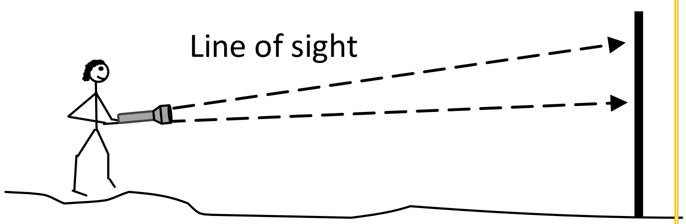
Radio Propagation

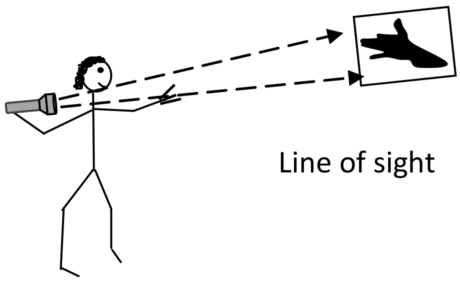
Radio waves travel in straight lines. This is like a torch beam which keeps going until it strikes something or it spreads out and becomes too weak to be seen.

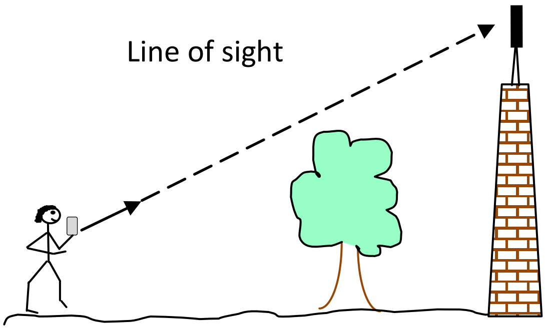


1. Shine a torch on a wall and watch how the dot changes as you move away from the wall. How far can you move back before the light cannot be seen on the wall? This is like what happens with Very High Frequency radio waves.

If an object is placed in the path of the light then the beam will be blocked.

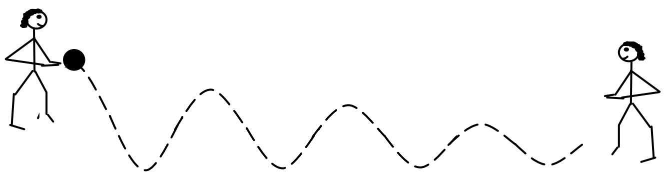
2. Use your torch to make some shadow pictures with your hands.

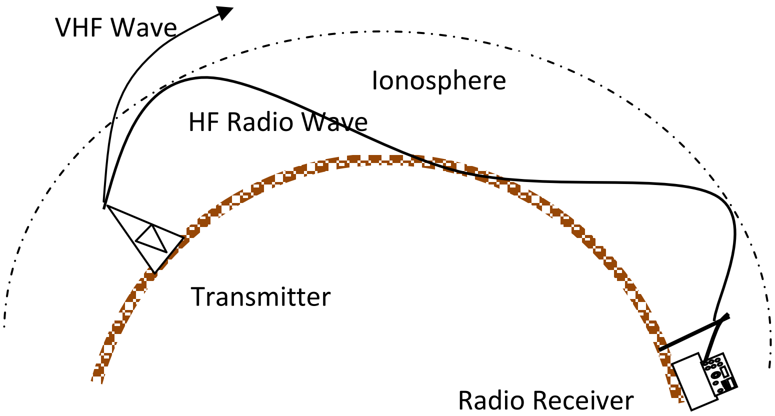




This is like using your phone amongst tall buildings. The signal from your mobile phone travels in a straight line so mobile phone towers need to be really tall.

3. Now bounce a ball to a friend. How many times can you get it to bounce before it is too low for your friend to catch?





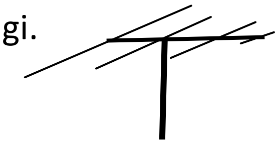
This is like shortwave radio signals travelling around the world. They bounce around between the Earth's surface and the upper layer of the atmosphere (ionosphere) getting weaker as they go. The strength of the ionosphere is controlled by emissions from sunspots on the Sun.

The ionosphere has 3 layers F, E & D. Radio waves travel further at night as only the F layer remains at night. The radio waves are *refracted* by the ionosphere and are returned to Earth where they are *reflected* back up again. Very high frequencies pass straight through the ionosphere and keep going.

4. Listen on a WebSDR receiver and see what radio stations you can hear. What type of radio stations are they? Where are they located?

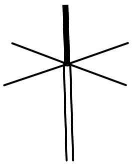
Antennas

Aerials (or antennas) are needed for both reception and transmission of radio waves. Most people are familiar with the typical television aerial. This is called a yagi. Yagis are directional antennas and can be horizontal or vertical.

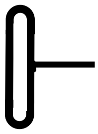


Yagi Antenna

You may also have seen some like these on high towers.

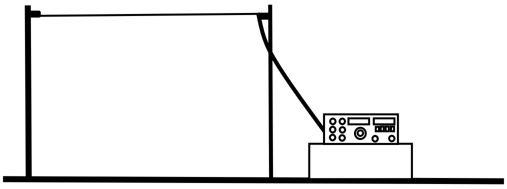


$\frac{1}{4}$ Wave Ground Plane

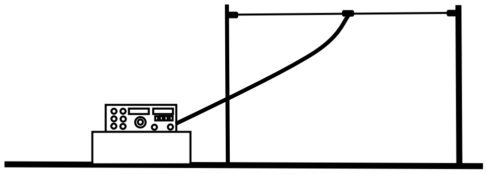


Folded Dipole

Long wire aerials are also used for radio reception and transmission.



Horizontal End Fed Wire

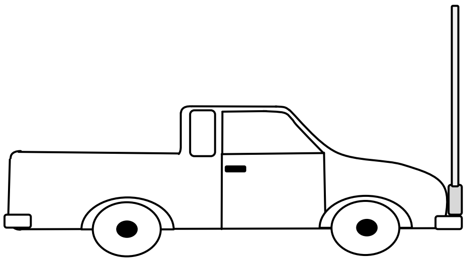


Horizontal Half Wave Dipole

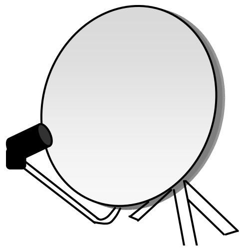
Radio aerials are needed on hand held radios, trucks and cars with two-way radios and for picking up satellite TV signals.

Care should be taken not to be too close to a receiving antenna when transmitting on a radio.

Hand-held Radio



Mobile radio



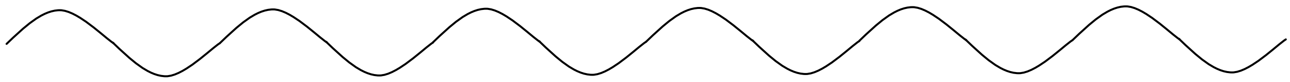
Satellite TV Dish

1. As you travel around look up and see how many different types of aerials there are around you. Draw pictures of them and try to identify what type they are.

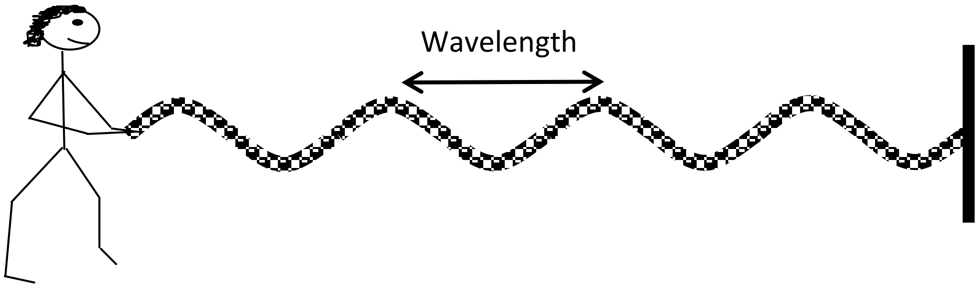
2. A mobile phone is really a radio. It transmits a signal to the nearest mobile phone base station tower. Build a fun antenna tower using marshmallows and toothpicks. Challenge yourself. How high can you build it?

Frequency and Wavelength

Alternating current (AC) moves electrons back and forth, sound waves vibrate the air, light travels in waves and radio transmitters send out electromagnetic energy.
All of these can be represented by a "Sine Wave" like this.



1. Waves can be demonstrated with a long rope with one end tied to a post. Quickly move the free end up and down so that waves are created along the rope.



2. Now move the end up and down more slowly. Notice that the slow waves are now further apart?

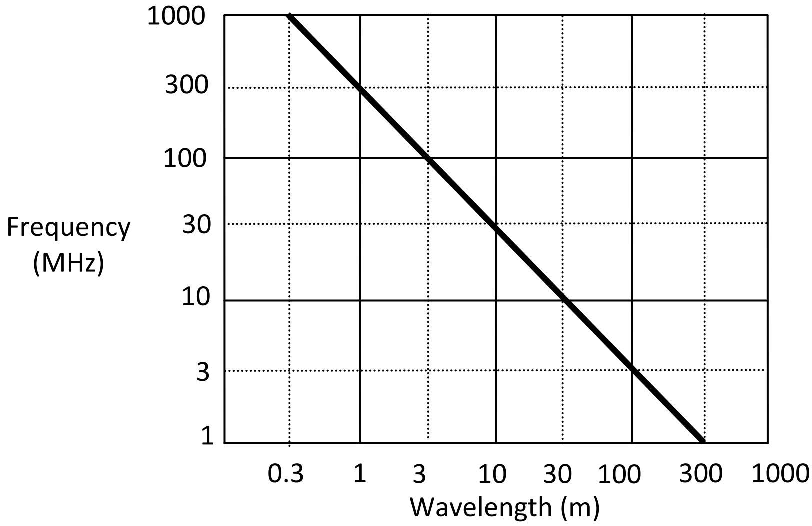
Frequency is the number of cycles (waves) per second and is measured in Hz (Hertz).
1 Hz is one wave per second. The wavelength is the distance between two wave peaks.

1 kHz (kilohertz) = 1 000 waves/second 1MHz (Megahertz) = 1 000 000 waves/second

If you have a radio look at the numbers on the dial or the numbers on the screen. These relate to the frequency of the radio waves transmitted by the radio stations.
As the frequency of a radio wave increases the wavelength decreases. This graph relates frequency and wavelength. It is not a normal linear scale as the numbers increase by powers of 10.

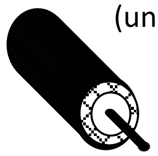
3. Complete the table by reading the values from the graph.

FREQUENCY	WAVELENGTH
300 MHz	
10 MHz	
	100 m
	30 cm



4. Estimate and measure out the wavelength of the radio station WSFM on 101.7 MHz.
5. Look up the frequency of an AM station and estimate it's wavelength from the graph.
6. How do the AM broadcast stations' wavelengths compare to those on the FM?

Transmission Lines



Coaxial (unbalanced) cable

A transmission line is required to connect the transmitter to the antenna so that the radio signal can be radiated out into space.

Transmission lines can be:

- unbalanced such as coaxial cable or
- balanced such a parallel line

Parallel (balanced) cable

A *balun* can be used to connect an unbalanced transmission line (coax) to a balanced antenna (like a dipole).

Connectors are used on the ends of cables to plug into the transmitter and antenna line.

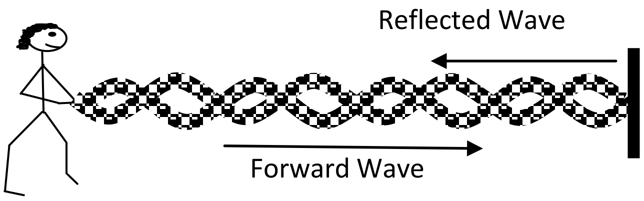
There are various types of connectors which are used on coaxial cable. Some of these are:

					
PL-259 (UHF) Plug	**UHF Socket**	**Type-N Plug**	**Type-N Socket**	**BNC Plug**	**BNC Socket**

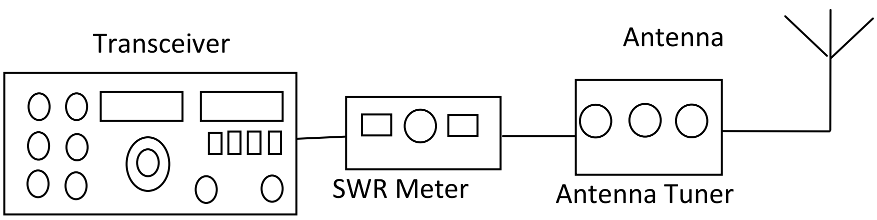
SWR (Standing Wave Ratio)

It is important that the transmitter is correctly matched to the antenna so that all the radiated power goes to the antenna and none of it is reflected back.

A standing wave will result if some of the signal comes back just like sending pulses down a rope tied to a pole.



A Standing Wave Ratio (SWR) meter and an antenna tuner can be used to correct any mismatch between the transmitter and the antenna.



Answers to Questions

Frequency and Wavelength

3.

FREQUENCY	WAVELENGTH
300 MHz	1m
10 MHz	30m
3 MHZ	100 m
1000 MHz	30 cm

4. Estimate and measure out the wavelength of the radio station WSFM on 101.7 MHz.
Wavelength = 3 m (approximately)

6. How do the AM broadcast stations' wavelengths compare to those of the FM?
AM broadcast stations wavelengths are longer than FM broadcast stations in Australia as the AM broadcast band is from 526.5 to 1606.5 kHz and the FM broadcast band is from 87.5 to 108 MHz.