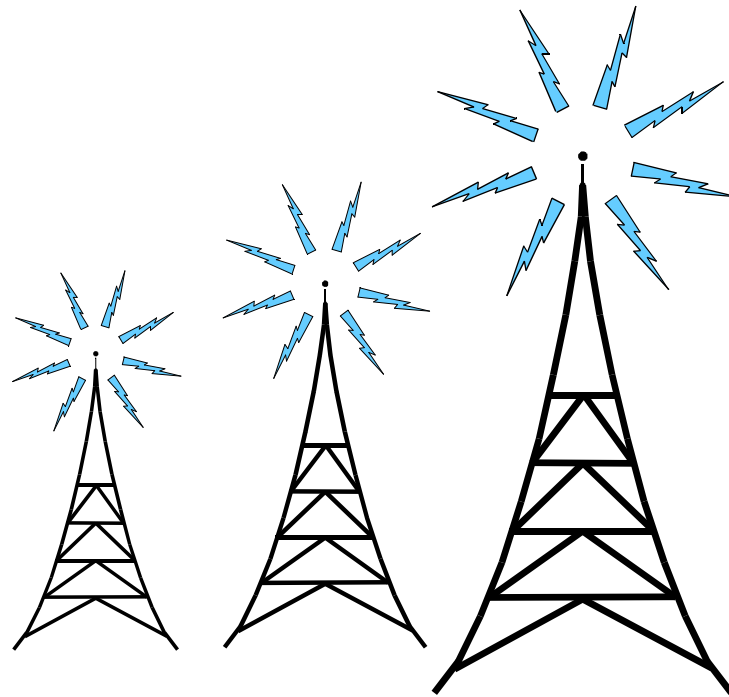


Standard Grade Physics

"TELECOMMUNICATION"



Name: _____

Class: _____

Teacher: _____

1) COMMUNICATION USING WAVES

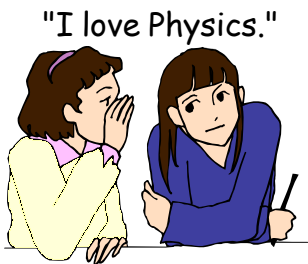
Introduction - Uses for Sound and Light Energy

Sound and light are important types of energy. We use them to **transmit (send)** signals from one place to another. This is known as **communication**.

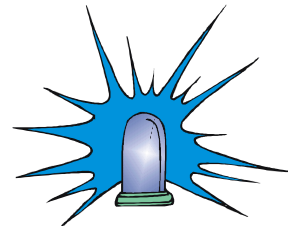
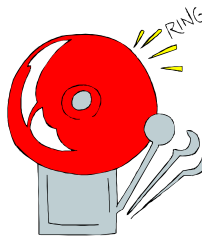
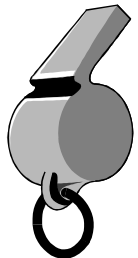
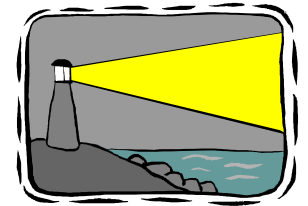
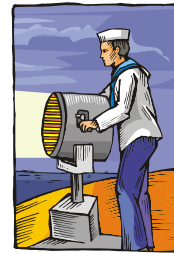
Transmitting (sending) signals over a long distance is known as **telecommunication**.

In each case below, write a short description of how sound or light is being used for **communication**:

• sound



• light



Comparing the Speed of Sound and Light in Air

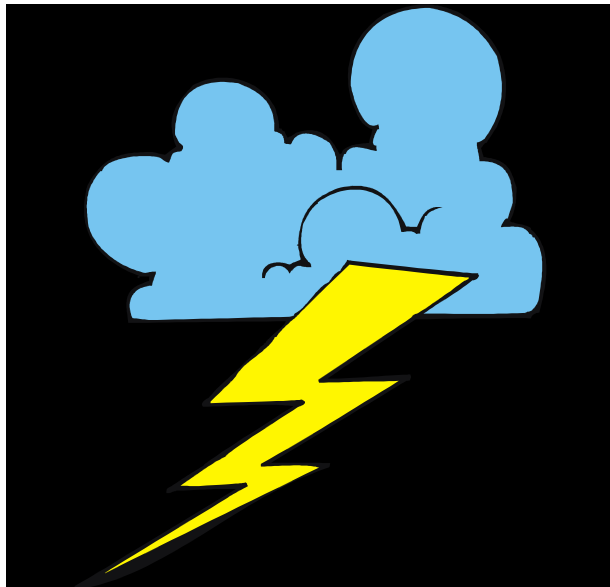
In air, speed of sound = ____ m/s

In air, speed of light = _____ m/s ($_ \times 10^{-}$ m/s)

In air, light travels almost _____ times faster than sound.

Use the **word bank** to complete the passage below.

hear less light light lightning see
 sound sound thunder



During a storm, **thunder** and **lightning** are produced at exactly the same time.

We _____ the _____ before we _____ the _____ because, in air, the speed of _____ is **less** than the speed of _____.

The _____ reaches us before the _____.

1) At a fireworks display, a rocket explodes high above your head, producing a loud explosion and a bright flash of light at the same time.

(a) What will reach you first? - the sound of the explosion or the flash of light:

(b) Explain why:



2) On a golf course, you observe a golfer in the distance hitting a golf ball with her club.

(a) What will you observe first? - the ball moving through the air or the sound of the club hitting the ball:

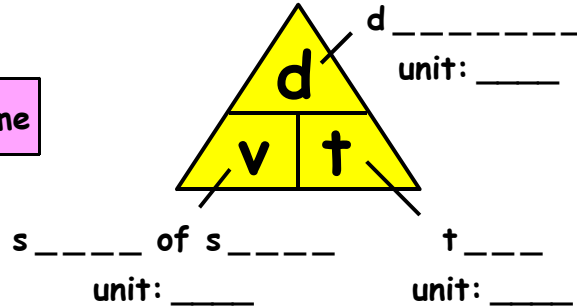


(b) Explain why:

Distance, Time and Speed of Sound Calculations

We can use this **formula** to solve problems about sound travelling through the air (or other materials):

distance = speed × time



3) Calculate the distance sound will travel through the air in 2 seconds.

4) How far will the sound of an explosion travel through the air in 5 seconds?

5) Calculate the time it will take sound to travel 1 020 meters through the air.

6) How long will it take the sound of a bell to travel 850 meters through the air?

7) Calculate the speed of sound in air if it takes 4 seconds for the sound to travel 1 360 meters.

8) The sound of a car horn is heard 1 190 meters away, 3.5 seconds after it has been sounded. Calculate the speed of the horn sound in air.

9) Susan shouts at a brick wall. After 0.8 seconds, she hears her "echo" - the sound of her shout reflected off the wall.

Calculate how far away from the wall Susan is. **BE CAREFUL!** - It might help if you draw the path taken by the sound on the diagram.



Susan



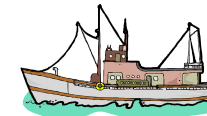
wall

Sound has a different speed in different materials. For example:

Speed of sound in steel = 5 200 m/s.
Speed of sound in water = 1 500 m/s.

10) A steel wire is 6 760 meters long. Calculate the time it will take sound to travel along the wire.

11) To find out the depth of water beneath its hull, a fishing boat sends a pulse of sound through the water from its hull to the sea bed.



After 1.2 seconds, the fishing boat detects the sound pulse reflected from the sea bed.

How deep is the sea?

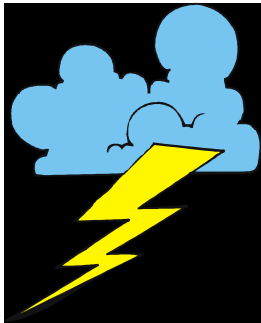
sea bed

Light is the fastest thing there is - Nothing can travel faster than light. Because light travels so quickly, we assume we see things happen at the instant they happen.

This lets us calculate how far away we are from something which happens.

The time between us **seeing** something happen and **hearing** it happen is the time it takes for the sound to reach us. Because we know the speed of sound in air, we can apply the formula:

$$\text{distance} = \text{speed of sound in air} \times \text{time for sound to reach us}$$



12) During a storm, **thunder** and **lightning** are produced at exactly the same time.

(a) You see a flash of lightning. After 5 seconds, you hear the thunder. How far away from you is the storm?

(b) A while later, you see another flash of lightning - but, this time, you hear the thunder after only 1.5 seconds. How far away from you is the storm now?

13) You see a flare exploding in the distance. After 3.5 seconds, you hear the sound from the explosion.

How far away from you was the flare when it exploded?



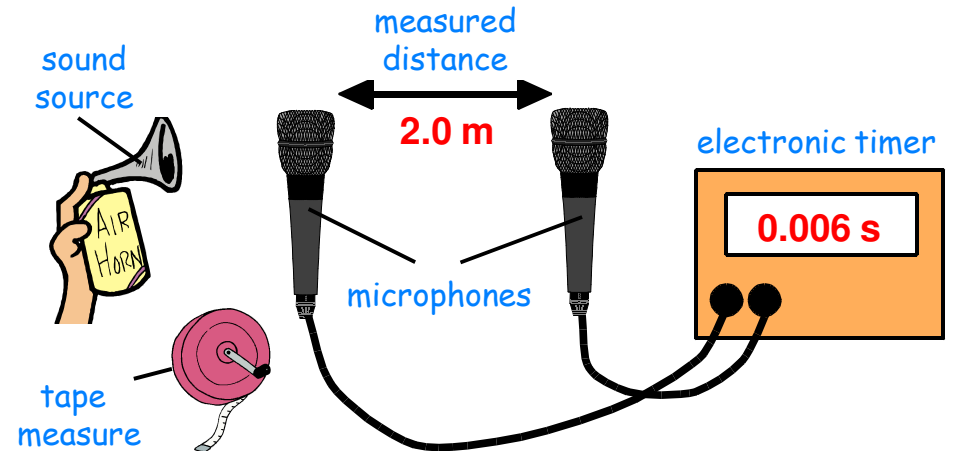
14) A soldier sees a shell explode. The sound from the explosion reaches him 0.2 seconds later.

How far away from the soldier did the shell explode?



Experiment to Measure the Speed of Sound in Air

We can perform an experiment to measure the speed of sound in air.



- We use a **t** _____ **m** _____ to measure the **d** _____ between the 2 **m** _____.
- We make a sharp **s** _____ next to the left hand **m** _____.
- The **s** _____ travels through the **a** _____ between the 2 **m** _____. The **t** _____ this takes is recorded on the electronic **t** _____.
- We calculate the speed of sound in air using the formula:

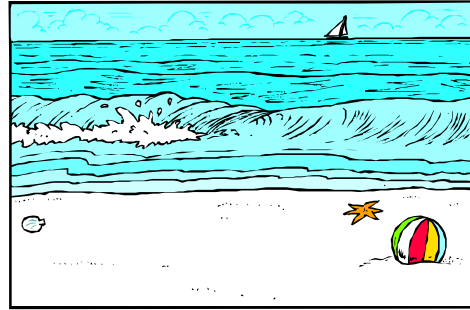
$$\text{speed} = \frac{\text{distance between microphones}}{\text{time for sound to pass between microphones}}$$

15) (a) What value for the speed of sound in air do you obtain using the values shown on the apparatus above?

(b) How could you improve this experiment?

Waves and Energy

Water waves on the sea or a pond are easy to see.



All waves **transfer (carry)** **e** _____ from one place to another - A tsunami sea wave transfers an enormous amount of **e** _____ which can cause extensive damage when the wave reaches land.

Waves and Signal Transmission

Sound and **light signals** are **transmitted (sent)** from one place to another by **w** _____.

w _____ also **transmit** signals for:



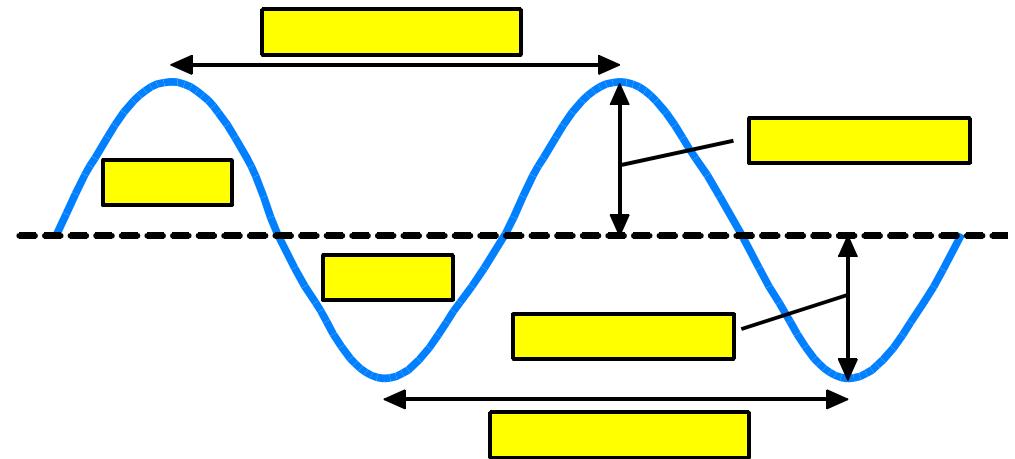
- _____
- _____
- _____
- _____

Wave Diagrams

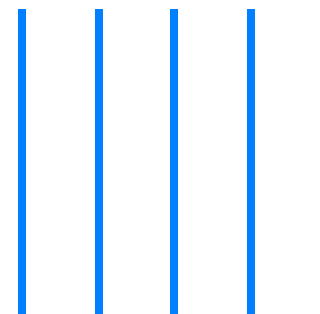
The diagram below represents a typical **wave** viewed from the side.

Use the **word bank** to label the **wave diagram**:

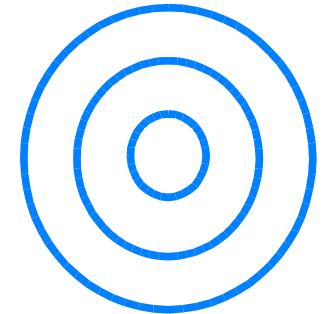
amplitude amplitude crest trough
wavelength wavelength



These diagrams represent **waves** viewed from above. The lines show the middle of **wave crests**.
No **wave troughs** are shown.



straight waves



circular waves

On each diagram, show the **wavelength**.

Describing Waves

Use the word bank to complete the table:

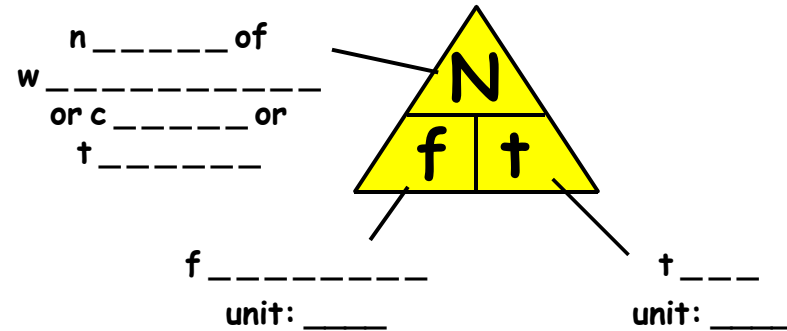
above amplitude amplitude below
 distance second wavelength
 f Hz λ m m m/s v

Quantity	Symbol	Unit	Description
wave crest			Part of wave _____ centre line.
wave trough			Part of wave _____ centre line.
			Height of wave crest or wave trough measured from the centre line. The higher the _____ of a wave, the more energy it carries.
	lambda		Distance between 2 identical neighbouring points on a wave, e.g., distance between 2 neighbouring wave crests.
frequency		hertz	Number of wavelengths (or crests or troughs) every _____.
speed			_____ wave travels every second.

The **frequency** of a wave is:

This can be represented by the formula:

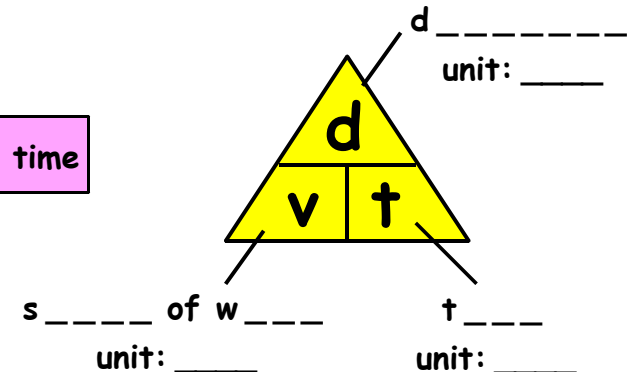
$$\text{frequency} = \frac{\text{number of wavelengths (or crests or troughs)}}{\text{time in seconds}}$$



The **speed** of a wave is:

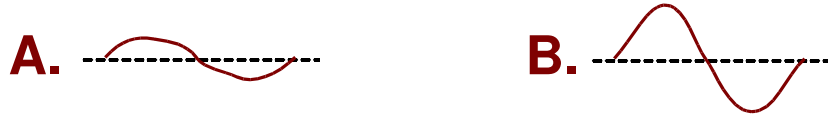
This can be represented by the formula:

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



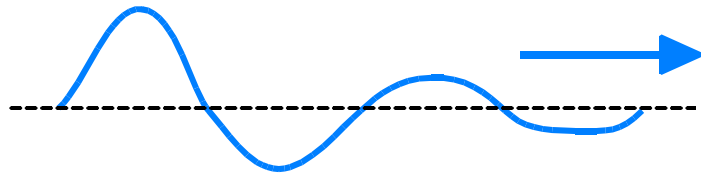
Water Wave Problems/Calculations

16) (a) Which of these waves is carrying the most energy? _____
 (b) Explain your answer: _____



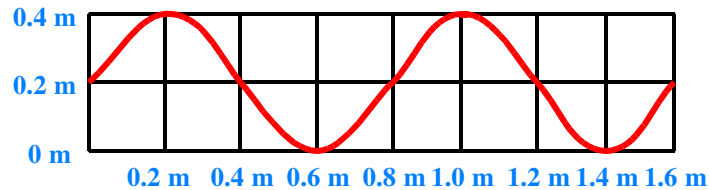
17) The wave shown below is travelling to the right.
 (a) As the wave travels, what happens to its amplitude?

(b) What must be happening to the wave's energy? _____



18) (a) State the value for this wave's:

(i) amplitude: _____ (ii) wavelength: _____



(b) The wave was produced in 1 second.

State the value for its frequency: _____

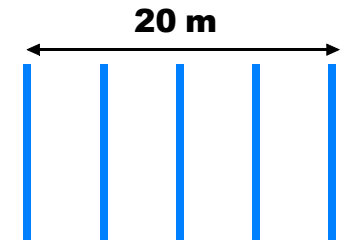
19) Determine the frequency of the wave in each case:

- (a) 5 wavelengths are produced every second.
 (b) 10 water waves pass the end of a pier in 2 seconds.
 (c) 12 circular waves spread across a pond in 20 seconds

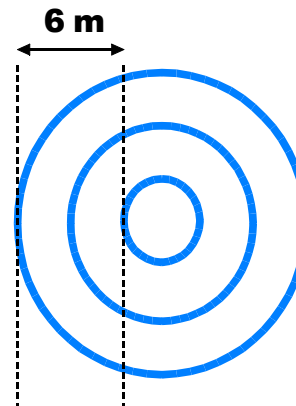
20) (a) For this wave, state the value of:
 (i) the amplitude _____
 (ii) the wavelength _____

(b) The wave was produced in 2 seconds. State the value for its frequency.

21) (a) Determine the wavelength of these water waves.



(b) These 5 wave crests were produced in 25 seconds.
 Determine the frequency of the waves.



22) (a) What is the wavelength of these circular water waves?

(b) The 3 wave crests were produced in 0.5 seconds. What is the wave frequency?

23) A tsunami sea wave takes 6 seconds to travel up a beach with a speed of 15 metres per second.



What distance does the wave travel up the beach?

24) When Sajidha threw a stone into a pond, circular waves travelled 7.5 metres across the water in 2.5 seconds.

Calculate the speed of these water waves.



25) Sea waves approach a cliff at 4 metres per second.



What time will the waves take to travel 20 metres?

26) Sid the surfer rides the crest of a sea wave travelling at 6 metres per second for 8 seconds.



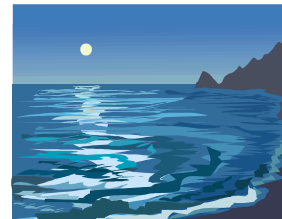
Calculate how far the wave carries Sid in this time.

27) A drop of water from a leaking tap causes waves on the surface of Brenda's bath water.

If these waves travel 0.4 metres in 1.6 seconds, at what speed are they travelling?



28) As the tide goes out, sea waves travel 50 metres with a speed of 2.5 metres per second.



How long do the waves take to travel this distance?

Another Wave Formula

For any wave, the **time** taken (**T**) to produce **1 wavelength** (**1 λ**) is related to the **frequency** (**f**) of the wave by the formula:

$$\text{frequency} = \frac{1}{\text{time}}$$

$$f = \frac{1}{T}$$

If **1 wavelength** (**1 λ**) is produced in **time** (**T**), a wave will travel a **distance** (**d**) of **1 wavelength** (**1 λ**) in **time** (**T**):

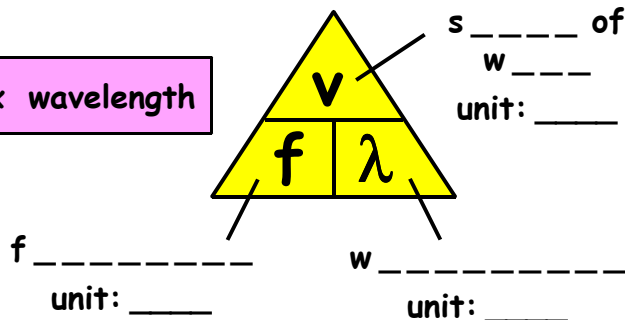
$$\text{speed (v)} = \frac{\text{distance (d)}}{\text{time (T)}} = \frac{1 \lambda}{T} = \frac{1}{T} \times \lambda$$

$$= \underline{f \times \lambda}$$

since $f = \frac{1}{T}$

We have another **formula** which applies to **waves**:

$$\text{speed} = \text{frequency} \times \text{wavelength}$$



Explain the equivalence of the 2 wave formulae:

$$\text{speed (v)} = \text{frequency (f)} \times \text{wavelength (λ)}$$

and

$$\text{speed (v)} = \frac{\text{distance (d)}}{\text{time (T)}}$$

Speed, Wavelength and Frequency Calculations for Water and Sound Waves

29) Calculate the speed of water waves which have a frequency of 2 hertz and a wavelength of 5 metres.

32) Every second, 2 waves are produced on Alan's bath water by water dripping from a tap. If these waves have a wavelength of 0.05 metres, calculate their speed.

35) Calculate the speed of sound waves in air which have a frequency of 500 hertz and a wavelength of 0.34 metres.

38) A submarine sends a pulse of sound through the sea. Determine the speed of the sound pulse if it has a frequency of 7 500 hertz and a wavelength of 0.2 metres.

30) Calculate the frequency of water waves in a harbour if they travel at 3 metres per second and have a wavelength of 4 metres.

33) The wind causes waves to travel across a puddle at 2.4 metres per second. If the waves have a wavelength of 0.6 metres, determine their frequency.

36) Calculate the frequency of sound waves in air which travel at 340 metres per second and have a wavelength of 1.7 metres.

39) Sound travels through steel at 5 200 metres per second. In the steel, sound waves have a wavelength of 2 metres. Calculate their frequency.

31) Calculate the wavelength of water waves on a pond which travel at 0.75 metres per second and have a frequency of 1.5 hertz.

34) A wave generator in a swimming pool produces 2.5 waves every second. The waves travel across the pool at 1.2 metres per second. Determine their wavelength.

37) Calculate the wavelength of sound waves in air if they travel at 340 metres per second and have a frequency of 6 800 hertz.

40) Ultrasound (frequency 21 000 hertz) travels through human muscle at 1 600 metres per second. Calculate the wavelength of ultrasound in the muscle.

2) COMMUNICATION USING CABLES

Introduction - Electrical Cables and Optical Fibre Cables

E _____ c _____ and o _____ f _____ c _____ are used in some **telecommunication systems**.

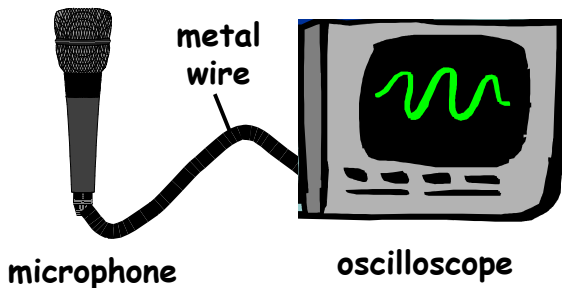
(a) Electrical Cables



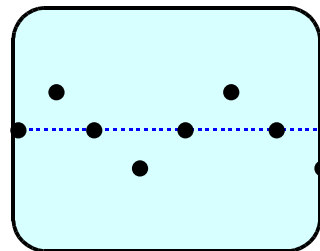
An e _____ c _____ contains many m _____ w _____ side by side. These are covered in p _____, so that **electric current** cannot pass from one to another.

An **electrical s _____** can be **transmitted (sent)** along a **metal wire** at a speed much **g _____** than the speed of s _____: At almost _____ m/s (_ x 10 - m/s).

A **microphone** changes s _____ energy to e _____ energy.
E _____ s _____ pass along the **metal wire** of the **microphone** and can be displayed as a pattern on the screen of an o _____.



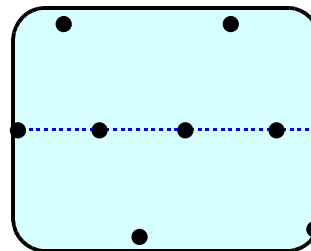
• quiet sound



Join the dots.

Quiet sounds have a l _____ energy, so the pattern has a l _____ amplitude.

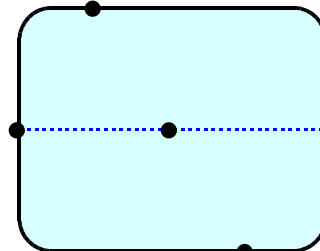
• loud sound



Join the dots.

Loud sounds have a h _____ energy, so the pattern has a h _____ amplitude.

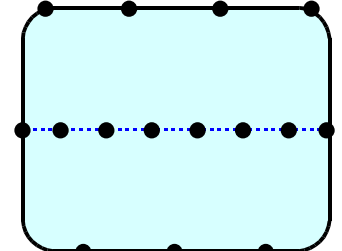
• low frequency sound



Join the dots.

Low pitch/frequency sounds (e.g., a g _____) have a l _____ number of v _____ every s _____, so the pattern has a l _____ number of w _____.

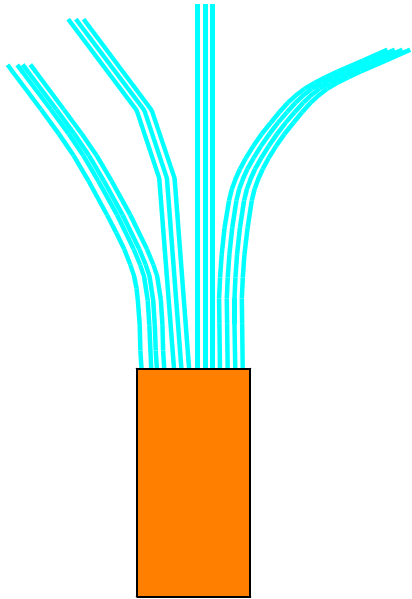
• high frequency sound



Join the dots.

High pitch/frequency sounds (e.g., a s _____) have a h _____ number of v _____ every s _____, so the pattern has a h _____ number of w _____.

(b) Optical Fibre Cables



An **optical fibre** is a long, flexible length of pure glass (or plastic), about 0.1 millimetres in diameter.

An **optical fibre cable** contains many **optical fibres** side by side. No light escapes from the outside of the **optical fibres**, so they are not covered in **plastic**.

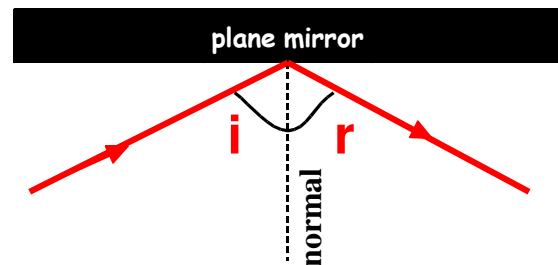
A **light signal** can be **transmitted (sent)** along an **optical fibre** at a very high speed: **200,000,000 m/s (2 x 10⁸ m/s)**.

- How does the speed of the **light signal** in an **optical fibre** compare with the speed of the **electrical signal** in a **metal wire**? _____

Reflection of Light

Light travels in **straight lines** called **light rays**.

When a **light ray** hits a surface like a **plane mirror**, the **light ray** is **reflected** off the surface.

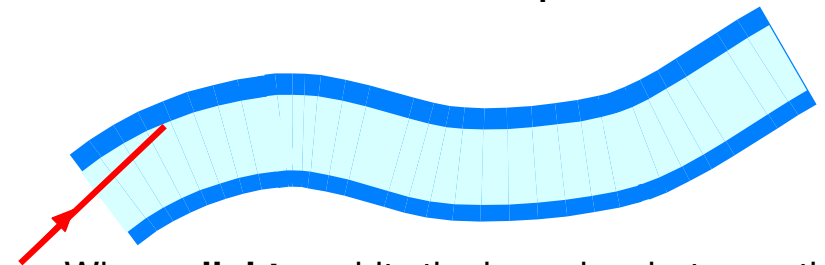


During **reflection**, the **angle of incidence (i)** is always **equal to** the **angle of reflection (r)**.

$$\text{angle of incidence} = \text{angle of reflection}$$

A normal is a dashed line drawn at 90° to a surface where a light ray hits the surface.

An **optical fibre** has a **dense solid glass core** surrounded by a **less dense solid glass coating**. Unlike a **mirror**, there is **not** a **"silvered surface"** in the **optical fibre**.

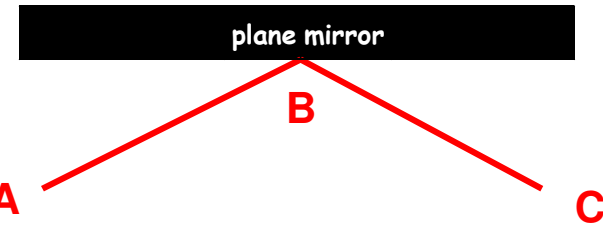


When a **light ray** hits the boundary between the **core** and **coating** at an angle greater than a **"critical angle"**, **all** of the **light ray** is reflected back into the **optical fibre** - This is known as **total internal reflection**.

- Complete the diagram to show how a **light ray** travels along an **optical fibre**.

The Principle of Reversibility of Ray Paths

If a **light ray** is shone from **A** to **C** via **B** or from **C** to **A** via **B**, it will follow **exactly the same path** but in the **reverse direction**.



This is the principle of **r** _____ of **r** ___ **p** _____.

Comparing the Properties of Electrical Cables and Optical Fibres

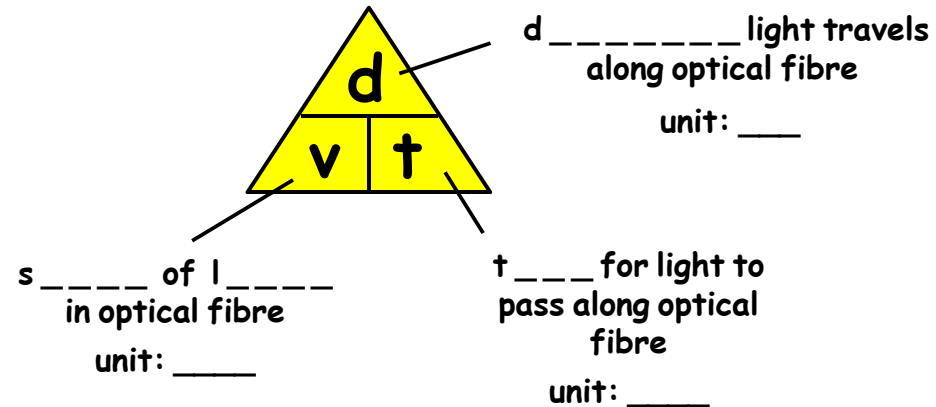
Complete the table by ticking the correct option in each case. You may like to make additional notes:

Property	Electrical Cable	Optical Fibre	Notes
smaller size			
lowest weight			
lowest cost			
fastest signal speed			
carries more signals			
clearest, highest quality signals			
less signal loss per kilometre			

Distance, Time and Speed of Light Calculations Involving Optical Fibres

We can use this formula to solve problems about light travelling along optical fibres:

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



A _____ s _____ can be transmitted (sent) along an optical fibre at a very high speed: _____ m/s (_____ x 10⁻ m/s).

41) It takes light 0.00025 seconds (2.5 x 10⁻⁴ seconds) to travel 50 kilometres along an optical fibre. Calculate the speed of the light in the optical fibre.

42) A pulse of laser light takes 0.0003 seconds (3 x 10⁻⁴ seconds) to travel along an optical fibre. How long is the fibre?

43) What time does light take to travel along a 100 kilometre length of optical fibre?

44) How fast does light travel through a 75 kilometre long optical fibre telecommunication system if it takes 0.000375 seconds (3.75 x 10⁻⁴ seconds) to do so?

45) If light takes 0.002 seconds (2 x 10⁻³ seconds) to travel along an optical fibre system, what distance does the light travel?

46) How long will it take a pulse of laser light to travel the entire length of a 250 kilometre optical fibre telecommunication system?

Electrical Cable Telecommunication Systems

(a) The Morse Code Telegraph

The **Morse code telegraph** was the first form of **telecommunication system** to send **coded messages** as **electrical signals** through **metal wires**.

By pressing a **tap key** at one end of the **metal wires**, a pulse of **electric current** was sent through the **wires** to a **buzzer** at the other end.

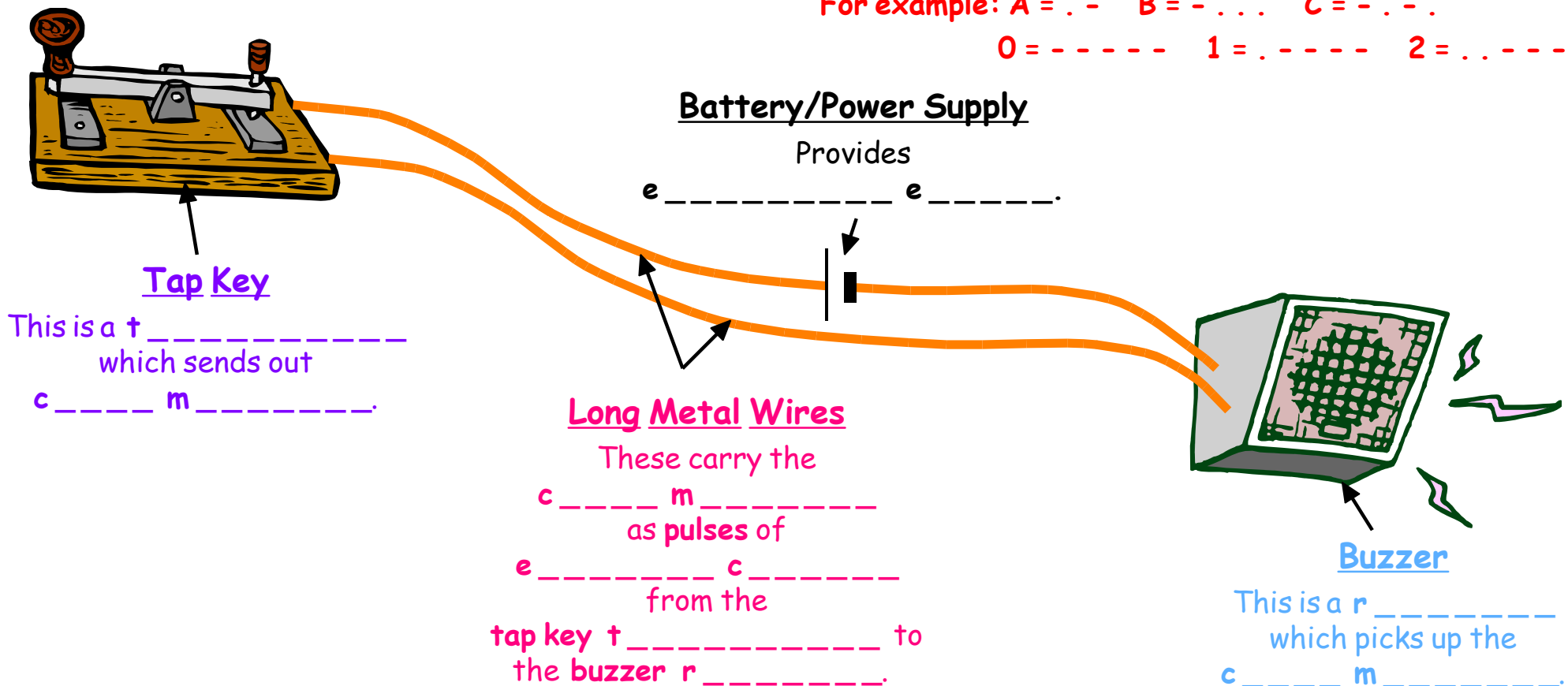
Short press (hence short buzz) = dot ●
 Long press (hence long buzz) = dash —

Morse Code

Each letter of the alphabet and the numbers 0 to 9 were represented by a combination of dots and dashes:

For example: A = . - B = - . . . C = - . - .

0 = - - - - - 1 = . - - - - 2 = . . - - -



(b) The Telephone

The **telephone** is an example of **long range communication** (**telecommunication**) between a **transmitter** and a **receiver**.

During **telephone communication**, changing **electrical signals** are **transmitted** (**sent**) along **metal wires** at a speed **much greater than the speed of sound**: At almost **300,000,000 m/s** (**3 x 10⁸ m/s**).

Long Metal Wires

These carry the changing **electrical signals** as an **electrical current** from the **transmitter** (mouthpiece) to the **receiver** (earpiece).
(**message**) to the **receiver** (earpiece).
(**electrical**).

The electrical signal pattern in the metal telephone wire keeps changing because the **loudness** and **frequency** of our voice keeps changing during a conversation.

Telephone Earpiece

The **earpiece** of a telephone is a **receiver** - It **produces** **electrical signals** from the **metal telephone wires**. It contains an **electromagnet** (coil) which changes **electrical energy** in the **metal wires** to **sound energy**.

Amplifier/Repeater Unit

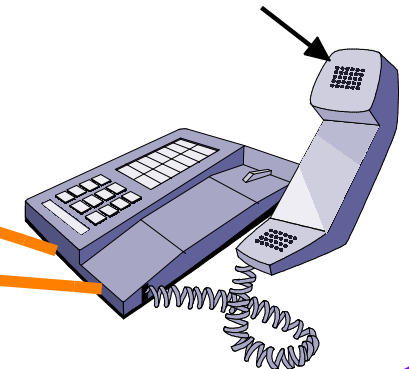
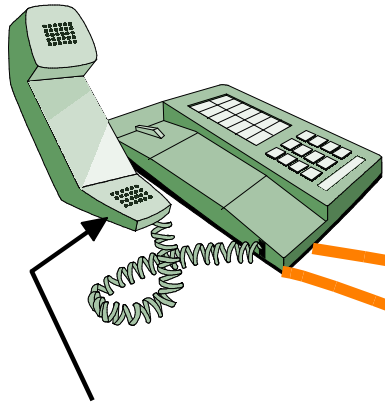
As the changing **electrical signals** travel along the **long metal wires**, the **signals** lose **energy**. The **signals** need to have their **energy** increased every **4 km** so they are strong enough to be detected by the **receiver**.

Telephone Mouthpiece

The **mouthpiece** of a telephone is a **transmitter** - It **sends** **electrical signals** through the **metal telephone wires**. It contains a **microphone** which changes **sound energy** in our voice to **electrical energy** - a changing **electrical current**.

Battery/Power Supply

Provides **electrical energy**.



Optical Fibre Telecommunication Systems

An **optical fibre telecommunication system** sends **coded signals** as **pulses of laser light** through **optical fibres**.
 The **signals** are coded in **binary**: All information is converted into a string of the numbers **0** and **1**.

The **laser** used to produce the **coded signals** can be switched **on** and **off** very quickly.

Laser OFF = 0 Laser ON = 1

Electrical to Light Converter

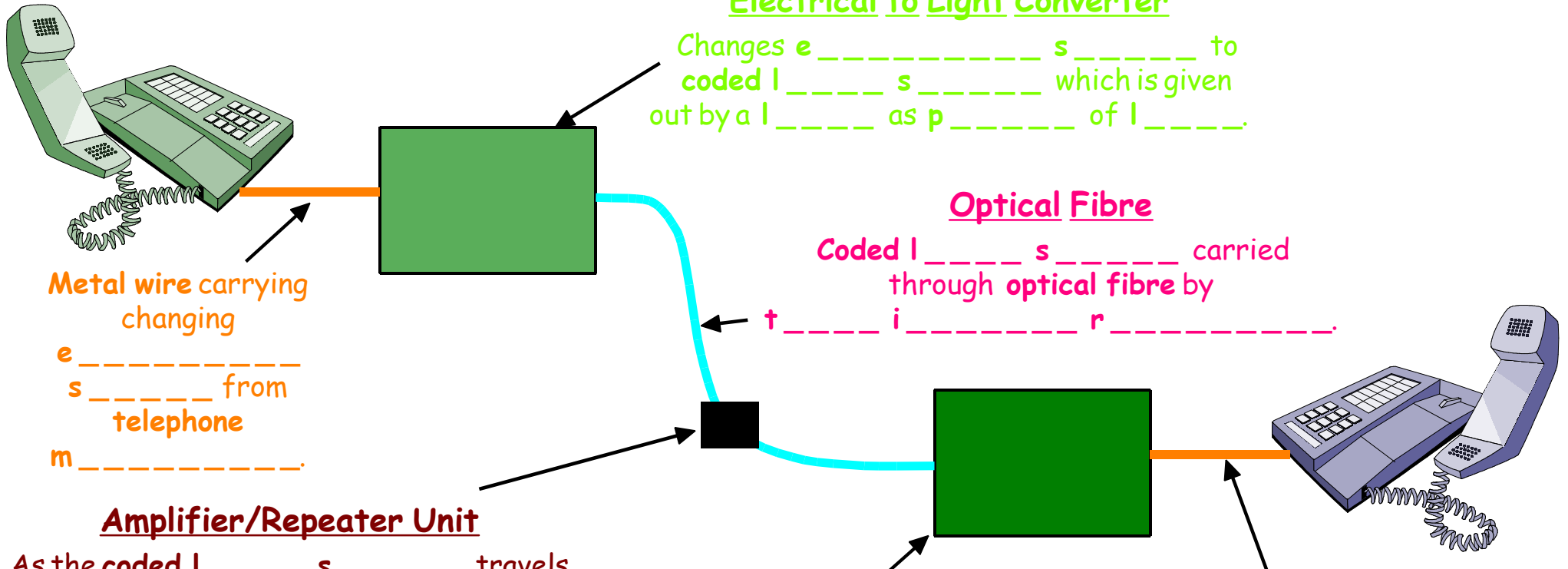
Changes **e** _____ **s** _____ to
coded l _____ **s** _____ which is given
 out by a **l** _____ as **p** _____ of **l** _____.

Optical Fibre

Coded l _____ **s** _____ carried
 through optical fibre by
t _____ **i** _____ **r** _____.

Light to Electrical Converter

Changes **coded**
l _____ **s** _____ back to
e _____ **s** _____.



Metal wire carrying changing

e _____
s _____ from
m _____
telephone

Amplifier/Repeater Unit

As the **coded l** _____ **s** _____ travels along the **optical fibre**, the **signal** loses **e** _____. The **signal** needs to have its **e** _____ increased every **100 km** so it is strong enough to be detected by the **receiver**
 - The **signal loss** is far **l** _____ than with **electrical wires**, so **l** _____ **amplifier/repeater units** are required.

Metal wire carrying changing
e _____
s _____ from
e _____
converter to telephone

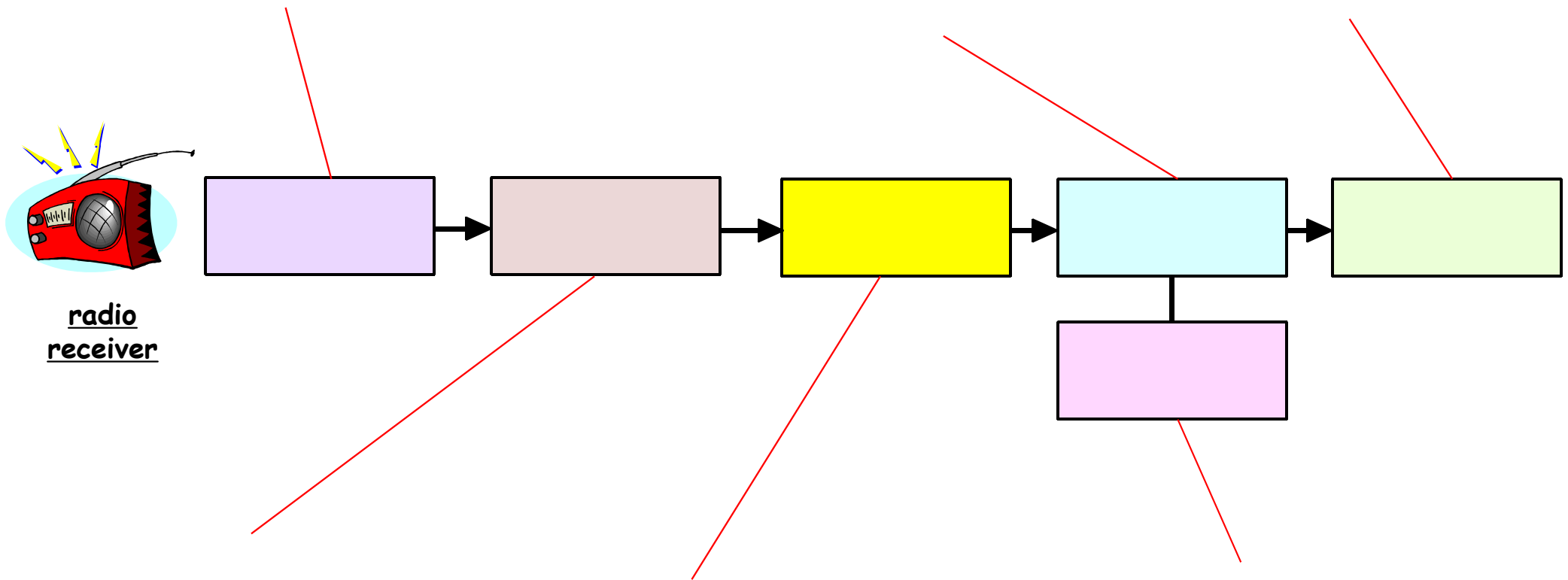
Notes

3) RADIO and TELEVISION

1) The Parts of Radio and Television Receivers

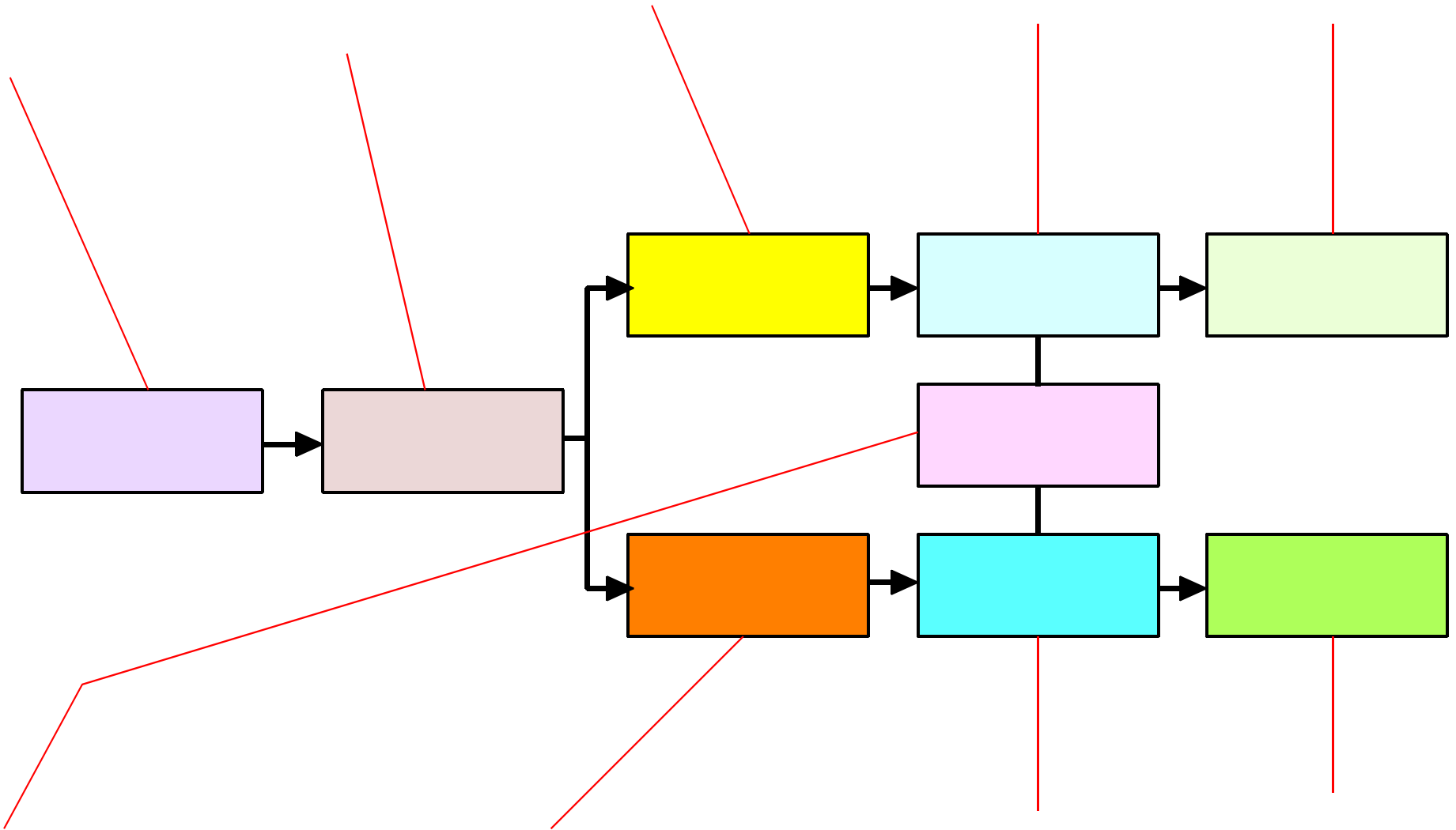
We can represent the main parts of a **radio receiver** and a **television receiver** on a **block diagram**:

Write the name of each part of the **radio receiver** and the **television receiver** in the correct block.
In the surrounding space, state the **function** of each part.

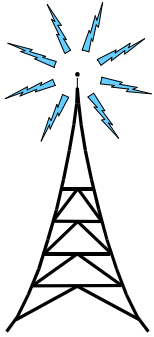




television receiver



2) Amplitude Modulation



At a **radio transmission station**, a low frequency **a** _____ (sound) **signal** is combined with a **very high frequency r** _____ **wave**.

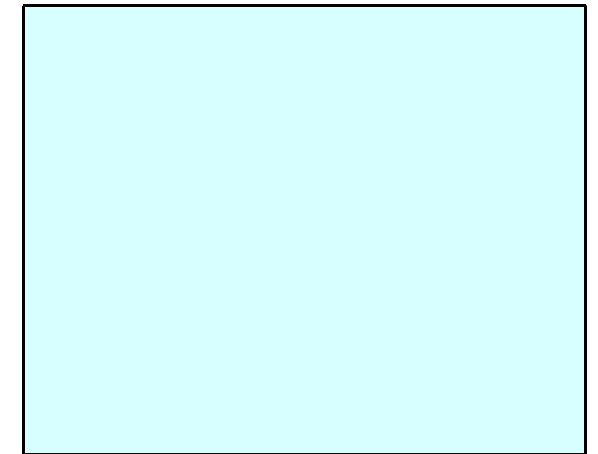
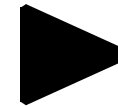
This changes the **a** _____ of the **r** _____ **wave** - The process is called **a** _____ **m** _____.

The resulting **a** _____ **m** _____ **r** _____ **c** _____ **wave** carries the **a** _____ (sound) **signal** a great distance through the air.

Complete the diagram below:



+



Low frequency **a** _____ (sound) **signal**

High frequency **r** _____ **wave**

A _____ **m** _____ **r** _____ **c** _____ **wave**

At a **television transmission station**, **a** _____ (sound) and **v** _____ (picture) **signals** are combined with **high frequency radio and television waves**.

The resulting **a** _____ **m** _____ **r** _____ and **t** _____ **waves** carry the **a** _____ and **v** _____ **signals** respectively a great distance through the air.

3) Black & White Television Picture

Line Build Up

The inside of a television screen is coated with a large number of **phosphor dots**, arranged in ___ lines.

When electrons hit the **phosphor dots**, the dots give out l ___ for a fraction of a second.

An electron beam is moved across the screen, one line at a time - As shown in the diagram.

Complete the diagram opposite:

This happens ___ times every second.

The process is known as l ___ b ___ u ___.

Image Retention

There are ___ different pictures on a television screen every second.

The human eye/brain system holds an image for a fraction of a second before replacing it with another image - This is known as

i ___ r _____.

Because the pictures on a television screen are changing so quickly, the eye/brain system cannot detect them changing. It blends successive pictures together, so we observe a moving picture.



Television Screen

Brightness Variation

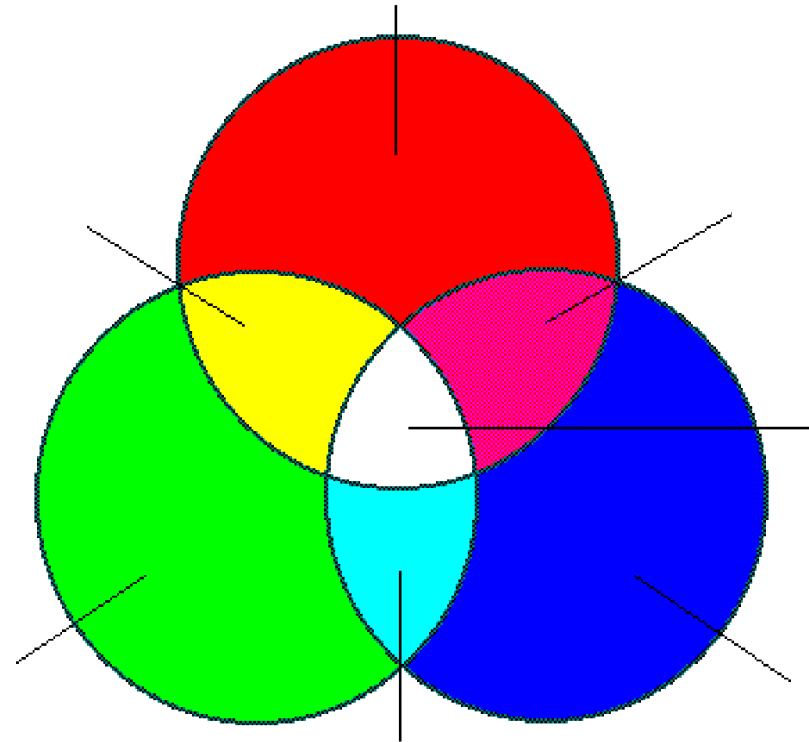
To **increase** the brightness of a television picture, **m ___** electrons are fired at the screen every second.

To **decrease** the brightness of a television picture, **l ___** electrons are fired at the screen every second.

4) Colour Television Picture

By mixing **r** ____, **g** _____ and **b** ____ lights
(**p** _____ **colours of light**), we can
produce all the **colours** seen on a colour
television screen.

Label the diagram opposite:



PRIMARY AND SECONDARY COLOURS OF LIGHT.

A **colour television screen** is covered with a series of **phosphor dots**.

One type emits **r** __ **light**, one type emits **g** _____ **light** and the other emits **b** ____ **light**.

By lighting different **colours** of **phosphor dot** at the same time, different colours are produced on the television screen.

No dots lit = black.

All dots lit = white.

Notes

4) TRANSMISSION of RADIO WAVES

Telecommunication Without Wires

Examples of **long range communication** which do not need **cables** between a **transmitter** and **receiver** include:



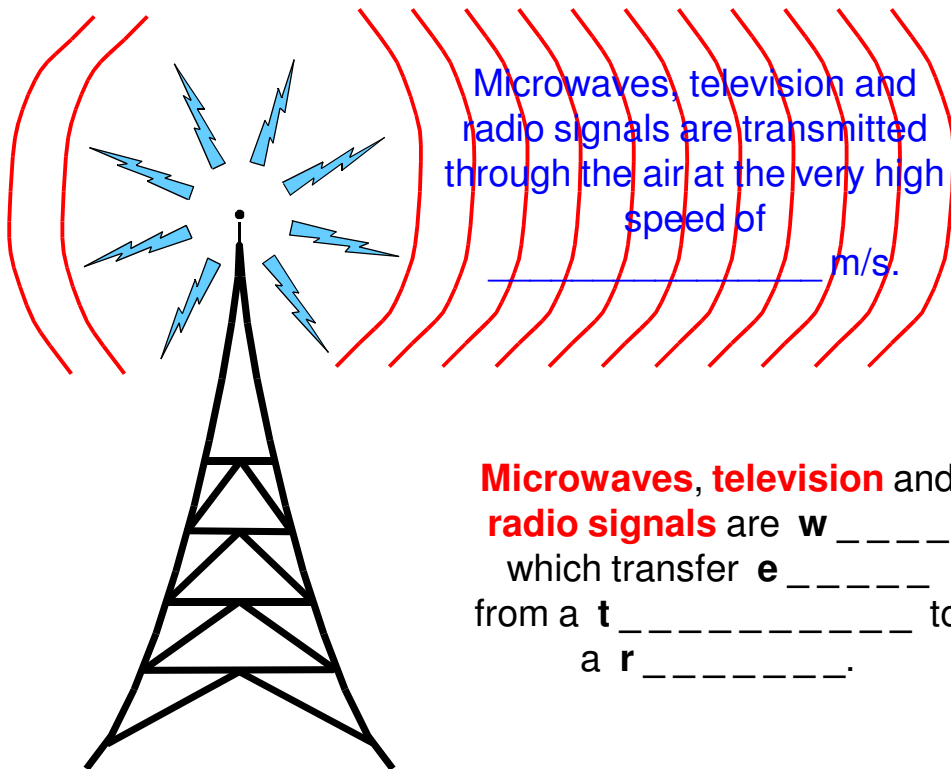
• _____



• _____



• _____



Microwaves, television and radio signals are **w** _____ which transfer **e** _____ from a **t** _____ to a **r** _____.

transmitter

Distance, Time and Speed Calculations

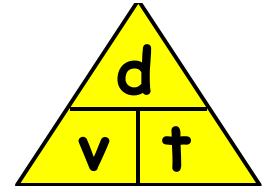
This formula applies to **microwaves**, **television** and **radio waves**:

$$\text{distance (d)} = \text{speed (v)} \times \text{time (t)}$$

m

m/s

s



47) Microwaves, television and radio waves travel 15 000 metres through the air in 0.00005 seconds. Calculate their speed.

48) It takes microwaves 0.00003 seconds to travel through the air from a transmitter to a receiver. Calculate the distance travelled.

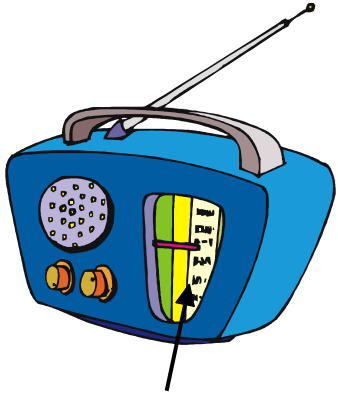
49) Television waves travel 6 000 metres through the air. Calculate the time this takes.

50) Radio waves take 0.00001 seconds to carry a signal through the air between two ships. How far apart are the ships?

51) What time will it take microwaves, television and radio waves to travel 12 000 metres?

Identifying Radio Stations

So that **radio signals** do not get "mixed up", every radio station sends out **radio waves** with a specific value of **wavelength** (and therefore **frequency**).

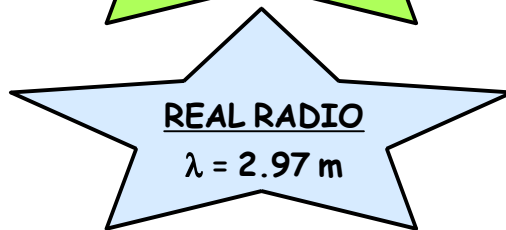
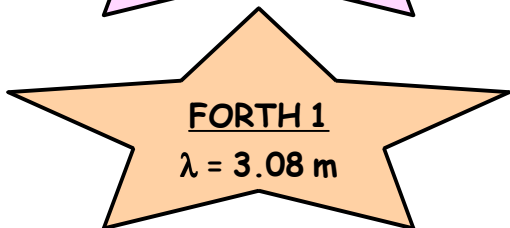
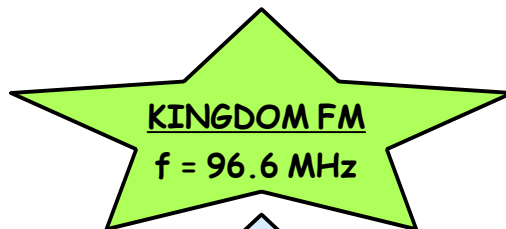
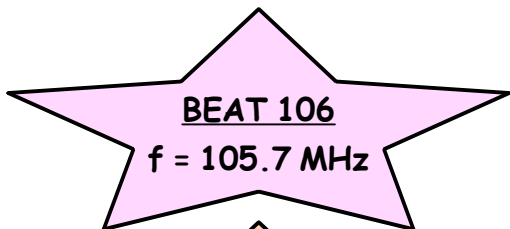


tuning display

On some radio receivers, the **tuning dial** and **display** (which we use to select the radio station we want to listen to) shows the **wavelength** value of radio stations. On other radio receivers, the **tuning dial** shows the **frequency** value of the radio stations.

We can identify a **radio station transmitter** by the **wavelength** (or **frequency**) of the **radio waves** it sends out.

For example, some of the radio stations people in Fife can receive:



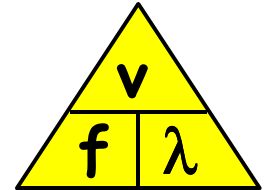
MHz = megahertz 1 MHz = 1 000 000 Hz = (1 x 10⁶) Hz

Use this **wave equation** to help you fill in all the spaces in the table below. (**Show all your working in the table**).

Remember: Speed of radio waves in air
= _____ m/s.

speed (v) = frequency (f) × wavelength (λ)

m/s Hz m



radio station	frequency	wavelength
Beat 106		
Forth 1		
Kingdom FM		
Real Radio		

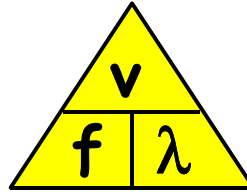
Speed, Wavelength and Frequency

Calculations

We have seen that the wave equation below applies to **radio waves**.

$$\text{speed (v)} = \text{frequency (f)} \times \text{wavelength (\lambda)}$$

m/s Hz m



It also applies to **microwaves** and **television waves**:

52) Microwaves with a frequency of 6×10^9 Hz are used to carry signals from Earth to a satellite. Determine the wavelength of these microwaves.

53) A satellite uses microwaves to send signals down to Earth. These microwaves have a wavelength of 0.075 m. Determine their frequency.

54) The Craigkelly television transmitter in Fife sends out television waves with a frequency of 550 MHz. Calculate the wavelength of these waves.

55) The Blackhill television transmitter near Glasgow transmits television waves of wavelength 0.48 m. Calculate the frequency of these waves.

Radio Bands

To make it easy for us to describe how **radio waves** behave, we put them into groups called **b _____**.

Radio waves in the same **b _____** have similar **wavelengths** (and **frequencies**), so behave in similar ways.

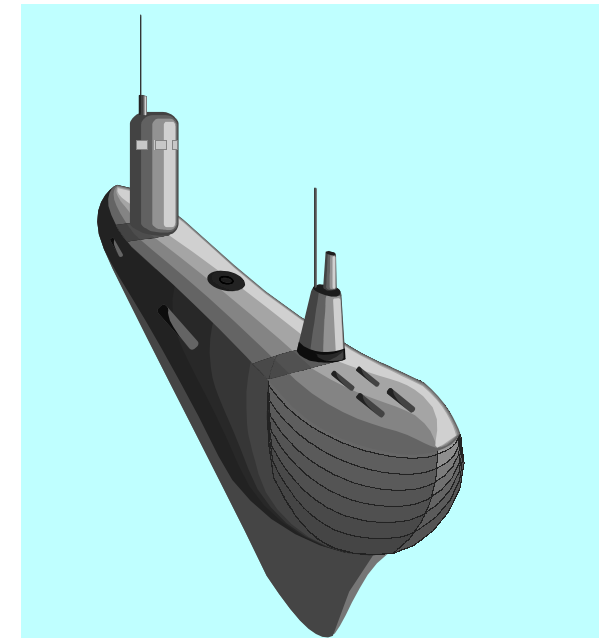
For example:

Band: ELF (E _____ L _____ F _____)

λ above 100 000 m

f = 30 Hz to 30 000 Hz

Can pass deep into the seas and oceans, so are used to communicate with submerged **s _____**.

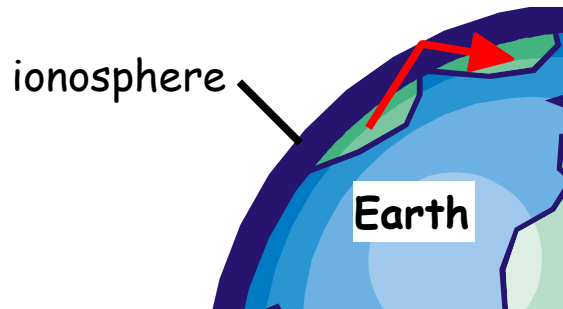


Band: HF (H _____ F _____)

$\lambda = 10 \text{ m to } 100 \text{ m}$

$f = 3\,000\,000 \text{ Hz to } 30\,000\,000 \text{ Hz}$

Used to send signals to far away parts of the Earth because the radio waves can travel long distances by reflecting off a layer in the Earth's atmosphere called the **i** _____.



Band: VHF (V _____ H _____ F _____)

$\lambda = 1 \text{ m to } 10 \text{ m}$

$f = 30\,000\,000 \text{ Hz to } 300\,000\,000 \text{ Hz}$

Travel in almost straight lines, so cannot be used to send signals over long distances - This is because the surface of the Earth curves **a** _____ from them. Used to carry high quality **s** _____ **sound r** _____ signals.



Band: UHF (U _____ H _____ F _____)

$\lambda = 0.1 \text{ m to } 1 \text{ m}$

$f = 300\,000\,000 \text{ Hz to } 3\,000\,000\,000 \text{ Hz}$

Same properties as VHF band. Used to carry high quality **t** _____ signals.



Band: SHF (S _____ H _____ F _____)

λ below 0.1 m

f above 3 000 000 000 Hz

Commonly known as **m** _____. They can pass through the Earth's atmosphere into Space, so are used to communicate with **s** _____.

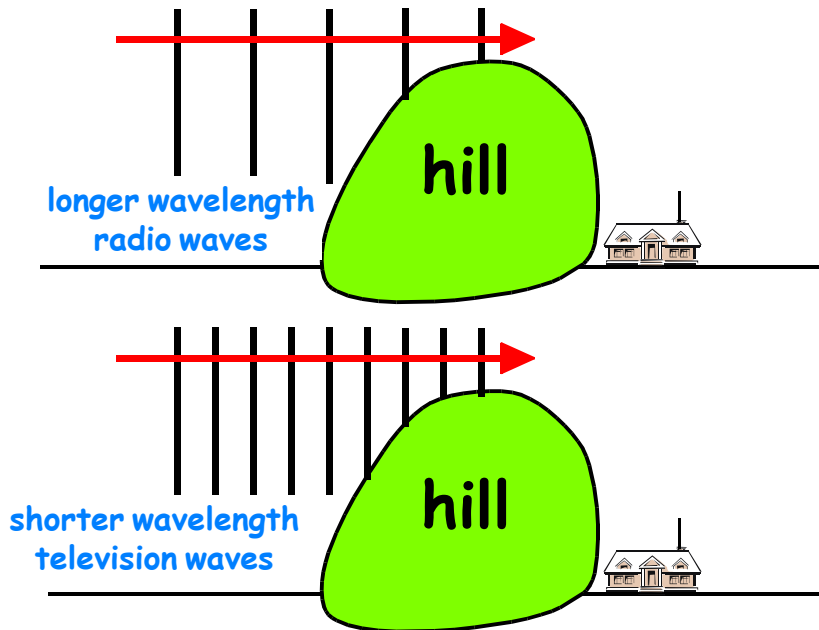


Diffraction - The Bending of Waves Around Obstacles

D _____ is the bending of w _____ around obstacles, such as hills.

W _____ with a longer wavelength (e.g., r _____ w _____) d _____ (b _____) around obstacles better than w _____ with a shorter wavelength (e.g., t _____ w _____).

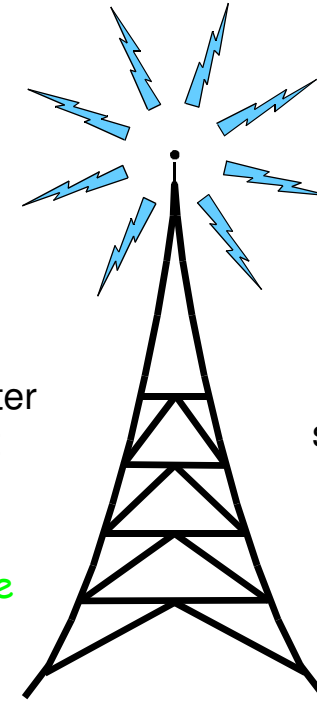
Show this by completing the diagrams:



The longer wavelength r _____ w _____ are able to d _____ (b _____) almost completely around the hill but the shorter wavelength t _____ w _____ cannot d _____ (b _____) as much - They do not reach the a _____ on the house.

This is why _____ reception is better than _____ reception in hilly areas.

Transmitters and Curved Reflectors



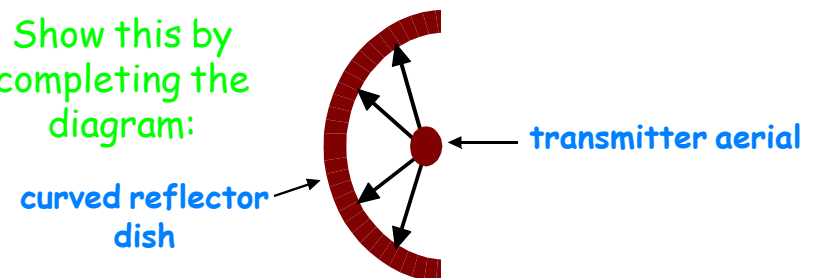
A normal transmitter aerial sends out waves in a _____ directions.

Because of this, the signals are n _____ as s _____ as they could be.

Show this on the diagram.

This can be overcome by fitting a c _____ r _____ d _____ to the aerial. This f _____ the signals into a n _____ b _____ which travels in o _____ direction - The signals are more c _____ and therefore s _____ than with the normal aerial. They can also be directed towards a specific r _____.

Show this by completing the diagram:



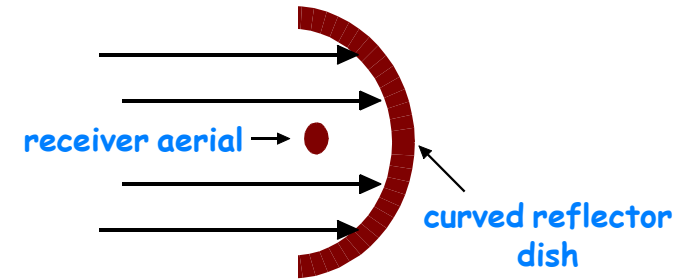
Receivers and Curved Reflectors

Fitting a **c** _____ **r** _____ **dish** to a **receiver aerial** can make the **received signal s** _____.

When incoming signals hit the **c** _____ **r** _____ **dish**, the **dish f** _____ them all onto the **r** _____ **a** _____

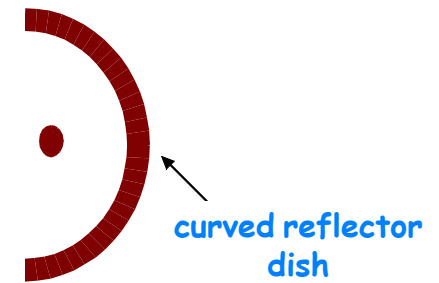
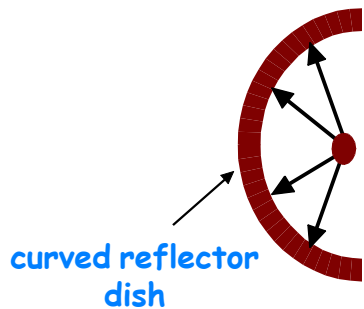
- The **r** _____ **a** _____ therefore receives a **s** _____ signal than it would if the **dish** was not fitted to it.

Show this by completing the diagram:



Curved Reflector Transmitter and Receiver Systems

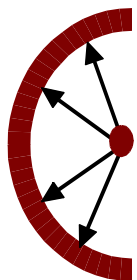
Complete the diagram below to show **signals** being transmitted from the **transmitter aerial** to the **receiver aerial**:



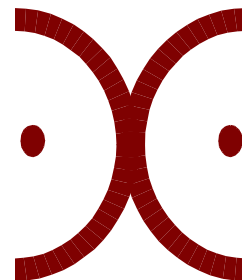
The above diagram could represent **signals** being passed from a **satellite** to the **Earth**, or a **TV link** (e.g., television signals being sent from a sporting event to the television studio).

Sometimes, if **signals** have to travel a long distance over the Earth's surface, the **signals** get **w** _____. We make the **signals s** _____ again by giving them **e** _____ at a **b** _____ station.

Show this on the diagram below:



main transmitter



booster receiver and transmitter station



main receiver

Satellite Communication

A **s** _____ is an object which **o** _____ (**circles**) around a larger object (such as a moon or planet).

The Moon is the natural **s** _____ of the Earth.

Human beings have made their own satellites which they launch into orbit around the Earth using rockets or the space shuttle.

- **Make a list of some of the things we use these satellites for:**

The time it takes a satellite to orbit the Earth (travel around it once) is called the **p** _____ of the satellite.

The **p** _____ depends on the **h** _____ of the satellite above the Earth's surface.

The greater the height, the **l** _____ the **p** _____.

A satellite at a height of 36 000 km above the Earth's surface is called a **g** _____ **satellite**. This is because it has a **p** _____ of _____ **hours** - It takes the satellite _____ **hours** to travel once round the Earth.

Because the Earth takes _____ **hours** to turn once, the satellite remains **above** the **s** _____ **p** _____ on the Earth's surface.

We can send **television signals** from one place to another on the Earth's surface using a **g** _____ **satellite** and _____ **2 d** _____ **a** _____.



A **m** _____ **signal** (carrying **picture** and **sound** information) is sent from a **t** _____ **d** _____ **a** _____ up to a **g** _____ **satellite**. Because this journey is **36 000 km**, the **m** _____ **signal** is **w** _____ when it reaches the **satellite**.

At the **satellite**, the **m** _____ **signal** is **amplified** (made **s** _____) before it is sent back down to a different place on the Earth's surface with a different **f** _____. The **m** _____ **signal** is received by a **r** _____ **d** _____ **a** _____.

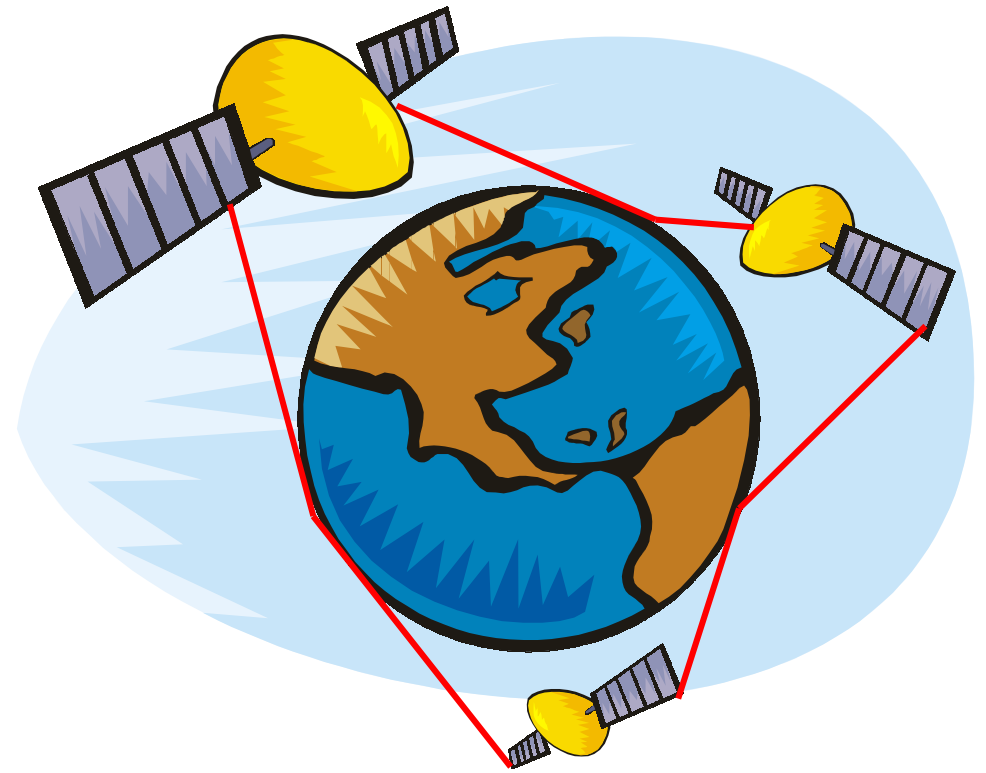
Having travelled a further **36 000 km** back to Earth, the **m** _____ **signal** is again **w** _____. It is **amplified** (made **s** _____) once again before being sent over the Earth's surface to its final destination by a network of **d** _____ **a** _____.

Complete the diagram, adding as much information as possible, to illustrate how a **television signal** is sent from one place on the Earth's surface via a **geostationary satellite**.



Explain what is shown in the diagram:

Using just **g** _____ **s** _____
and suitably placed **t** _____ / **r** _____
d _____ on the Earth's surface, signals can be sent
from any place on the Earth's surface to any other place
on the surface.



Explain what is shown in the diagram:

Notes