Airdrie Academy

N4 Physics

Waves and Radiations

Summary Notes

Name______________________________

Class______________________________

N4 Wave characteristics	☺	😐	☹
I can make comparison of longitudinal and transverse waves.			
I can explain frequency as the number of waves per second.			
I can describe the wavelength and amplitude of transverse waves.			
I can make use of numerical or graphical data to determine the frequency of a wave.			
I can use the relationship between wave speed, frequency and wavelength.			
I can make appropriate use of the relationship between distance, speed and time for waves.			
N4 Sound	☺	😐	☹
I can analyse sound waveforms where amplitude and frequency change.			
I can make use of different methods to measure the speed of sound in air.			
I can make sound level measurements (including use of the decibel scale).			
I can identify noise pollution; risks to human hearing and methods of protecting hearing.			
I can describe & explain applications of sonar and ultrasound.			
I can describe sound reproduction technologies.			
I can describe applications of noise cancellation.			
N4 Electromagnetic Spectrum	☺	😐	☹
I can describe applications and hazards associated with electromagnetic radiations.			
I can describe approaches to minimising risks associated with electromagnetic radiations.			
N4 Nuclear Radiation	☺	😐	☹
I can identify natural and artificial sources of nuclear radiation and associated medical and industrial applications.			
I can explain some the pros and cons of generating electricity using nuclear fuel.			
I can make comparisons of risk due to nuclear radiation and other environmental hazards and describe the management of this risk.			

N4 Wave Characteristics

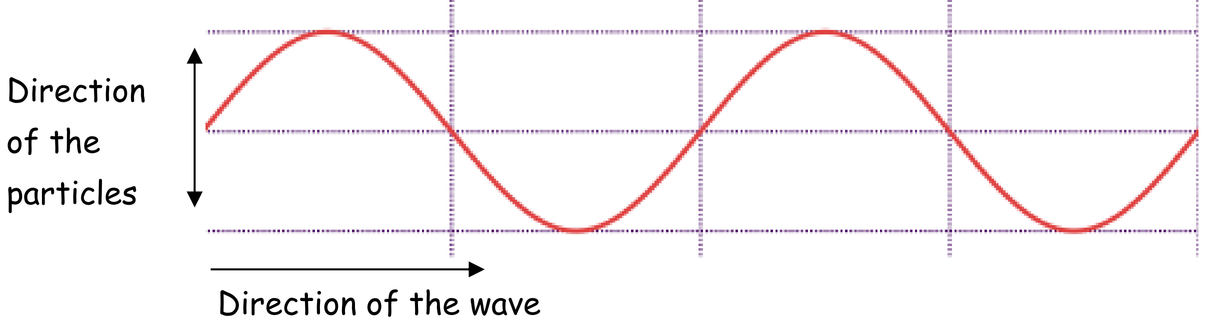
- *Comparison of longitudinal and transverse waves.*
- *Frequency as the number of waves per second.*
- *Wavelength and amplitude of transverse waves.*
- *Use of numerical or graphical data to determine the frequency of a wave.*
- *Use of appropriate relationship between wave speed, frequency and wavelength.*
- *Use of appropriate relationship between distance, speed and time for waves.*

Types of wave

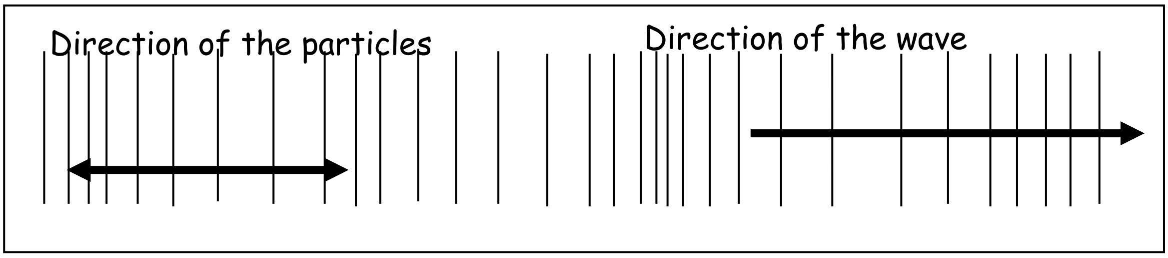
There are two different types of waves you will meet in this course, **transverse** waves and **longitudinal** waves

In transverse waves the particles vibrate at right angles to the motion of the wave.

Examples of transverse waves - light waves, radio waves, microwaves.



In longitudinal waves the particles vibrate in the same direction as the motion of the wave

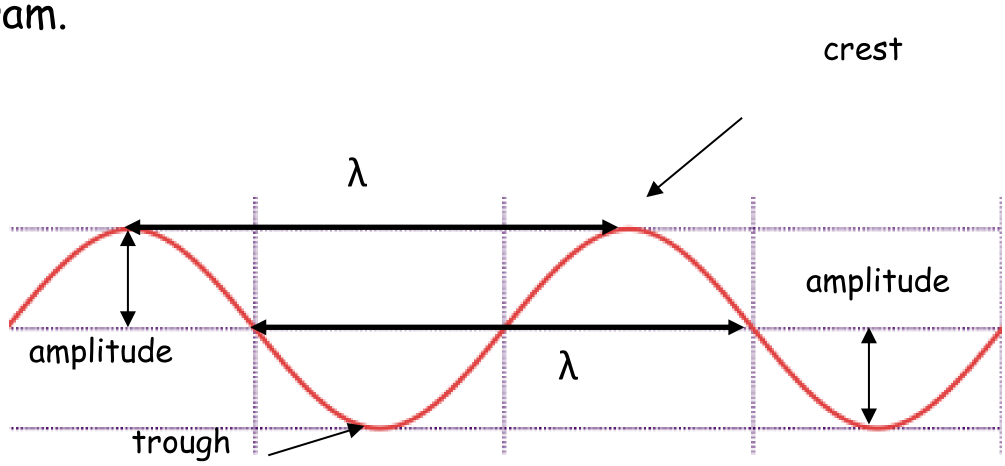


Sound is an example of a longitudinal wave.

Properties of waves

Waves are used to transfer energy.

Several important features of a wave are shown in the diagram.



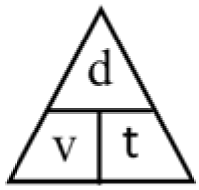
These are explained in the following table

Wave property	**Symbol**	**Definition**	**Unit**	**Unit symbol**
Crest		highest point of a wave		
Trough		lowest point of a wave		
Frequency	f	number of waves produced in one second	Hertz	Hz
Wavelength	λ (lambda)	horizontal distance travelled by one complete wave	Metre	m
Amplitude		half the vertical distance between crest and trough	Metre	m
Wave speed	v	distance travelled per unit of time	Metres per second	$m\ s^{-1}$

Distance, speed and time

One of the most important equations you will meet in Physics concerns the relationship between distanc and time.

$$d = v\,t$$



where d is the distance travelled in metres (m)
v is the average speed in metres per second ($m\,s^{-1}$)
t is the time in seconds (s)

<u>Example</u> A wave travels 100 m in 25 s. Calculate the speed of the wave.

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

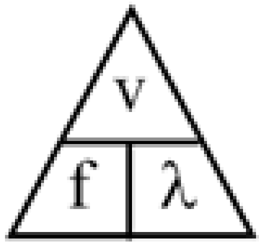
$$= \frac{100}{25}$$

$$= 24\ ms^{-1}$$

Wave speed, frequency and wavelength

By multiplying the frequency and wavelength we find that this is equal to the speed of the wave.

$$v = f\lambda$$



where v is the average speed in metres per second (ms^{-1})

f is the frequency in hertz (Hz)

λ is the wavelength in metres (m)

Example A wave has a wavelength of 0.5m and a frequency of 4 Hz.

Calculate the wave speed.

$v = f\lambda$

$= 4 \times 0.5$

$= 2\ ms^{-}$

N4 Sound

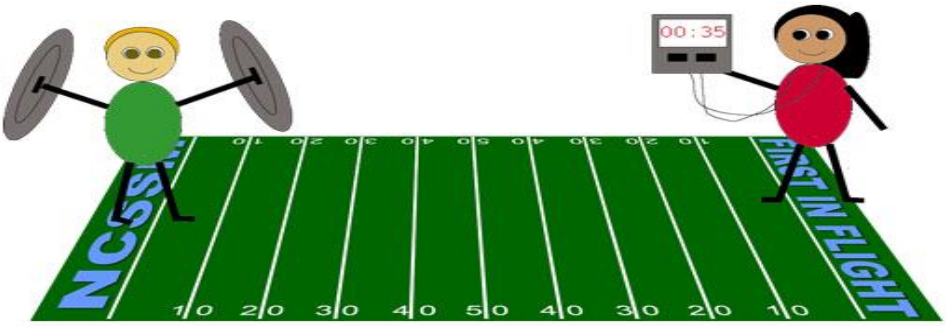
- *Analysis of sound waveforms including changing amplitude and frequency.*
- *Different methods of measurement of speed of sound in air.*
- *Sound level measurement including decibel scale.*
- *Noise pollution; risks to human hearing and methods of protecting hearing. Applications of sonar and ultrasound.*
- *Sound reproduction technologies.*
- *Noise cancellation.*

Sound is caused by **vibrations**.
Sound can travel through solids, liquids and gases, but not a vacuum.

Measuring the speed of sound.

We can use two methods to measure the speed of sound in air.

Method 1

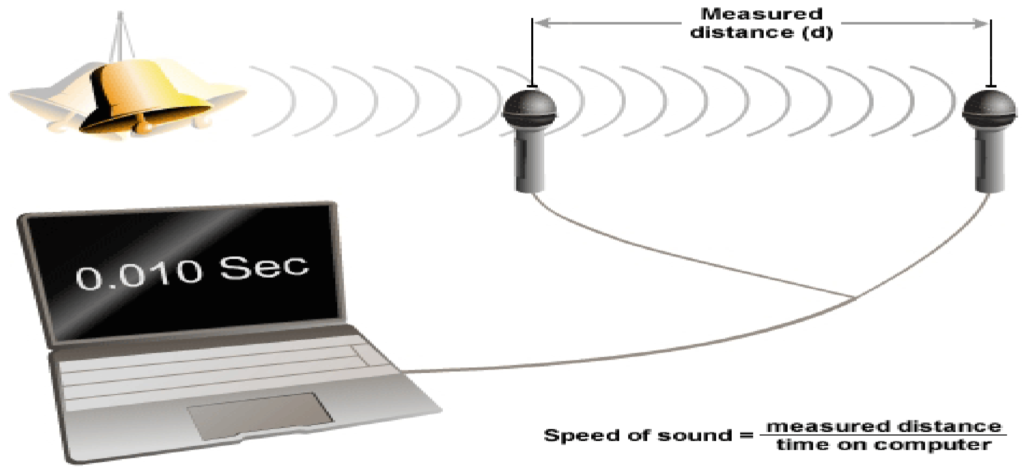


Distance travelled (d)

Large cymbals are clashed a long distance (d) from the observer. The observer starts the stop clock when he sees the signal that the cymbals have been clashed and stops it when the sound is heard.
The distance travelled and the time on the stop clock.
The equation **d = vt** is used to calculate the speed of sound.

This is not a particularly accurate method as it relies on human reaction time.

Method 2



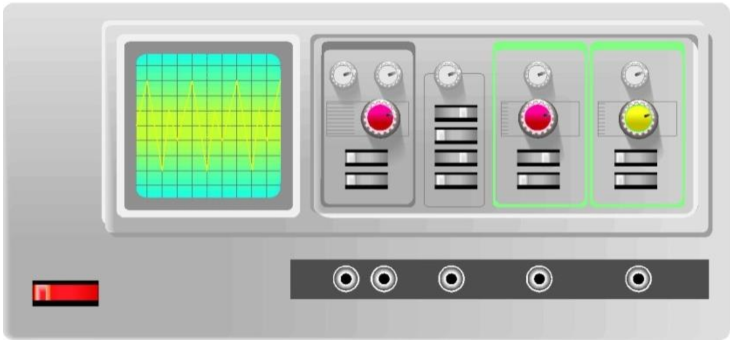
The distance (d) is measured with a metre stick. The hammer is struck against the block. As the sound reaches the first microphone the timer (t) is started, when it reaches the second microphone the timer (t) is stopped.
The equation **d = vt** is used to calculate the speed.

This is a much more accurate method as it does not rely on human reaction time.

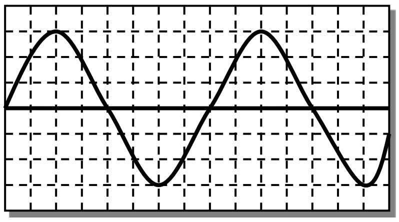
The speed of sound in air it is **340 ms^{-1}**.

Amplitude and Frequency

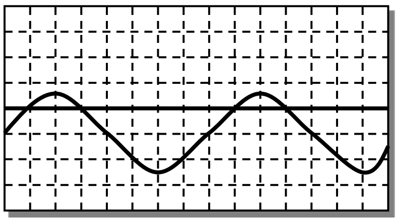
We can analyse waveforms by using a device called an oscilloscope (CRO).



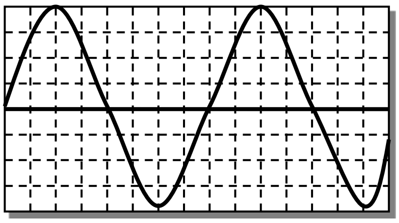
The oscilloscope allows us to view waves and see what effect changing certain properties has.



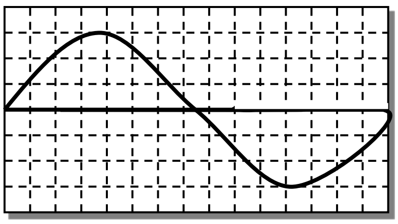
original wave



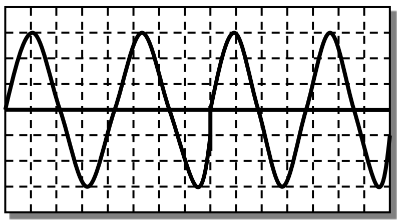
smaller amplitude



larger amplitude



lower frequency



higher frequency

If we were to think of these in terms of sound, waves with small amplitudes would be quiet and those with large amplitudes would be loud.

Decibel scale and noise pollution

Noise levels are measured in **decibels** (dB). These can be measured using a sound level meter. Regular exposure to sounds above 80 dB can cause damage to hearing. Some typical noise levels are given below:

Situation	*Decibels*
Threshold of human hearing	0
Whisper, rustling paper	30
Inside average home	50
Normal conversation at 1m distance	60
Threshold of hearing damage	80
Truck heard from pavement, busy factory	90
Hair dryer	100
Rock concert 1m from loudspeaker	120
Jet engine at a distance of 50m	130
Threshold of pain	120 - 140

We can protect against damage to hearing by loud noises by wearing ear protectors.

Sonar and Ultrasound

Humans can hear sounds with frequencies between 20Hz and 20000Hz. Sound with a frequency above 20000Hz is called **Ultrasound**.

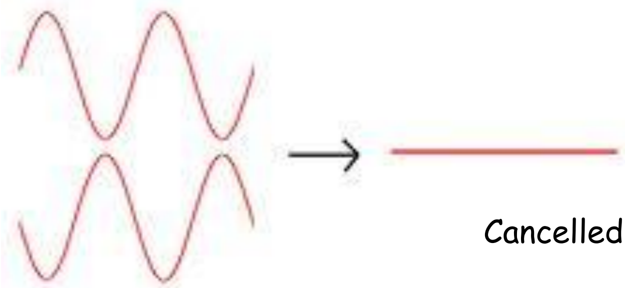
Ultrasound can be used to examine a foetus in the womb. A picture is built up by timing how long it takes to receive an echo from an ultrasound pulse. Ultrasound can also be used to break up kidney stones without the need for invasive surgery.

Boats and submarines use **sonar** to detect shoals of fish, the sea bed or other submarines. Pulses of sound are sent out and then the echo is detected. This is similar to how bats and dolphins use echolocation.

Sound reproduction and noise cancellation

Sound is a signal that varies continuously.

If two waves travelling in opposite directions were to meet, the result would be that they cancel each other out. The same would happen any time a crest of one wave meets a trough of another. We can make use of this effect in noise cancelling technology.



Cancelled Wave

N4 - Electromagnetic spectrum

- *Applications and hazards associated with electromagnetic radiations.*
- *Approaches to minimising risks associated with electromagnetic radiations*

The different bands of the electromagnetic spectrum differ in wavelength and frequency.

Increasing frequency ↑

Gamma rays

X-rays

Ultraviolet

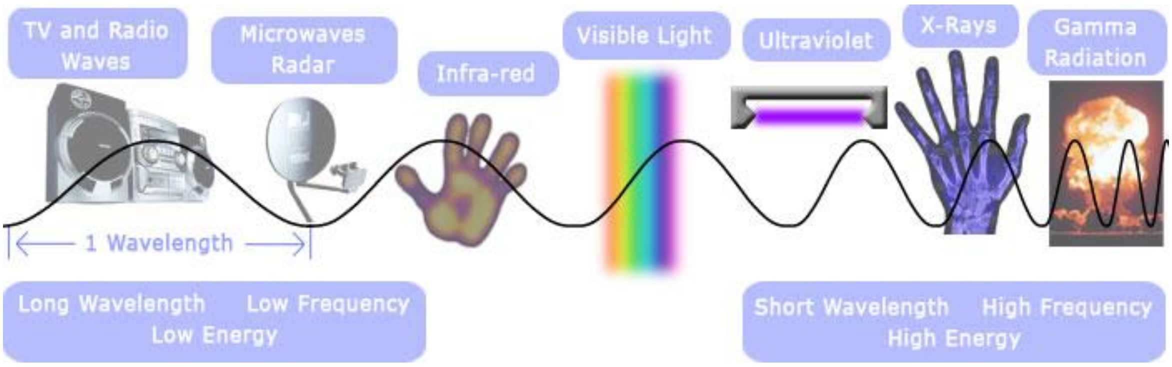
Visible light

Infrared

Microwaves

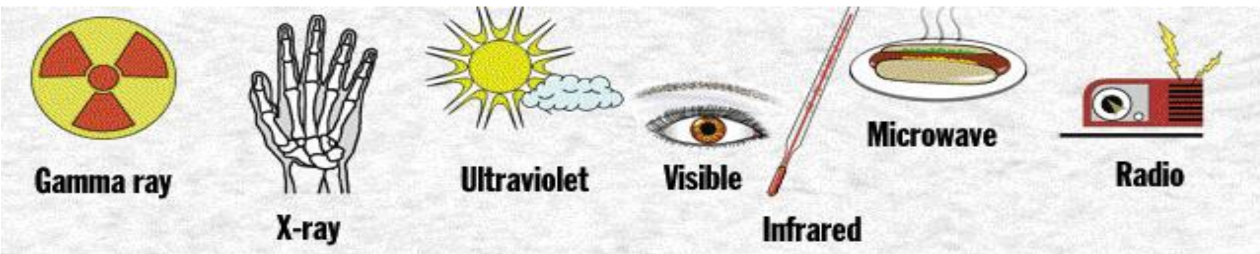
Radio & TV

Increasing wavelength ↓



Some information on each part of the spectrum is given below:

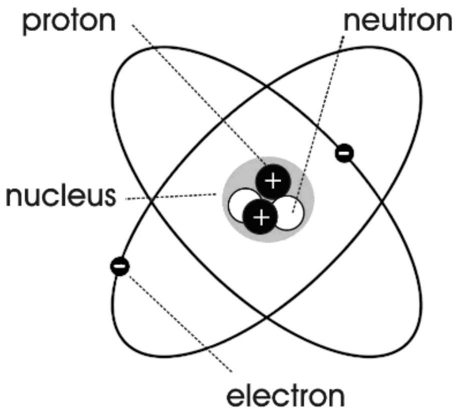
Type of e-m radiation	**Typical source**	**Application**	**Detector**	**Possible hazard**
Radio & TV	Electrical antennae	Telecommunications	Aerial	Potential increased cancer risk
Microwaves	Cosmic sources, magnetron	Cooking, Telecommunications	Diode probe	Heating of body tissues
Infra-red	Heat-emitting objects	Thermograms	Phototransistor, blackened thermometer	Heating of body tissues
Visible light	Stars	Vision	Eye, photographic film	Intense light can damage the retina
Ultraviolet	Sunlight	Treating skin conditions	Fluorescent paint	Sunburn, Skin cancer
X-rays	X-ray tube, cosmic sources	Medical imaging CT Scan	Photographic plates	Detecting broken bones
Gamma rays	Nuclear decay	Treating tumours	Geiger–Müller tube and counter, Photographic film	Destroys cells which can lead to cancer



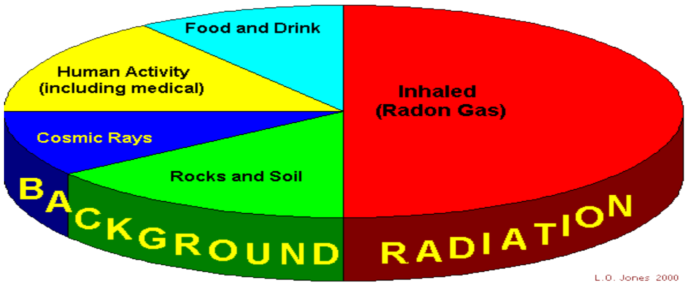
N4 Nuclear Radiation

- *Natural and artificial sources of nuclear radiation and associated medical and industrial applications.*
- *Consideration of the pros and cons of generating electricity using nuclear fuel.*
- *Comparison of risk due to nuclear radiation and other environmental hazards and the management of this risk.*

Nuclear radiation is so called because it originates in the nucleus of an atom. The diagram shows the structure of an atom.



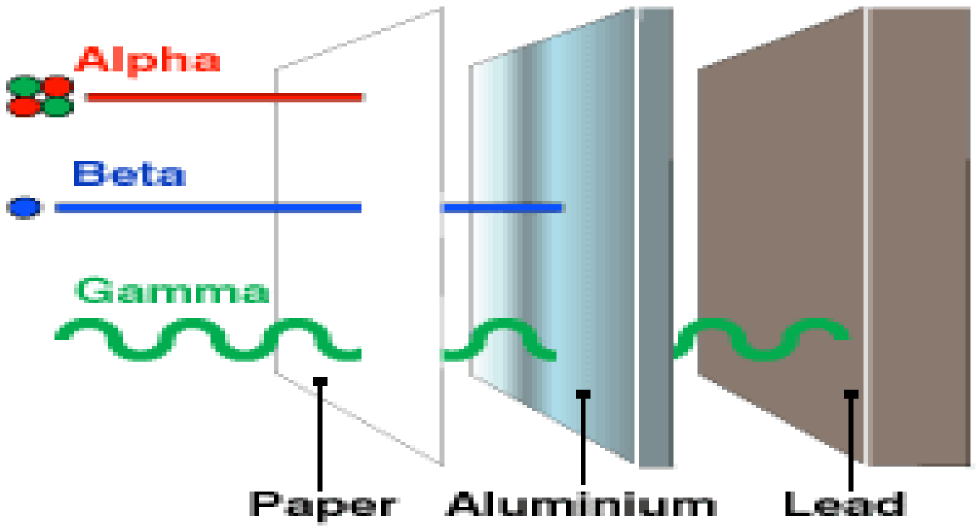
Nuclear radiation is always present in our environment. This is known as **background radiation**.
Nuclear radiation can come from natural and artificial sources such as:



Natural Sources	***Artificial Sources***
Rocks (granite)	Industry
Radon gas	Medical
Cosmic rays from space	Nuclear power stations
Uranium	

There are three different types of nuclear radiation:

Type of radiation	Symbol	Nature	Absorbed by
Alpha	α	Two protons and two neutrons (helium nucleus)	A sheet of paper or few centimetres of air
Beta	β	Fast-moving electron	A few centimetres of aluminium
Gamma	γ	Electromagnetic wave	Lead or concrete



Applications of Nuclear Radiation

1. Nuclear Power

The energy released as a result of a nuclear reaction can be used to turn water into steam, which in turn can be used to turn a turbine that is linked to a generator. The generator produces electricity as it turns. Vast quantities of energy are potentially available from small quantities of radioactive fuel.

Generation of electricity in this way produces dangerous radioactive waste that takes decades to decay.

2. Non-destructive testing

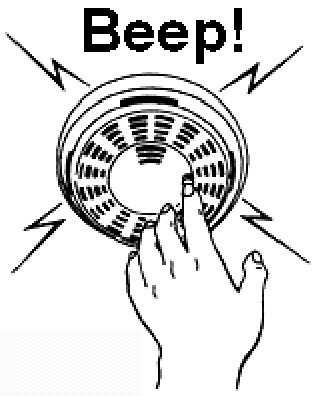
Nuclear radiation can be used to penetrate solid objects to find if there are any cracks or failures. For example, aircraft wings and oil rig legs.

3. Thickness Gauges

A source and detector are placed at either side of a container. The level of radiation received is an indication of the thickness of material placed between the source and detector.

4. Smoke Detectors

Most smoke detectors have a small radioactive source.



5. Sterilisation of Medical Tools and Equipment

Tools are placed in a container and then exposed to nuclear radiation that kills off any bacteria.

6. Radioactive Tracers

A radioactive substance can be injected into the blood stream. By taking pictures with special cameras or by taking blood samples at different points in the body, many things can be found out about a patient's condition.

7. Radiation Therapy

Cancerous tumours within the body are targeted by beams of nuclear radiation. The cancerous tissue is killed off by the radiation.