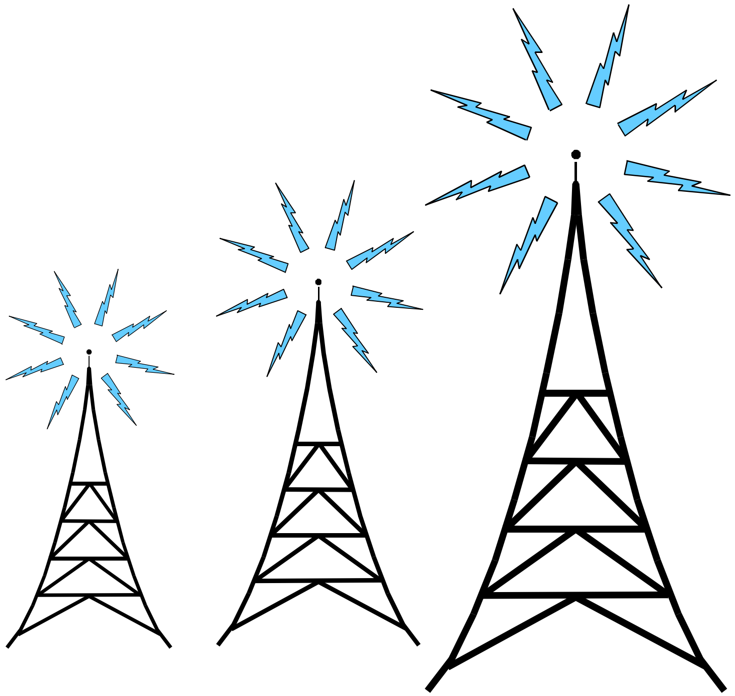
# Standard Grade Physics

## "TELECOMMUNICATION"



Name: ______________________________ Class: ______ Teacher: ______________________

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| | Section 1 – Communication Using Waves | | | | |
|---|---|---|---|---|---|
| 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. | | | | |
| 7. | Carry out calculations involving *wavespeed = frequency x wavelength* in problems on both water and sound waves. | | | | |
| 8. | Explain why wavespeed can be calculated using either *frequency x wavelength* or $\frac{distance}{time}$. | | | | |

| Section 2 – Communication Using Cables | | | | | |
|---|---|---|---|---|---|
| 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. | | | | |
| 8. | Describe the effect on a C.R.O. signal pattern due to a change in a sound's: *(a)* loudness; and *(b)* frequency. | | | | |
| 9. | Describe how these terms relate to sound signals: *frequency, amplitude.* | | | | |
| 10. | State what is meant by the term '*optical fibre'.* | | | | |
| 11. | Describe one practical use of optical fibres in telecommunications. | | | | |
| 12. | State that both electrical cable and optical fibres can be used in telecommunication systems. | | | | |
| 13. | State that light can be reflected. | | | | |
| 14. | Describe how a ray of light is reflected from a flat mirror with the help of the *Law of Reflection.* | | | | |
| 15. | State that light signals pass along an optical fibre at very high speeds. | | | | |
| 16. | Explain how changes in the loudness and frequency of a sound signal affect the corresponding electrical signal pattern. | | | | |
| 17. | Compare the properties of electrical cables and optical fibres. | | | | |
| 18. | Explain what is meant by *reversibility of light.* | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 19. | Describe how an optical fibre transmission system works. | | | | |
| 20. | Carry out calculations using $speed = \frac{distance}{time}$ in problems on light travelling through optical fibres. | | | | |

| **Section 3 Radio and television** | | | | | |
|---|---|---|---|---|---|
| 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. | Explain how radio transmission works using these terms: *transmitter; carrier wave; amplitude modulation; receiver.* | | | | |
| 10. | Explain how television transmission works using these terms: *transmitter; carrier wave; amplitude modulation; video and audio receivers.* | | | | |
| 11. | Describe how a moving picture is seen on a television screen using these terms: *line build-up; image retention; brightness variation.* | | | | |
| 12. | Describe the effects of mixing red, green and/or blue light. | | | | |

| Section 4 – Transmission of Radio Waves | | | | | |
|---|---|---|---|---|---|
| 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. | State that a radio transmitter can be identified by wavelength or frequency values. | | | | |
| 6. | State the purpose of the curved reflector on certain aerials. | | | | |
| 7. | Explain the effect the curved reflector has on the received signal. | | | | |
| 8. | Describe one use of curved reflectors in telecommunications. | | | | |
| 9. | Say how a satellite's height affects the time it takes to complete an orbit around the earth. | | | | |
| 10. | Explain the meaning of the word *period*. | | | | |
| 11. | State the meaning of a *geostationary satellite*. | | | | |
| 12. | Describe how geostationary satellites and dish aerials can be used to allow satellite television broadcasting. | | | | |
| 13. | Describe how geostationary satellites and ground stations make intercontinental communications possible. | | | | |
| 14. | Carry out calculations involving the relationship between speed ($v$), distance ($d$) and time ($t$) in problems on microwaves, television and radio waves. | | | | |
| 15. | Carry out calculations involving the relationship between speed ($v$), wavelength ($\lambda$) and frequency ($f$) for microwaves, television and radio waves. | | | | |
| 16. | Explain some of the differences between radio bands in terms of source strength, ability to diffract, reflection, etc. | | | | |
| 17. | Explain how wavelength affects radio reception in terms of *diffraction*. | | | | |
| 18. | In addition to ***6*** above, explain the action of curved reflectors on certain transmitters. | | | | |

# 1) COMMUNICATION USING WAVES

## Introduction - Uses for Sound and Light Energy

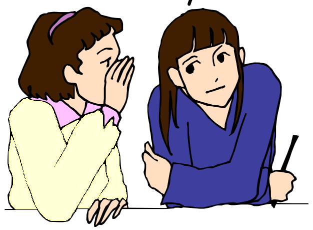
**Sound** and **light** are important types of **energy**. We use them to **transmit** (**send**) **signals** from one place to another. This is known as **communication**.

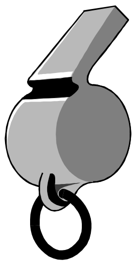
**Transmitting** (**sending**) **signals** over a **long distance** is known as **telecommunication**.

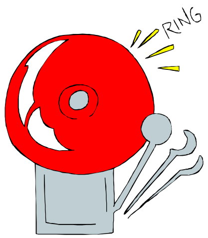
In each case below, write a short description of how **sound** or **light** is being used for **communication**:

- **sound**

"I love Physics."

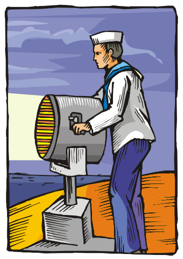


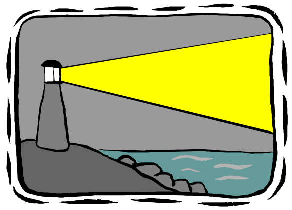


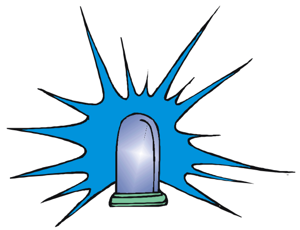


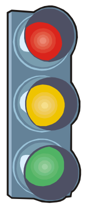


- **light**





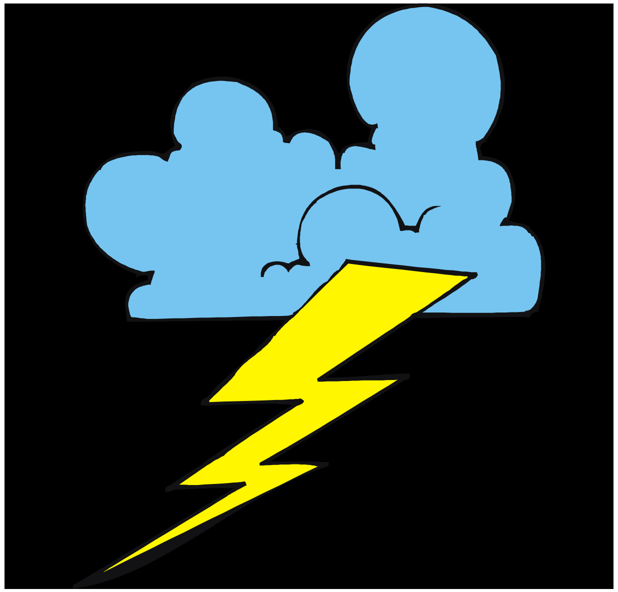




# Comparing the Speed of Sound and Light in Air

In air, speed of sound = ___ m/s
In air, speed of light = ___ ___ ___ m/s (_ x 10 - m/s)

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



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

**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:

____________________

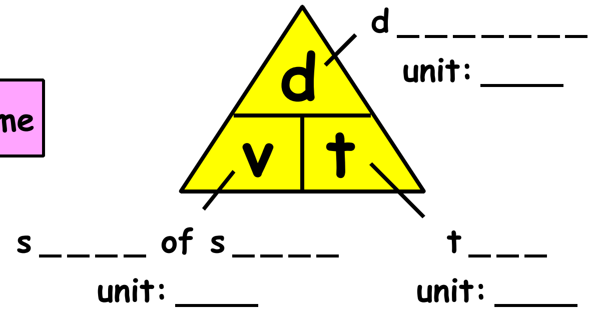
(b) Explain why:

____________________
____________________
____________________
____________________
____________________

# 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 x 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.

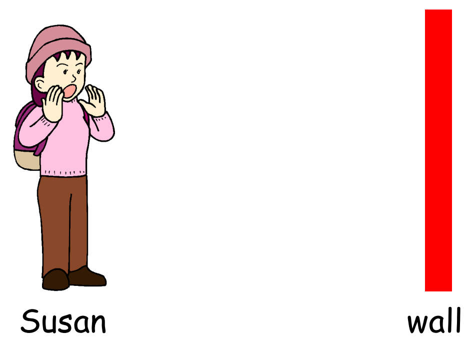
**6)** How long will it take the sound of a bell to travel 850 meters through the air?

**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.



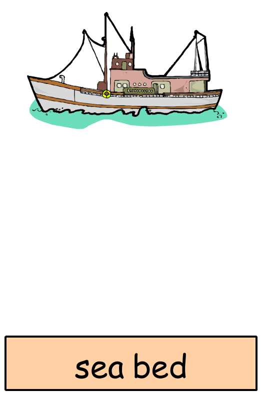

Sound has a different speed in different materials. For example:

**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?

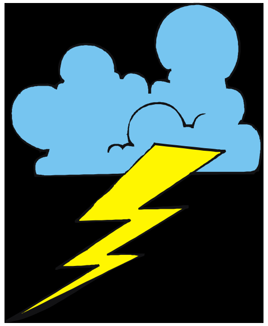


**Light** is the fastest thing there is - Nothing can travel faster than light. Because light travels so quickly, we assume we see things happen at the instant they happen.

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:

**distance = speed of sound in air x time for sound to reach us**



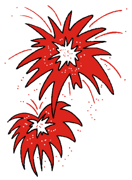
**12)** During a storm, **thunder** and **lightning** are produced at exactly the same time.

(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?

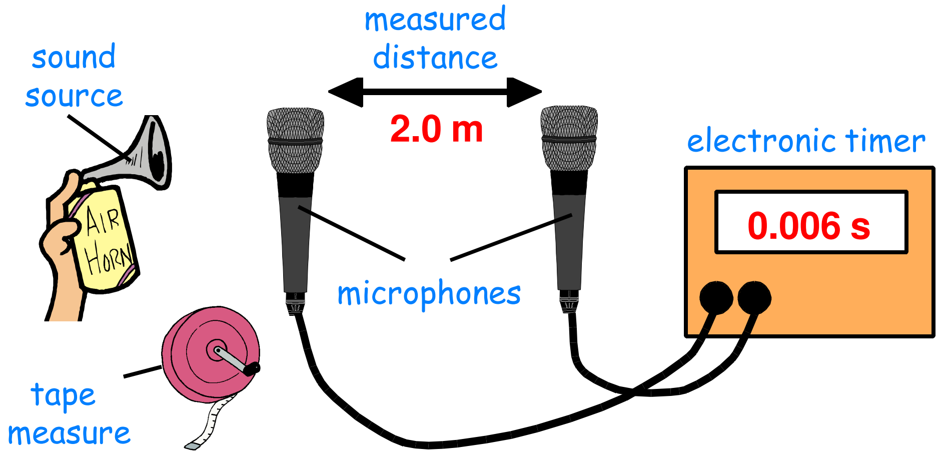


**14)** A soldier sees a shell explode. The sound from the explosion reaches him 0.2 seconds later.

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.

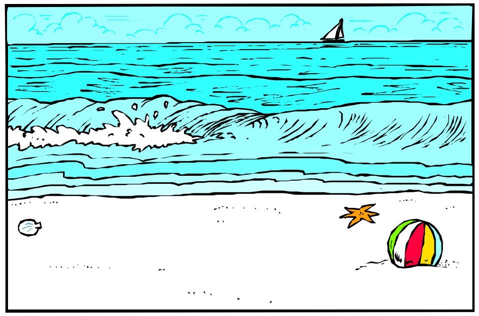



$$\text{speed} = \frac{\text{distance between microphones}}{\text{time for sound to pass between microphones}}$$

**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.

A tsunami sea wave transfers

## Waves and Signal Transmission

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

**w** _ _ _ _ also **transmit** signals for:

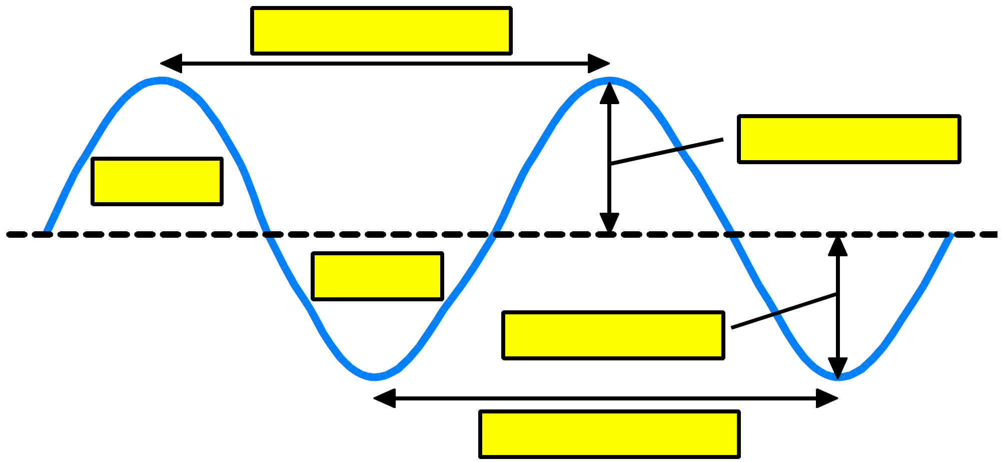
• ________ • ____________ • ________ ________ • ____________

## Wave Diagrams

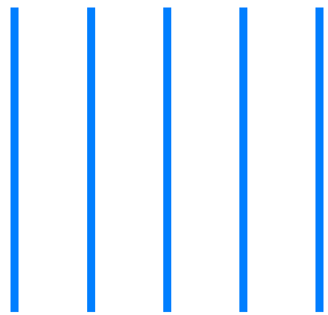
The diagram below represents a typical **wave** viewed from the side.

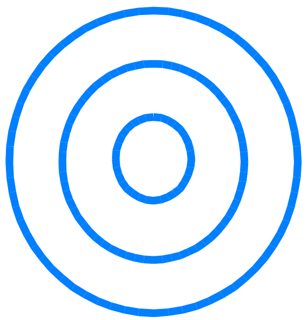
Use the **word bank** to label the **wave diagram**:

| |
|---|
| **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 | [redacted] | [redacted] | Part of wave ________ centre line. |
| wave trough | [redacted] | [redacted] | Part of wave ________ centre line. |
| | [redacted] | | 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:

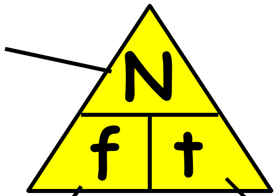
______________________________________________

______________________________________________

This can be represented by the formula:

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

n ______ of
w ____________
or c ______ or
t _______




f _________
unit: _____

t ___
unit: _____

The **speed** of a wave is:

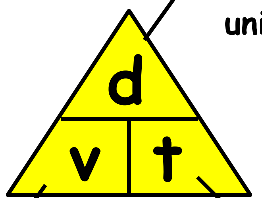
______________________________________________

______________________________________________

This can be represented by the formula:

distance = speed × time

d ________
unit: _____




s ____ of w ___
unit: _____

t ___
unit: _____

# Water Wave Problems/Calculations

**16)** (a) Which of these waves is carrying the most energy? __________

(b) Explain you answer: ______________________________________________

______________________________________________________________

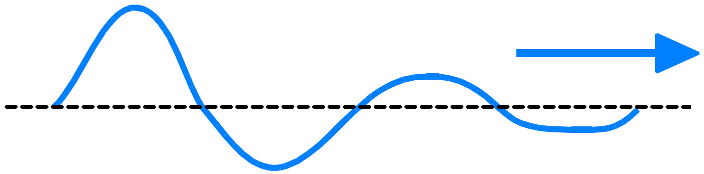

**17)** The wave shown below is travelling to the right.

(a) As the wave travels, what happens to its amplitude?

______________________________

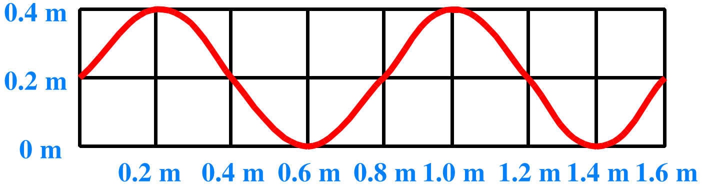
(b) What must be happening to the wave's energy? ______________

______________________________________________________________



**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: ______________________________

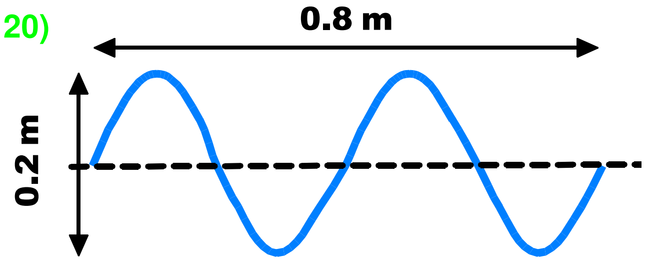
**19)** Determine the frequency of the wave in each case:

(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

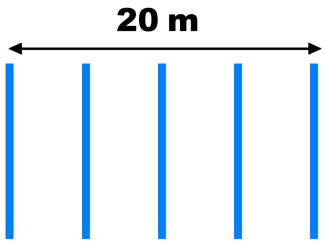
________

(ii) the wavelength

________

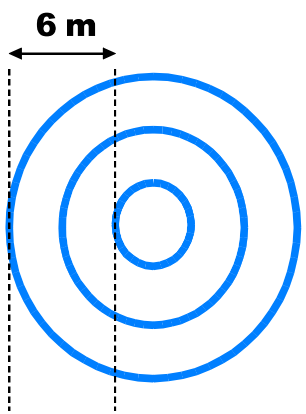
(b) The wave was produced in 2 seconds. State the value for its frequency.

**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:

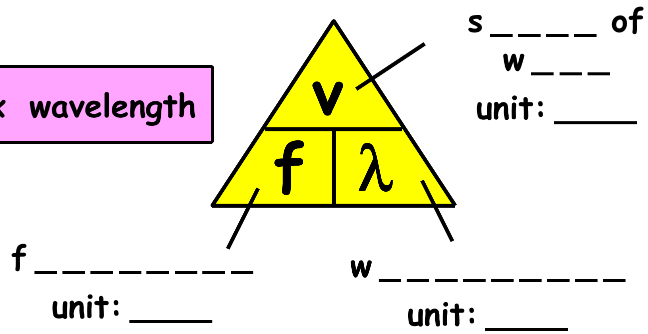
$$\text{frequency} = \frac{1}{\text{time}}$$

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

Example

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

**speed = frequency x wavelength**




Explain the **equivalence** of the 2 **wave formulae**:

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

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.

**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.

**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.

**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.

**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.

**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.

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

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

**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.

**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.

**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.

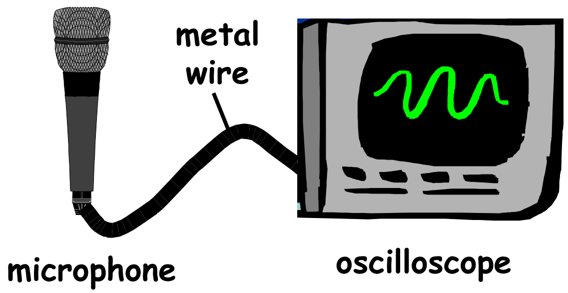
**40)** Ultrasound (frequency 21 000 hertz) travels through human muscle at 1 600 metres per second. Calculate the wavelength of ultrasound in the muscle.

# 2) COMMUNICATION USING CABLES

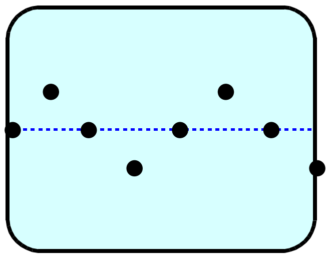
## Introduction - Electrical Cables and Optical Fibre Cables

### (a) Electrical Cables

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 _ _ _ _ _ _ _ _ _ _ _ _**.

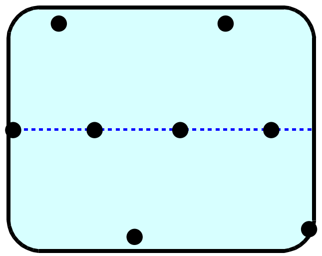



- quiet sound



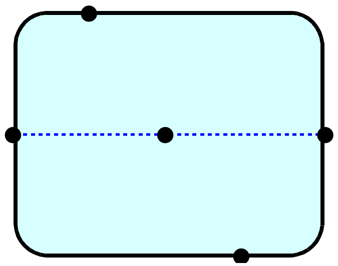
Join the dots.

- loud sound



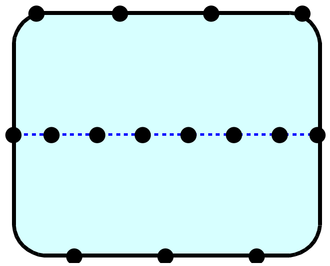
Join the dots.

- low frequency sound



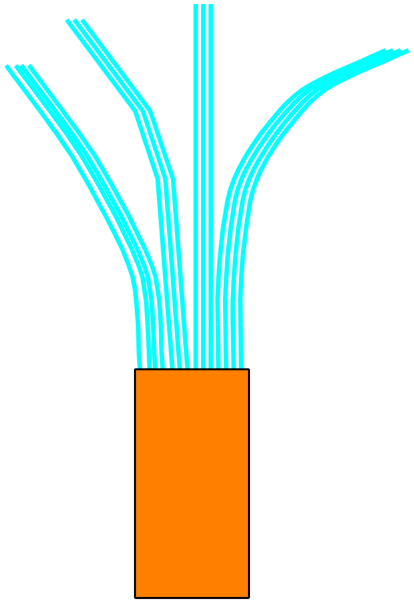
Join the dots.

- high frequency sound



Join the dots.

# (b) Optical Fibre Cables

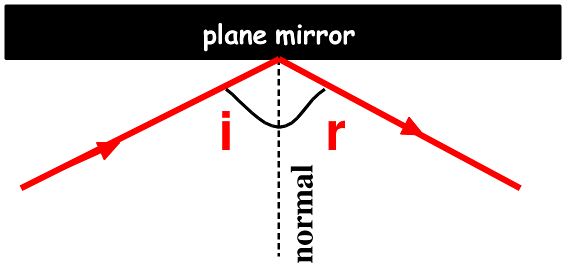


## Reflection of Light

**Light** travels in **straight lines** called **light r _ _ _**.

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

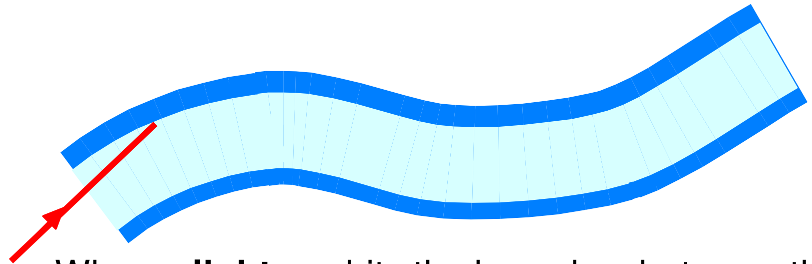
**A normal is a dashed line drawn at 90° to a surface where a light ray hits the surface.**




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

__ = __

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**.



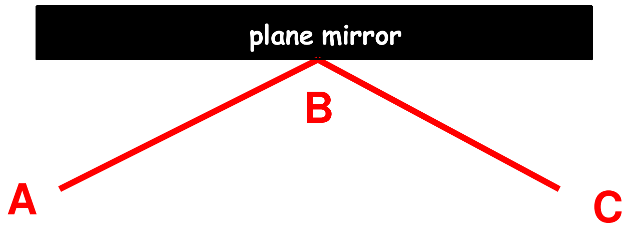
When a **light ray** hits the boundary between the **core** and **coating** at an angle greater than a "**c** _ _ _ _ _ _ _ _ **a** _ _ _ _", **all** of the **light ray** is reflected back into the **optical fibre** - This is known as **t** _ _ _ _ **i** _ _ _ _ _ _ _ _ **r** _ _ _ _ _ _ _ _ _ _.

- 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

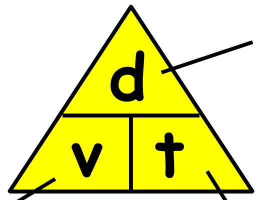
Complete the table by ticking the correct option in each case. You may like to make additional notes:

| 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**:

| distance = speed x time |
|---|




d _ _ _ _ _ _ _ _ light travels along optical fibre

unit: ___

s _ _ _ _ of l _ _ _ _ in optical fibre

unit: ____

t _ _ _ for light to pass along optical fibre

unit: ____

A **l _ _ _ _ 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 ($2.5 \times 10^{-4}$ 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 ($3 \times 10^{-4}$ 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 ($3.75 \times 10^{-4}$ seconds) to do so?

**45)** If light takes 0.002 seconds ($2 \times 10^{-3}$ 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**,

**Short press (hence short buzz) = dot ●**

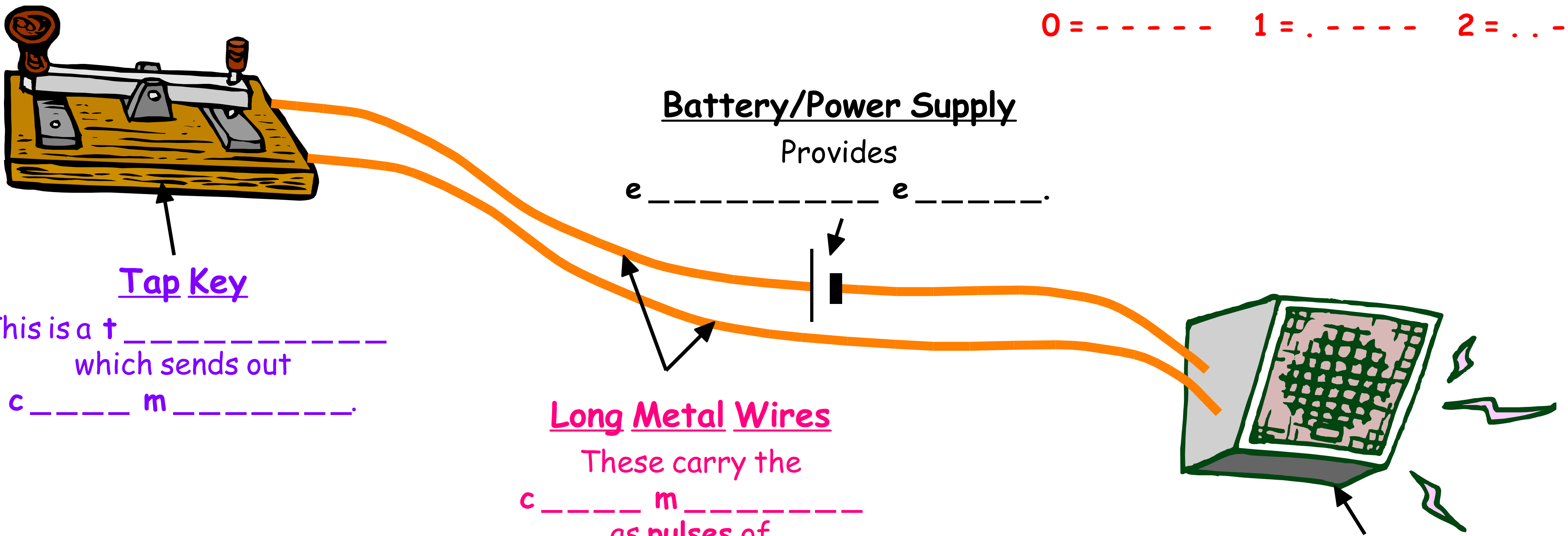
**Long press (hence long buzz) = dash ▬**

### 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 = . . - - -**



**Battery/Power Supply**

Provides

**e** ___________ **e** ______.

**Tap Key**

This is a **t** ____________

which sends out

**c** _____ **m** _________.

**Long Metal Wires**

These carry the

**c** _____ **m** _________

as **pulses** of

**e** _________ **c** ________

from the

**tap key t** ____________ to

the **buzzer r** _________.

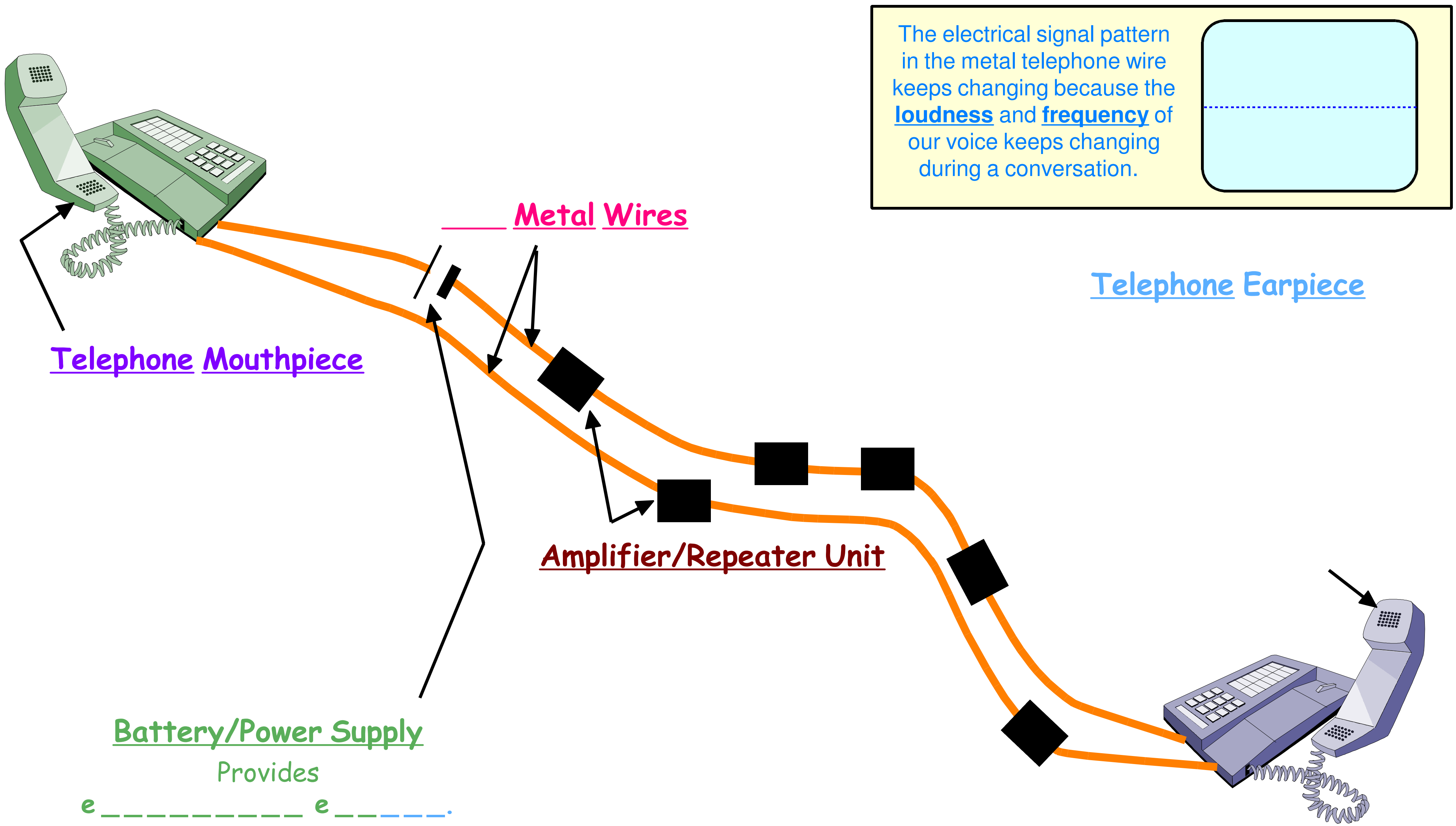
**Buzzer**

This is a **r** _________

which picks up the

**c** _____ **m** _________.

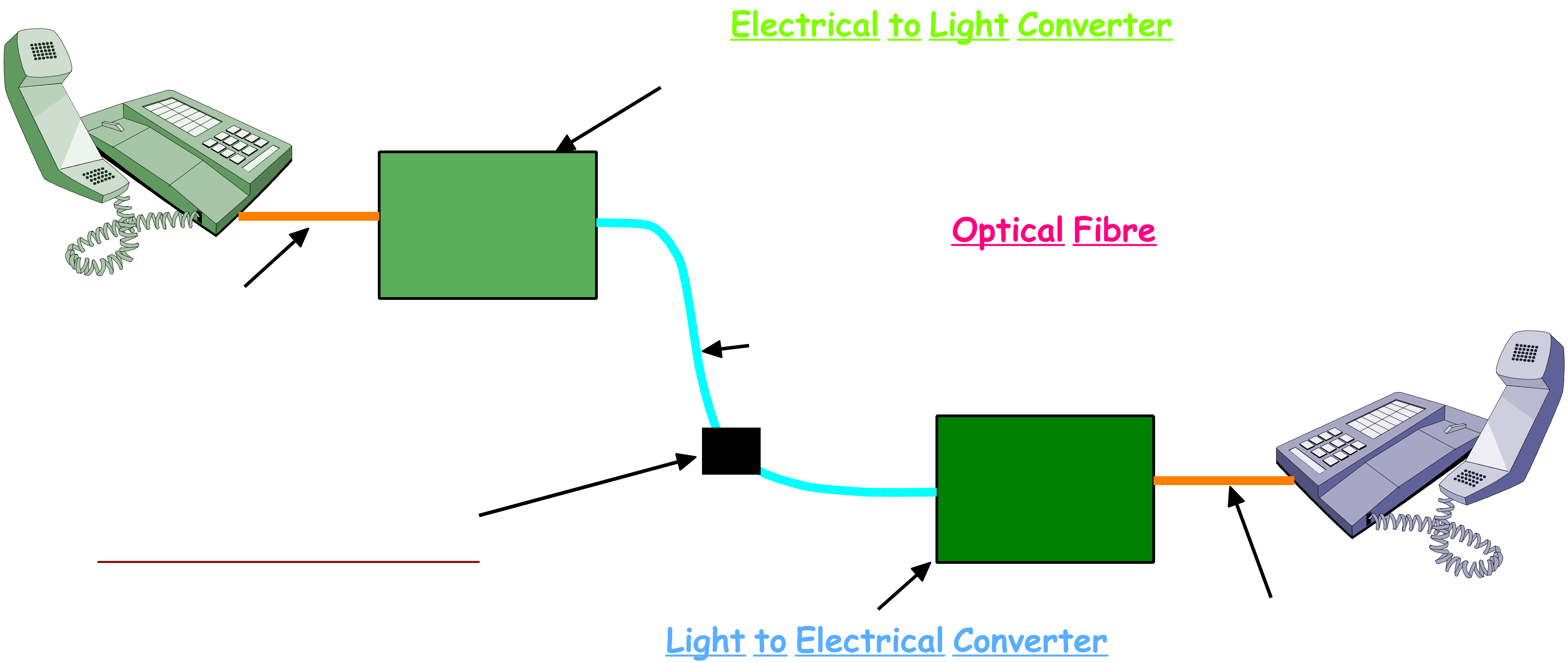
## (b) The Telephone



# Optical Fibre Telecommunication Systems

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

**Laser OFF = 0**  **Laser ON = 1**

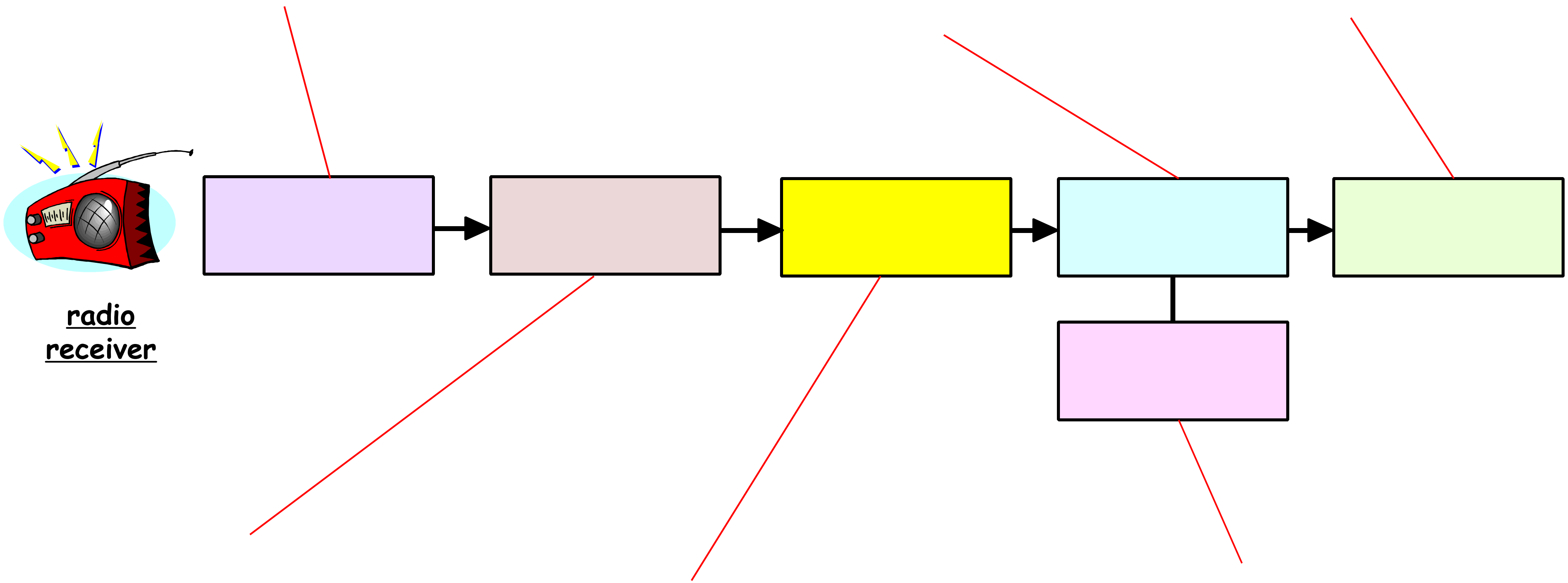


# 3) RADIO and TELEVISION

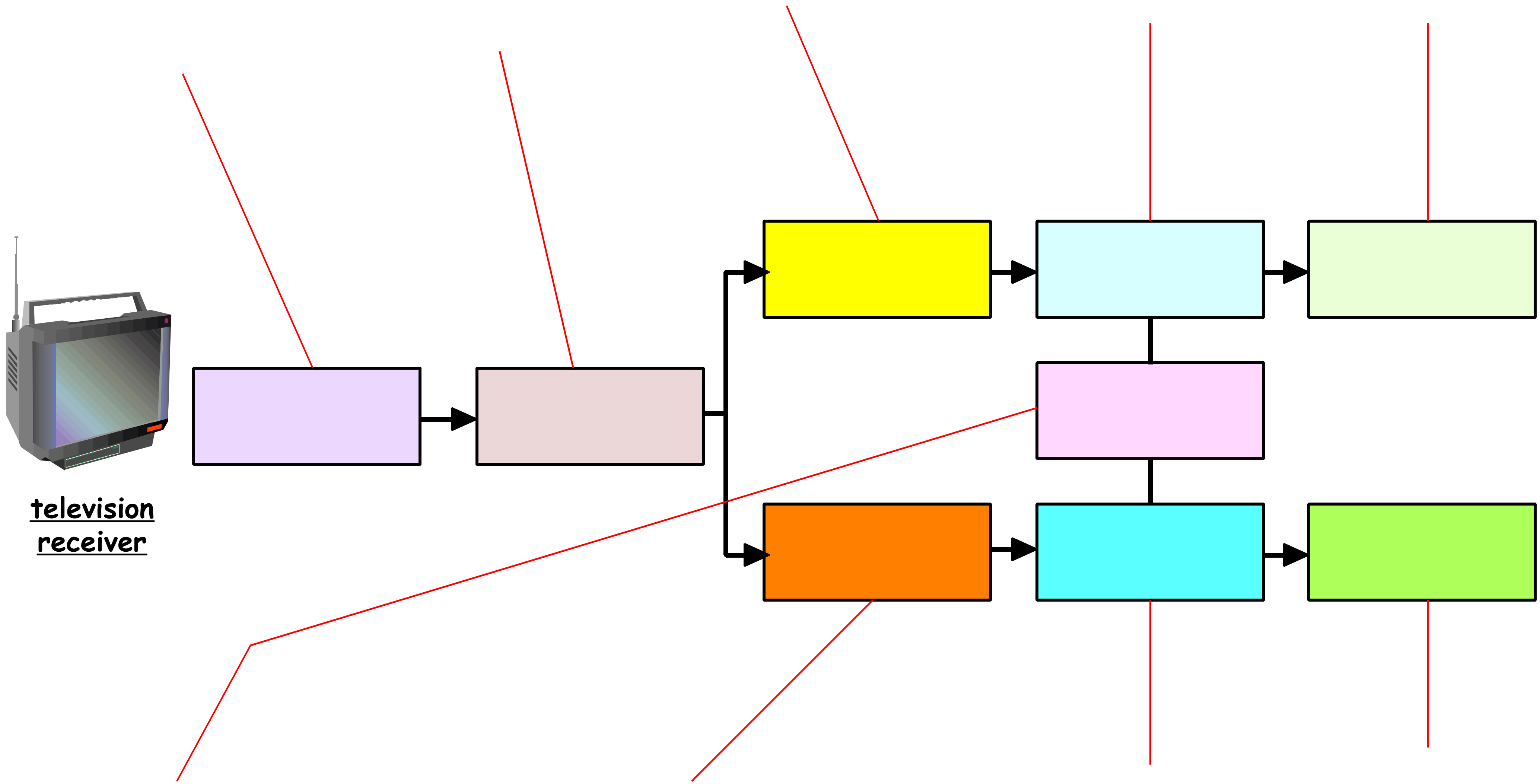
## 1) The Parts of Radio and Television Receivers

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

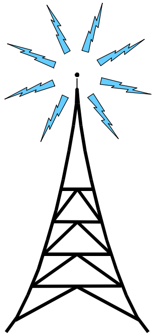
Write the name of each part of the **radio receiver** and the **television receiver** in the correct block.
In the surrounding space, state the **function** of each part.



**radio receiver**


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**.

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

# 3) Black & White Television Picture

## Line Build Up

## Image Retention

**Television Screen**

## Brightness Variation

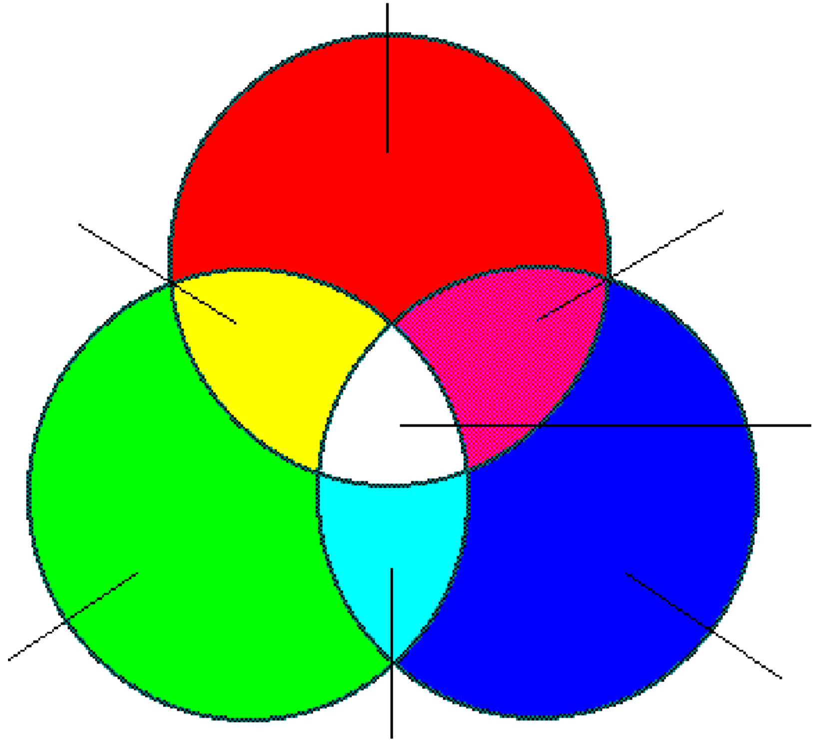
To **increase** the brightness of a television picture, **m** _ _ _ electrons are fired at the screen every second.

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.

Clipart copyright S.S.E.R. Ltd

# 4) TRANSMISSION of RADIO WAVES

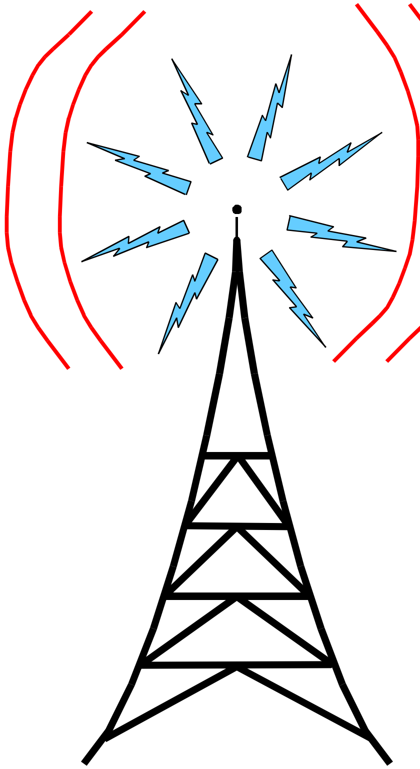
## Telecommunication Without Wires

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

- ________ ________

- ________

- ___________



Microwaves, television and radio signals are transmitted through the air at the very high speed of ____________________ m/s.

**transmitter**

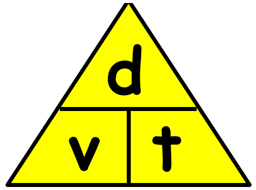
**Microwaves**, **television** and **radio signals** are **w** _ _ _ _ which transfer **e** _ _ _ _ _ from a **t** _ _ _ _ _ _ _ _ _ _ to a **r** _ _ _ _ _ _ _.

## Distance, Time and Speed Calculations

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

**distance (d) = speed (v) × 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.

---

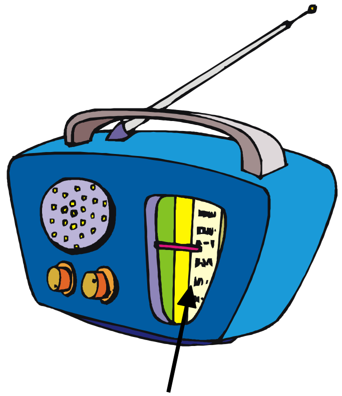
**50)** Radio waves take 0.00001 seconds to carry a signal through the air between two ships. How far apart are the ships?

---

**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:

BEAT 106
f = 105.7 MHz

KINGDOM FM
f = 96.6 MHz

FORTH 1
$\lambda$ = 3.08 m

REAL RADIO
$\lambda$ = 2.97 m

**MHz = megahertz** **1 MHz = 1 000 000 Hz = (1 x $10^6$) 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) x wavelength ($\lambda$)

m/s Hz m

$$v = f \times \lambda$$

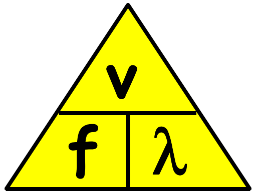
| radio station | frequency | wavelength |
|---|---|---|
| Beat 106 | | |
| Forth 1 | | |
| Kingdom FM | | |
| Real Radio | | |

## Speed, Wavelength and Frequency Calculations

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

**speed (v) = frequency (f) x wavelength (λ)**

m/s Hz m




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

**52)** Microwaves with a frequency of 6 x $10^9$ 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.

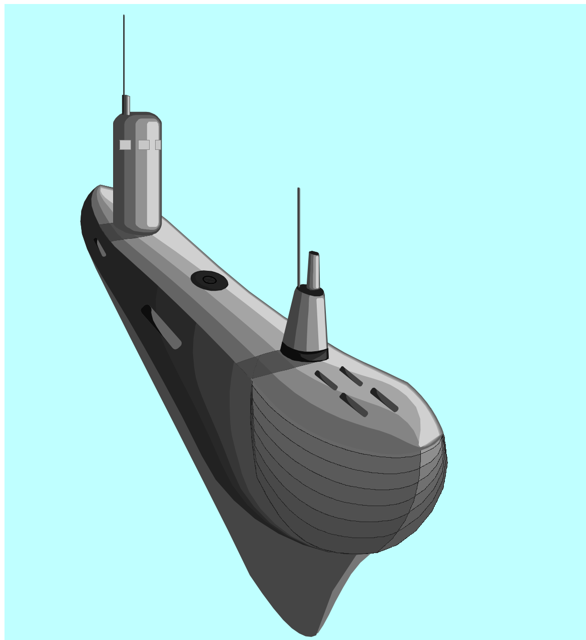
**For example:**

**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** _ _ _ _ _ _ _ _ _.

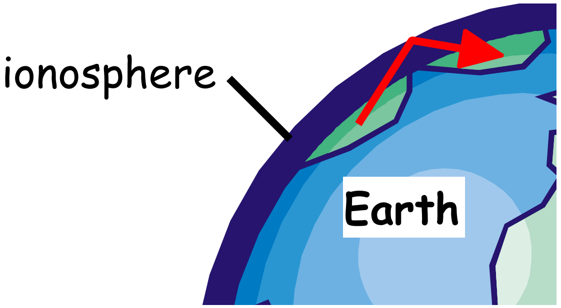


## Band: HF (H _ _ _ F _ _ _ _ _ _ _ _ _)

**λ = 10 m to 100 m**

**f = 3 000 000 Hz to 30 000 000 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 _ _ _ _ _ _ _ _ _)

**λ = 1 m to 10 m**

**f = 30 000 000 Hz to 300 000 000 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 _ _ _ _ _ _ _ _ _)

**λ = 0.1 m to 1 m**

**f = 300 000 000 Hz to 3 000 000 000 Hz**

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

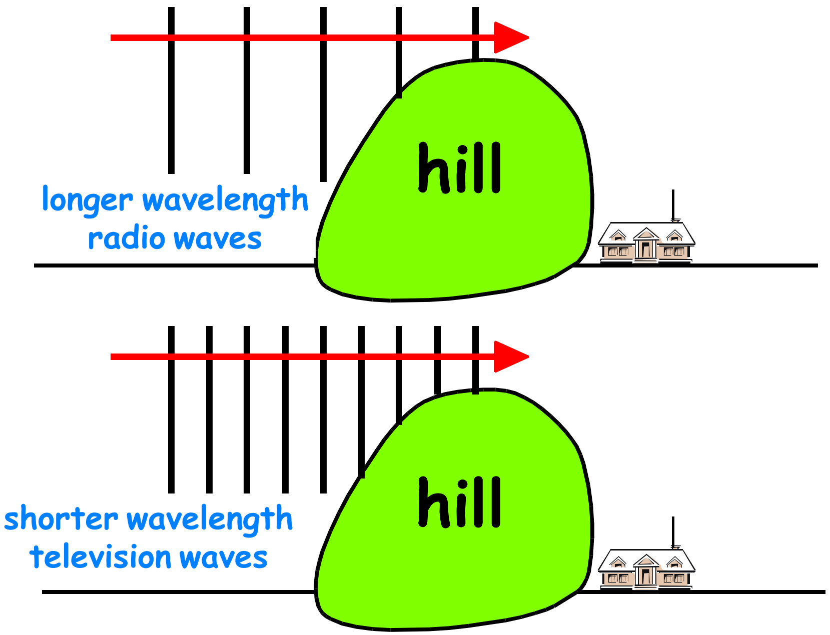
## Band: SHF (S _ _ _ _ H _ _ _ F _ _ _ _ _ _ _ _ _)

**λ below 0.1 m**

**f above 3 000 000 000 Hz**

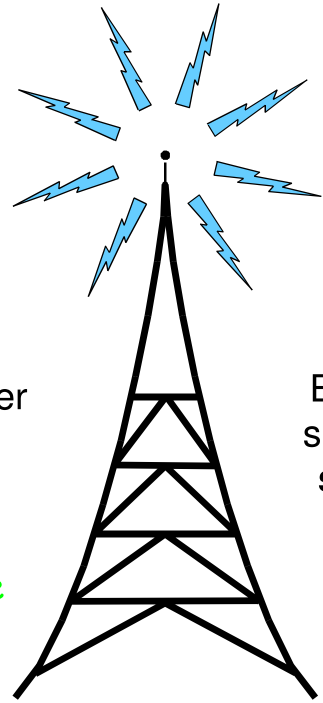
Commonly known as **m** _ _ _ _ _ _ _ _ _ _. They can pass through the Earth's atmosphere into Space, so are used to communicate with **s** _ _ _ _ _ _ _ _ _ _.

# Diffraction - The Bending of Waves Around Obstacles




The longer wavelength **r** _ _ _ _ **w** _ _ _ _ are able to

# Transmitters and Curved Reflectors



A normal transmitter aerial sends out waves in **a** _ _ directions.

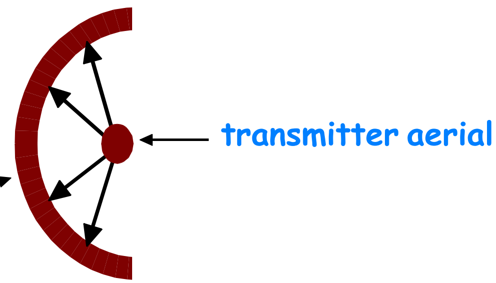
Show this on the diagram.

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

This can be overcome by fitting a **c** _ _ _ _ _ **r** _ _ _ _ _ _ _ _ **d** _ _ _ to the aerial.

This **f** _ _ _ _ _ _

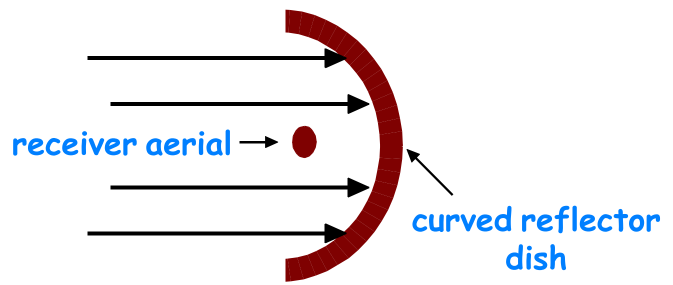
Show this by completing the diagram:



# Receivers and Curved Reflectors

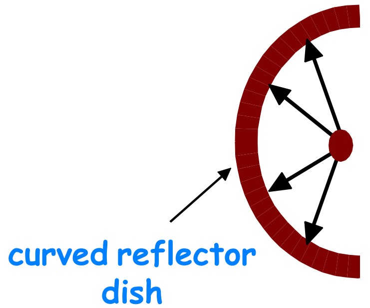
Fitting a **c _ _ _ _ _ r _ _ _ _ _ _ _ _ _ dish** to a **receiver aerial** can make the **received signal s _ _ _ _ _ _ _ _**.

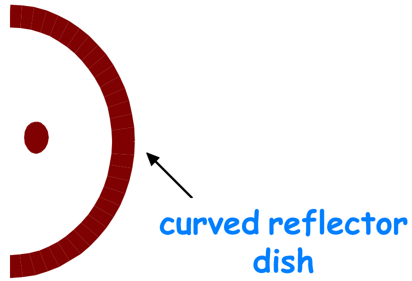
When incoming signals hit the




# 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:

# Satellite Communication

- 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

.

A satellite at a height of 36 000 km above the Earth's surface is called a **g _ _ _ _ _ _ _ _ _ _ _ _ satellite**.

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**,

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

Explain what is shown in the diagram:

______________________________________________

______________________________________________

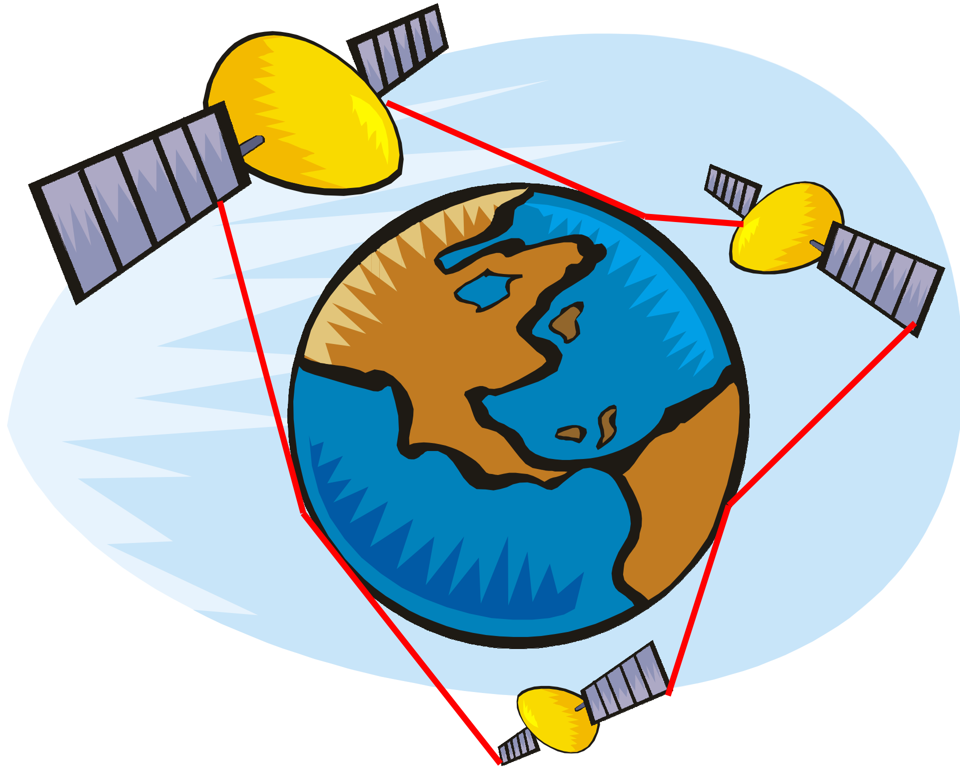
______________________________________________

______________________________________________

______________________________________________

______________________________________________

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:

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________