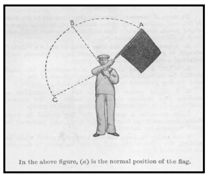
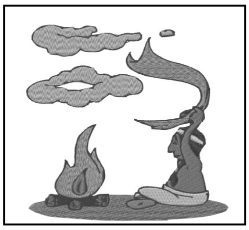




Telecommunications

Introduction

Since the earliest times, human beings have communicated with each other and have strived to improve the means by which they communicate. In modern times, telecommunications (communication over a large distance) has become a major industry involving computers, optical fibres and satellites. In the past, telecommunications was less sophisticated. What methods of telecommunications were used in the past ?

The Speed of Sound

The light from fireworks are seen before the sound is heard.

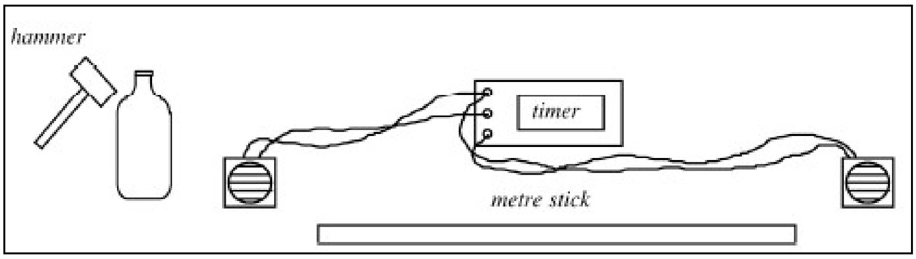
Light travels very much faster than sound. So lightning is seen before thunder is heard, and an athlete sees a puff of smoke from the starter's gun before hearing the bang.

The speed of *sound* in air is about 340 metres per second.

The speed of *ligh*t in air is 300 000 000 metres per second.

Measuring the Speed of Sound

In the laboratory the apparatus below is used to measure the speed of sound in air.



Dolphins use sound waves to communicate. The speed of sound in water is approx. 1500 m/s.

The bottle is struck to make a sound. This sound passes the first sound sensor to start the timer, covers the distance between the sensors and stops the timer when passing the second sound sensor. The time taken by the sound to pass between the sensors is recorded and the distance between the sensors is measured with the metre stick. The speed of sound is calculated by using the formula :

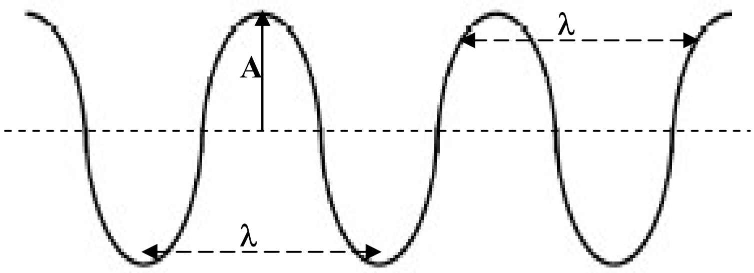
$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

(See example 2 on page 3)

Waves

Man has always relied upon sound waves to communicate.
Waves are widely used in telecommunications, in many modern telecommunication systems messages are carried by invisible waves.

Wave Characteristics



Wavelength: the distance between any point on one wave and the corresponding point on the next wave.

The symbol for wavelength is λ (the Greek letter lambda).

Wavelength is measured in metres (m).

Speed or velocity: the distance a wave travels in one second.

The symbol for speed or velocity is **v**.

Speed or velocity is measured in metres per second (m/s).

Frequency: the number of waves which pass a point in one second.

The symbol for frequency is **f**.

Frequency is measured in hertz (Hz).

Amplitude: the height of the wave measured from the centre line to the top of the crest, or bottom of the trough. The amplitude is a measure of the energy the wave possesses. The bigger the amplitude, the more energy the wave carries.

The symbol for amplitude is **A**.

Waves — you think water. In communication many other waves are used.

Microwaves, radio waves and TV waves all travel at the speed of light.

A Tsunami has gigantic swells, often many kilometres deep and can move the entire depth of the ocean.

Calculating the Speed of Waves

If the distance travelled in a given time is known, speed can be calculated from :

$$\boldsymbol{v = \frac{d}{t}}$$

Example 1

Water waves travel a distance of 50 m in 10 s. At what speed are the waves travelling ?

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

$$= \frac{50}{10}$$

$$= 5 \text{ m/s}$$

Example 2

A diver 4.5 km away from a diving bell hears the sound which signals his return 3 s after it is sounded. What value does this give for the speed of sound in water ?

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

$$= \frac{4500}{3}$$

$$= 1500 \text{ m/s}$$

However it can also be calculated from the **wave equation**.

Children use walkie talkies, which use radio waves, to communicate over short distances.

Tsunamis can travel at a speed of 100 miles per hour.

The Wave Equation

If the wavelength and frequency are known then speed can be calculated from the wave equation :

speed = frequency x wavelength

$$v = f \times \lambda$$

Example 1

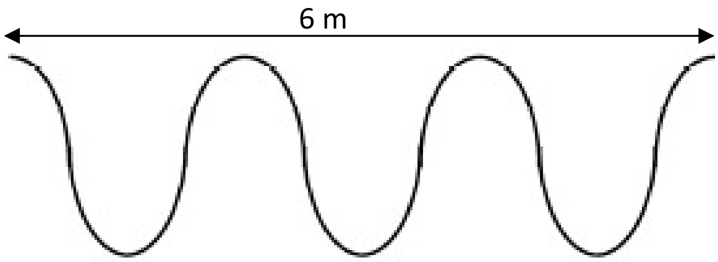
A wave has a wavelength of 0.5 m and a frequency of 680 Hz. Calculate its speed.

$$v = f \times \lambda$$

$$= 680 \times 0.5$$

$$= 340 \text{ m/s}$$

Example 2



The waves shown in the diagram above have a frequency of 20 Hz.

Find (a) the wavelength
(b) the speed.

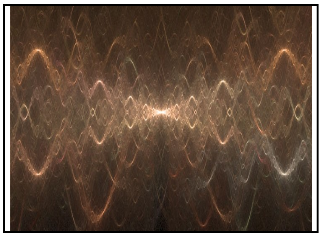
(a) $\text{wavelength} = \dfrac{6}{3}$

$$= 2 \text{ m}$$

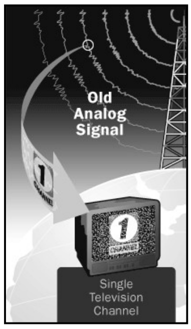
(b) $v = f \times \lambda$

$$= 20 \times 2$$

$$= 40 \text{ m/s}$$



Radio waves have wavelengths ranging from millimetres to kilometres.

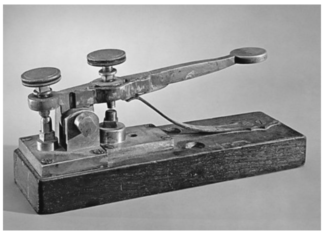


TV waves have a higher frequency than radio waves

A mobile phone mast.

Communication Using Cables

The Telegraph

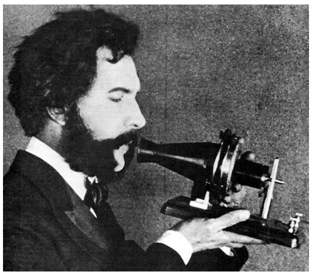


The telegraph was developed in the 1830s. Above is an early tap key that may have been used .

A Morse code telegraph sends coded messages along wires as pulses of electricity. These pulses are produced by closing and then opening a switch in a simple circuit containing wires, a switch, a battery and a buzzer (or a lamp). The electrical pulses move along the wires at **almost 300 000 000 m/s**.

In most telecommunications systems the message is sent out by a **transmitter** - in this case the switch - and is collected at the other end by a **receiver** - in this case the buzzer.

The Telephone



In 1876, at the age of 29, Alexander Graham Bell invented his telephone.

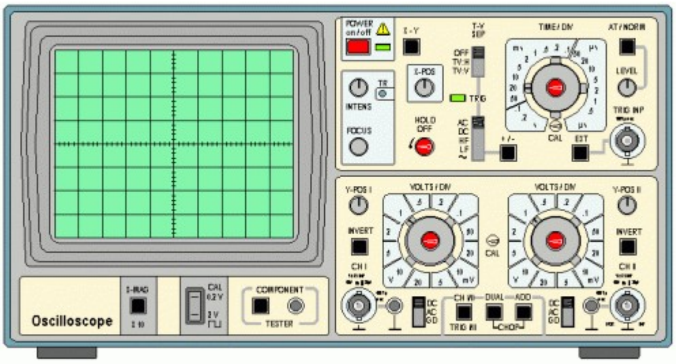
The telephone is another example of long range communication which uses cables between the transmitter and receiver. It, also, sends messages along wires as pulses of electricity at **almost 300 000 000 m/s**. In this case, speech patterns are transmitted down the wires. The **microphone** in the **mouthpiece** of the telephone (the **transmitter**) changes **sound energy into electrical energy**, and the **loudspeaker** in the **earpiece (**the **receiver)** changes **electrical energy** back **into sound energy** again.

Advantages of using Wires to Transmit Information

1. Messages can be sent over long distances.
2. Messages travel very quickly - almost at the speed of light (300 000 000 m/s).
3. A good degree of privacy can be maintained.

The iPhone combines three devices in one - phone, iPod and internet device.

Wave Patterns



An oscilloscope can be used to look at sound wave patterns and the patterns of electrical waves in wires, such as telephone wires.

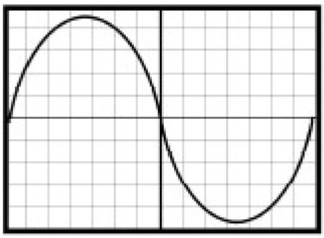
Loudness and Frequency

An oscilloscope shows whether a sound wave is loud or quiet, or has a high or low frequency (pitch).

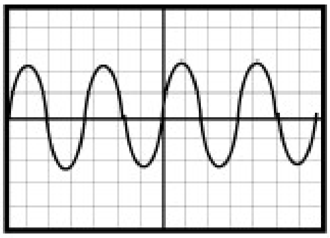
The greater the height of the wave pattern, the louder the sound.

The greater the number of waves, the greater the frequency or pitch.

The oscilloscope patterns below display examples of sound -



loud, low pitch sound



quiet, high pitch sound

Optical Fibres

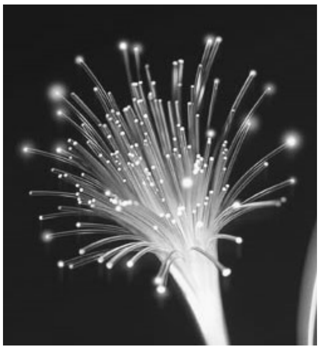
An **optical fibre** is a very thin glass fibre, through which light pulses can be transmitted at very high speeds (**200 000 000 m/s**). The light travels by being totally internally reflected along the optical fibre.

Optical fibres are usually grouped together into thicker optical cables which carry a great many messages at the same time. They are used in telephone links, cable TV and broadband communications.

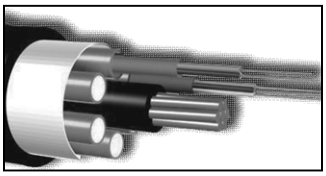
Advantages of using Optical Fibres in Communications

1. There is little loss of energy and so only a small number of booster stations are needed along the route.
2. Optical signals are free from interference from high voltage electric cables.
3. Cables made from optical fibres are lighter than metallic cables.
4. They cost less.
5. They can carry many more signals *at the same time* than is possible with metal cables.
6. The signal quality at the end of the cable is much better.

Human hearing has a range from 20 to 20000 Hertz.



Optical Fibres



The telecommunication companies use cables to carry bundles of fibres for TV, radio, phone and broadband.

Marconi sent the first radio transmissions over long distances.

Each mobile phone is a miniature radio transmitter and receiver which operates by battery.

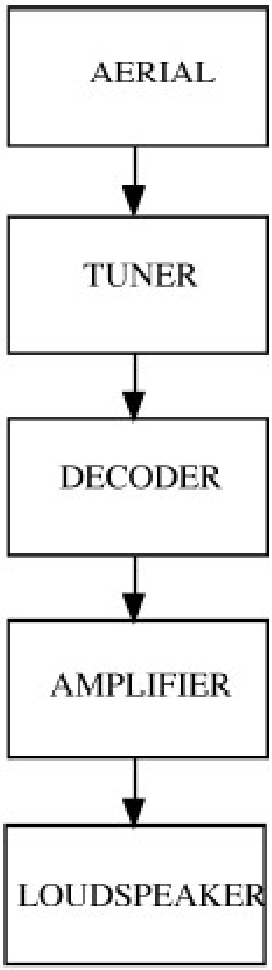
Digital radio is sometimes called DABS (Digital Audio Broadcasting Service).

Radio

Radio (and television) signals travel through space as waves. They carry energy and travel at the same speed as light (**300 000 000 m/s**) This means that they travel a long distance in a short time.
A radio **transmitter** sends out the signal and a radio **receiver** picks up the signal. A radio receiver is an electronic device made up of five main parts, which converts radio waves into speech and music. Each part has a specific job.

Parts of a Radio Receiver

Function of the parts



Picks up all the radio signals.

Selects one radio station by selecting its radio frequency.

Sorts out the electrical information from the radio wave.

Increases the size of the electrical signal.

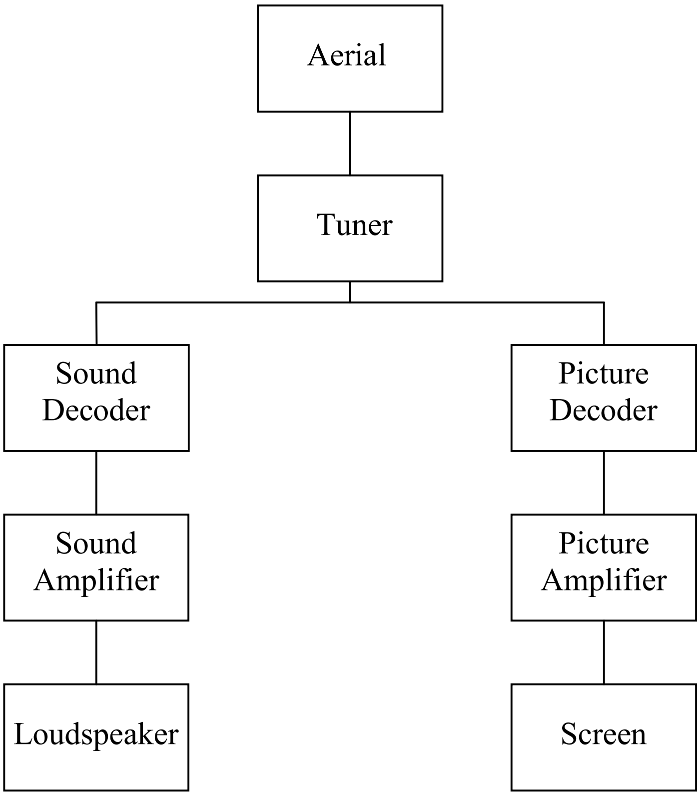
Changes the electrical signal into sound.

Every radio receiver needs energy to make it work . This energy is supplied by an **electricity supply**.

Television

Television signals are sent out from a transmitter and are collected by the aerial of the receiver. The receiver, therefore, must decode the sound information and the picture information.

Parts of a Television



Colour Pictures

All the colours seen on a TV screen are produced by mixing different brightnesses of the three primary colours : RED, GREEN and BLUE.

When RED, GREEN and BLUE are all mixed together WHITE is made.

RED + GREEN = YELLOW

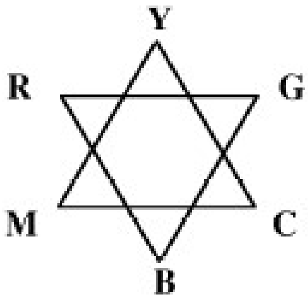
GREEN + BLUE = CYAN

BLUE + RED = MAGENTA

The star, in the box to the right, may help you remember the mixing of the primary colours.

On October 2, 1925, John Logie Baird successfully transmitted the first TV picture in his laboratory.

LCD screens use special crystals which light up when an electrical signal operates them.



Rich Young Girls Can Buy Meals.

Satellites

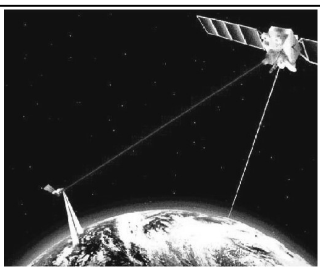
Satellites are objects which orbit a planet. When we think of satellites, we tend to think of man-made ones. We forget our moon is a natural satellite of our planet. Man-made satellites affect our daily lives without us even knowing. Satellites have many uses and transmit various signals back to ground. Signals which help with weather forecasting, reconnaissance, navigation and space exploration.

The natural satellite of our planet - the Moon.

Period of a Satellite

Man-made satellites are placed in orbits at different heights. The height is determined by the job of the satellite. Some are close to the surface of the Earth, while others are further away. The time a satellite takes to orbit a planet is called its period. The period depends on the height of the satellite above the surface.

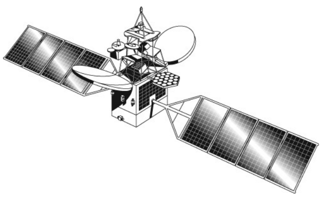
If the satellite is at a high altitude, it will have a longer distance to travel around the Earth. It will, therefore, take a long time to go around – it will have a long period. However if the satellite is closer to the surface, in a lower orbit, then it will take less time to go around – it will have a short period.



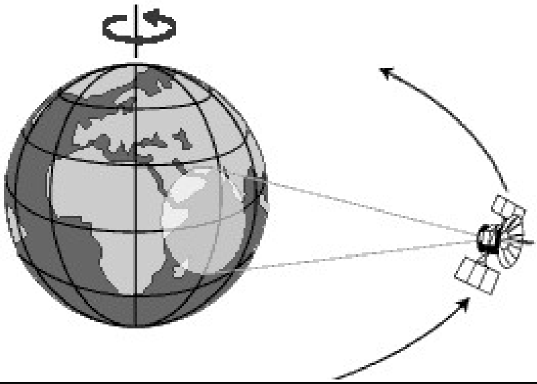
Geostationary satellites allow signals to be sent from one side of the planet to the other in an instant.

Geostationary Satellites

A geostationary satellite is one which takes 24 hours to orbit the Earth. To achieve this orbit, the satellite must be at an altitude of 36,000 km. It travels around the Earth at the same speed as the Earth is rotates. This means that a geostationary satellite always stays above the same point on the Earth's surface. This makes geostationary satellites suitable for telecommunications as they can maintain communications between two ground stations on opposite sides of the planet.

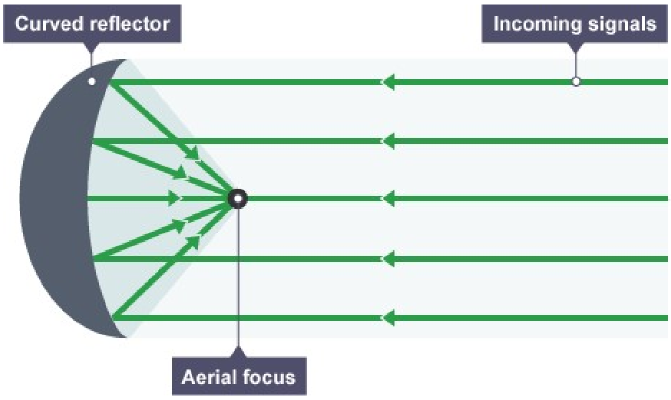


Communication satellites use frequencies between 4 Gigahertz (GHz) and 6 GHz. This means the waves used are microwaves.



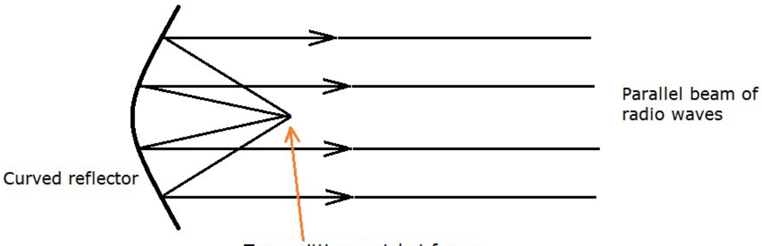
Curved Reflectors

The signals from satellites travel great distances and an aerial cannot pick up a strong enough signal. A curved reflector can bring the radio waves to a focus just like curved mirrors cause light rays to meet at a focus.

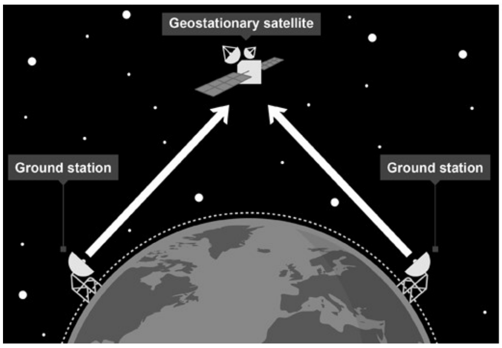


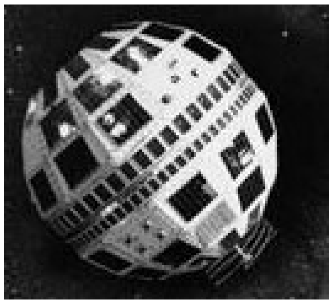
A strong radio signal can be detected if the aerial is positioned at the focus of the curved reflector. More of the wave energy is also collected when these aerials are used, which improves the signal.

These reflectors are also used for transmitting signals. The signals move in the opposite direction and are sent in a beam towards the satellites in space.



Ground stations send signals to the satellite using a curved dish transmitter to transmit a strong signal. At the satellite the weakened signal is collected by a curved dish receiver. It is then amplified and finally retransmitted, at a different frequency, back to the ground using another curved dish transmitter.





Telstar 1 launched in 1962 - the first communications satellite.

Satellite TV made curved reflectors common place.

Sputnik 1 launched in 1957 - the first man-made satellite in space sent radio waves.