marks

Homework 1.2 - Communication Using Waves II

1. Copy the table below and fill in the symbol, unit and definition for each term. (4)

WAVE TERM	SYMBOL	UNIT	DEFINITION
frequency			
wavelength			
speed			

2. The questions below refer to this diagram.



(a) Calculate the wavelength of the waves shown. (2)
(b) If the waves took 6 seconds to travel this distance, what is their frequency? (2)
(c) What is the amplitude of these waves? (2)

Total 10 marks

Homework 1.3 - Communication Using Cables I

1. Messages can be sent down copper cables by code. Name one code that has been used for this. (1)

2. Match the following parts of a telephone handset: (2)

   transmitter; receiver; loudspeaker; microphone.

3. Write the main energy changes in:
   (a) a loudspeaker. (½)
   (b) a microphone. (½)

4. (a) What is the approximate speed of a telephone signal in a copper cable? (1)
   (b) What is the speed of the light signal in an optical fibre? (1)

5. (a) What two types of signal is used to carry telephone messages along a copper cable? (2)
   (b) What speeds do they travel at (2)

Total 10 marks

Homework 1.4 - Radio and Television I

1. (a) Complete the table below for parts of a Radio, and fill in the correct definition for each term: (5)

PART	FUNCTION
Aerial	

(b) Draw a block diagram to show how these parts of a radio receiver are connected together. (5)

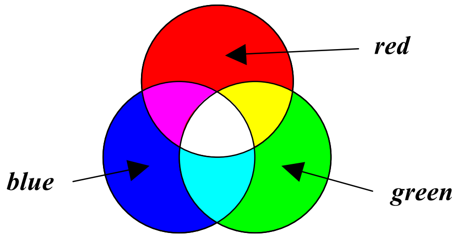
Total 10 marks

Homework 1.6 - Radio and Television II

1. A colour television can produce millions of different colours on screen.
   (a) How many colours of emitters are on a colour television's screen? (1)
   (b) Name these colours. (1)
   (c) How are these colours used to produce the millions of colours seen on screen? (2)

2. How does a television show moving pictures? (2)

3. (a) Copy and complete this diagram to show how red, green and blue light mix. You don't need to use coloured pencils – labels will do! (2)



   (b) How is a black area produced on a television screen? (1)

Total 10 marks