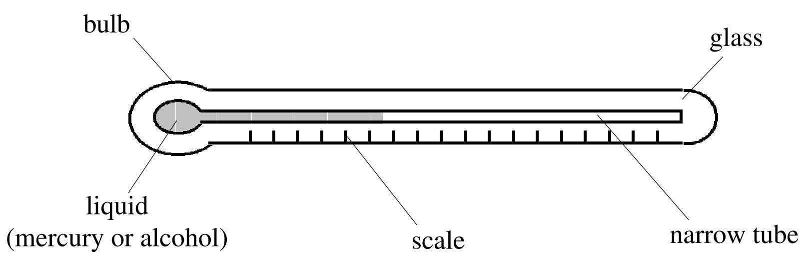
Section 1 - Thermometers

Types of Thermometer

A thermometer requires some *measurable physical property that changes with temperature*.

Type of thermometer	Property that changes
liquid-in-glass	volume of liquid
digital	resistance of thermistor
crystal strip	crystals have different melting points
rotary	different rates of expansion in bimetallic strip
thermocouple	voltage produced

Liquid-in-glass Thermometer



The liquid inside the thermometer expands when it is heated. It's volume increases and it rises up the tube.

The liquid expands more than the glass

Clinical thermometer

Measures over a **smaller range** so it can be more accurate (35-43°C)

Keeps **highest reading** for ease of use (the constriction breaks the thread when the liquid cools and contracts)

Glass tube **shaped like a lens** to magnify the thin thread of liquid.

Using a clinical thermometer

Shake to reset
Place bulb of thermometer in mouth
Wait a few minutes
Read temperature from scale

Body temperature

Normal body temperature is around 37°C.

If body temperature is above 38°C the person has a **fever**.

If body temperature is below 34°C the person has **hypothermia**.

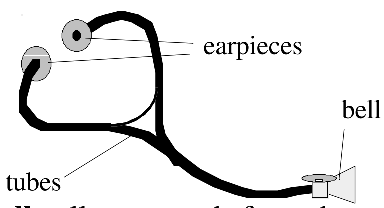
Section 2 - Using Sound

Sound is caused by **vibrations**.

Sound can travel through solids, liquids and gases, but <u>not</u> a vacuum

Stethoscope

The **stethoscope** is a device for listening to sounds from within a patient's body.



The **bell** collects sounds from the patient. (open bell for low frequency heart sounds, closed bell for high frequency lung sounds)

The **tubes** carry the sounds to the earpieces.

The **earpieces** pass the sounds into the doctors ears while blocking out background noises.

Ultrasound

Ultrasound is sound with a frequency above the range of human hearing. (above 20 000 Hz)

The Ultrasound Scanner

An ultrasound scanner can be used to examine the inside of a patient (e.g. an unborn baby inside the mothers womb).

Ultrasonic waves are directed into the patient and **reflect** off objects inside the patient. It takes different times for the sound waves to return from different depths and so an image of the patient can be built up using a computer.

A layer jelly is placed on the skin to prevent sound waves reflecting off the skin.

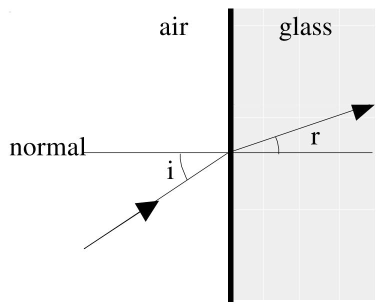
Noise Levels

Noise levels are measured in **decibels , dB**.

Regular exposure to noise levels above 90 dB (e.g. pneumatic drills or heavy traffic) can cause damage to hearing.

Typical noise levels :	0 dB	Threshold of hearing
	60 dB	Normal conversation
	95 dB	Heavy lorry
	100 dB	Pneumatic drill
	130 dB	Jet engine
	140 dB	Pain threshold

Section 3 - Light and Sight



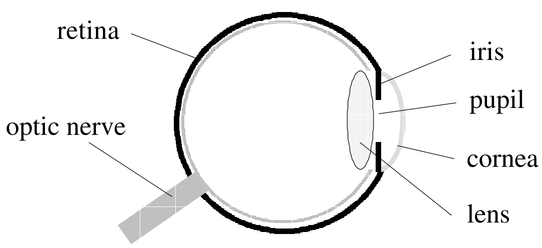
i = angle of incidence
r = angle of refraction

Refraction

Refraction is the *bending of light as it passes from one material into another.*

When light passes from air into glass it bends towards the **normal** and when it passes from glass into air it bends away from the normal.

The Eye

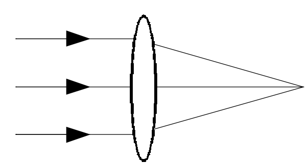


Light is focused on the retina of the eye by the **cornea** and **lens**.

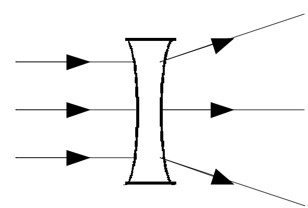
Most of the refraction takes place at the cornea. The lens changes shape and allows the eye to focus on objects at different distances.

Lenses

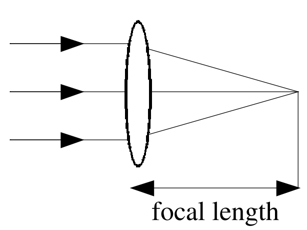
A convex (converging lens) causes rays of light to be brought to a focus.



A concave (diverging lens) causes rays of light to spread apart.



Focal length



i = angle of incidence
r = angle of refraction

Focal length is the *distance between a lens and the point where parallel rays of light are brought to a focus.*

The focal length of a convex lens can be measured experimentally by placing the lens in front of a screen and moving the lens until a *sharp image of a distant object* is obtained on the screen, then measuring the distance from the lens to the screen (this is the focal length).

Power of a lens

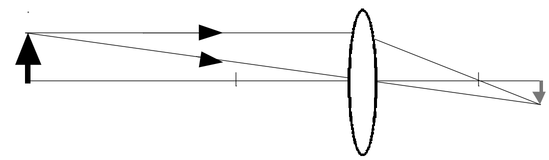
The power of a lens is measured in **dioptres**, D, and can be calculated using the formula :

$$\underbrace{\textbf{power}}_{\text{D}} = \frac{\textbf{1}}{\underbrace{\textbf{focal length}}_{\text{m}}}$$

Convex lenses have a positive (+) power.
Concave lenses have a negative (-) power.

Image Formation in the Eye

The eye forms an image which is **upside-down** (inverted) and **back-to-front** (laterally inverted).



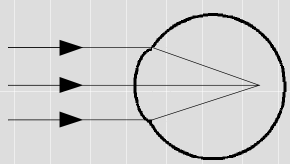
The image is also **smaller** than the object being viewed.

Sight Defects

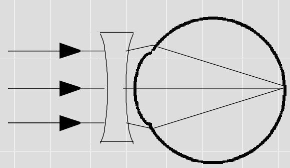
Short-Sight

People with **short-sight** are unable to focus on distant objects clearly. Short-sight can be corrected by using a **concave** lens.

Short-sight occurs because parallel rays of light from a distant object are brought to a focus in front of the retina. (Image is short of retina)



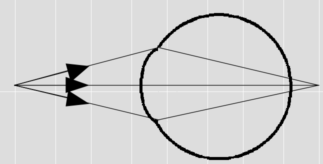
Short-sight can be corrected by placing a concave lens in front of the eye to diverge the rays of light entering the eye



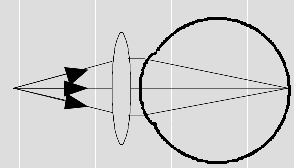
Long-Sight

People with **long-sight** are unable to focus on close objects clearly. Long-sight can be corrected by using a **convex** lens.

Long-sight occurs because diverging rays of light from a nearby object are brought to a focus behind the retina (Image is long of retina)



Long-sight can be corrected by placing a convex lens in front of the eye to converge the rays of light entering the eye



Optical Fibres and Endoscopes

In **optical fibres** only light is transmitted along the fibre, but <u>not</u> heat. The optical fibre is therefore said to transmit '**cold light**'.

(Also see Telecommunications topic)

Optical fibres are used in endoscopes to view the insides of a patient without the need for surgery.

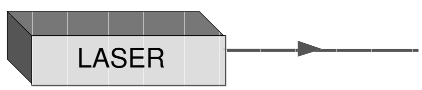
In an endoscope one bundle of fibres is used to carry 'cold light' down into the patient. A second bundle is then used to send the image back to the surgeon's eye. The bundles are flexible and so can be moved around inside the patient.

Section 4 - Using the Spectrum

Lasers

A **laser** is a very *intense beam of light* that carries a great deal of energy. It can cut through human body tissue and seals blood vessels as it cuts due to the intense heating effect.

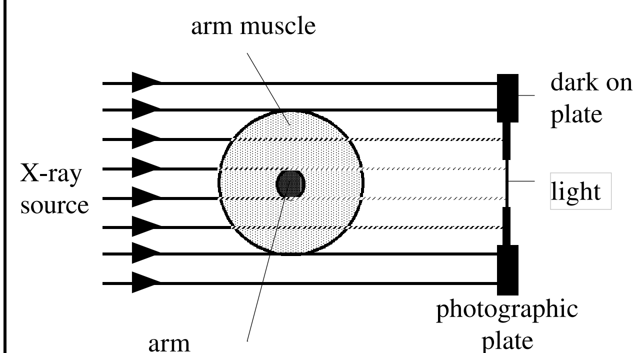
Lasers are used in medicine for **eye surgery**, **to remove birthmarks** and to **remove cancerous tumours**.



X-rays

X-rays can be used to find broken bones.

A beam of X-rays is aimed the patient. Since bone is more dense than the surrounding tissue it absorbs more X-rays. A ‘shadow’ is therefore cast on the **photographic film** placed behind the patient. The X-rays blacken the film, so the bones show up white and any breaks as dark lines.



Photographic film is frequently used as a detector of X-rays.

Computerised Tomography

In computerised tomography a series of horizontal X-ray images are taken of the body. A computer then uses these ‘slices ‘ to build up a 3-dimensional (3-D) picture of the body. This enables small tumours to be found very accurately and provides more detailed images than a conventional X-ray pictures.

Infrared

Infrared radiation is simply heat radiation with a wavelength longer than that of visible light.

Infrared radiation is used by physiotherapists to speed up the recovery of injured muscles and tissues.

Infrared radiation is also used in a thermal imaging camera where objects at different temperatures show up as different colours on a picture called a **thermogram**. Tumours are warmer than surrounding tissue and therefore show up on a thermogram.

Ultraviolet

Ultraviolet radiation is radiation with a wavelength shorter than that of visible light.

Ultraviolet radiation is used to treat skin problems and to sterilise medical instruments.

Excessive exposure to ultraviolet radiation (e.g. from the Sun) can cause skin cancer.

Section 5 - Nuclear Radiation

Medical Uses of Radiation

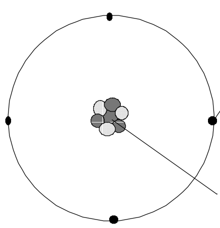
Radiation can *kill or damage living cells*.

Nuclear radiation is used in medicine to **sterilise medical instruments** by killing germs. It can also be used to **kill cancerous cells** either by placing an alpha source next to the tumour or by firing a beam of gamma rays at the tumour from a variety of different directions (therefore only the tumour receives a large radioactive dose and the surrounding tissue is relatively unharmed).

Radiation is also used for diagnosis. A radioactive **tracer** (a gamma source) is injected into the patient. The tracer is carefully chosen so that it will collect in the organ being studied and an image of the organ can be then be taken with a **gamma camera**.

The Atom

An atom is the smallest particle into which matter can be divided. It is made up of a central **nucleus** with orbiting **electrons**.



The nucleus contains positively charged **protons** and uncharged ("neutral") **neutrons**. The nucleus makes up nearly all the mass of the atom and contains all the positive charge

The electrons orbit the nucleus at high speed. They are negatively charged and much lighter (1/2,000 th) than neutrons or protons.

An atom is normally electrically neutral as it has the same number of negative electrons orbiting the nucleus as positive protons in the nucleus.

Types of Radiation

There are three types of nuclear radiation. These are **alpha** (α), **beta** (β) and **gamma** (γ)

Whenever radiation passes through a material (medium) some of it's **energy is absorbed** by the material. The amount of absorption depends on the type of radiation and the material it is passing through.

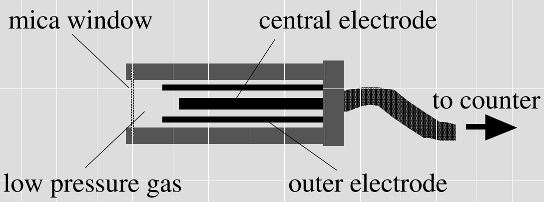
Type	Range in Air	Absorbed by
α	20 cm of air	sheet of paper
β	a few metres	2-3 mm Aluminium
γ	not absorbed	2-3 cm Lead

Ionisation

Ionisation is the *addition, or removal, of an electron from an uncharged atom*. If the atom gains an electron it has an overall positive charge, if it loses an electron it has an overall negative charge.

Alpha radiation causes more ionisation than beta or gamma radiation

Ionisation is used to detect radiation in the **Geiger-Muller tube**.

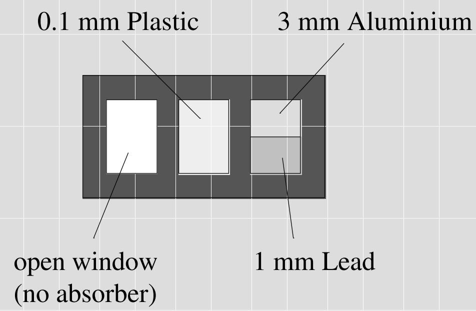


When radiation enters the tube through the thin mica window it causes ionisation in the gas. This allows the gas to conduct and a pulse of current passes between the electrodes. This pulse of current is 'counted' by the counter.

Photographic fogging

Radiation can blacken (fog) photographic film.

Photographic fogging is used in to detect radiation in a **film badge**. In a film badge different sections of a piece of photographic film are covered by various thicknesses and types of absorber.



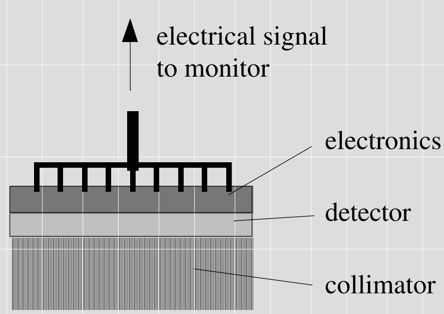
The **type** of radiation can be determined by which sections of the film are blackened (e.g. gamma radiation blackens all the sections).

The **amount** of radiation can be determined by how black the film is.

Scintillation

Radiation can cause some materials (e.g. zinc sulphide) to **scintillate**. In scintillation the material absorbs the energy of the radiation and re-emits it as light.

Scintillation is used to detect radiation in a **gamma camera**.



The **collimator** is a large piece of lead with thousands of holes in it. The collimator ensures that although gamma rays are given off in all directions from the source, only parallel rays reach the detector.

The **detector** converts radiation into light by scintillation.

The **electronics** turn the pattern of light into an electrical signal, which can then be transmitted to a monitor for viewing

Activity

The **activity** of a radioactive source is *the number of atoms that decay each second* (number of radioactive particles released each second).

The activity of a radioactive source is measured in **Becquerels**, **Bq**.

The activity of a radioactive source decreases with time.

Half-life calculations

Example 1:

If a 8,000 Bq source of activity has a half-life of 6 days what activity will it have 18 days later ?

18 days = 3 x 6 days
= 3 half-lives

$8{,}000 \xrightarrow{1} 4{,}000 \xrightarrow{2} 2{,}000 \xrightarrow{3} 1{,}000$

The activity after 18 days is <u>1,000 Bq</u>

Example 2:

Calculate the half-life of a source that decreases in activity from 32 kBq to 8 kBq in 24 days.

$32 \xrightarrow{1} 16 \xrightarrow{2} 8$

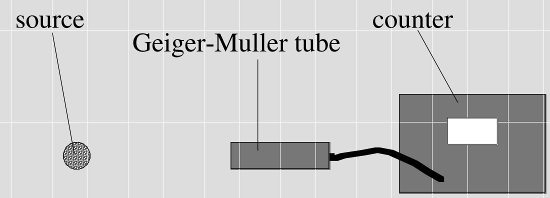
2 half-lives = 24 days
1 half-life = 12 days

The half-life of the source is <u>12 days</u>

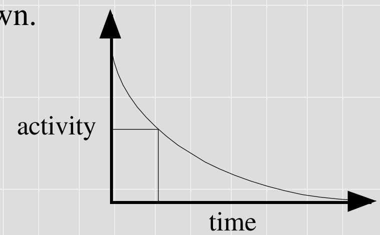
Half-life

The **half-life** of a radioactive source is the *time taken for it's activity to half.*

The half-life of a radioactive source can be measured by taking measurements of the activity of the source at regular intervals of time using a Geiger-Muller tube and counter.



Background activity is then subtracted from each reading and a graph of activity against time is drawn.



The time taken for the activity to half can then be established from the graph

Safety

Safety precautions need to be taken when handling radioactive materials. These include :

- Always handle with forceps
- Point source away from body
- Store in lead container
- Label all sources
- Wash hands after use

Dose equivalent

The biological effect of radiation depends on:
- the type of absorbing tissue
- the type of radiation
- the total energy absorbed

The **dose equivalent** of a radioactive source is a *measure of the biological risk* of the source and is measured in **Sieverts**, **Sv**.

The dose equivalent takes into account the type of radiation and the total energy absorbed.