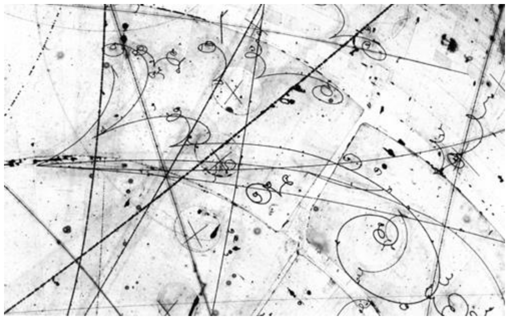
P3 Topic 1

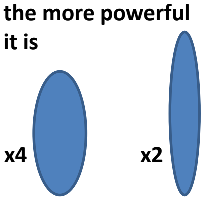


Physics

P3 Topic 1

Magnification:

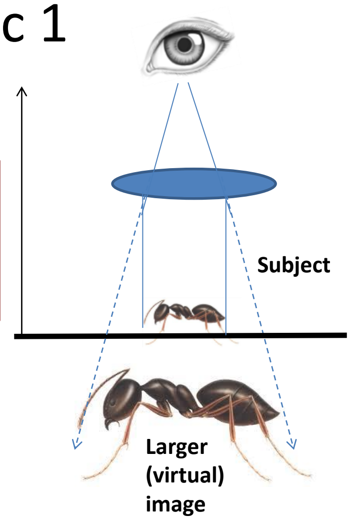
The 'fatter' the lens, the more powerful it is



Power of lens:

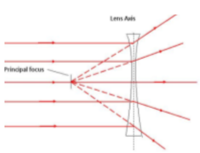
$$\text{Dioptre (D)} = \frac{1}{\text{focal length}}$$

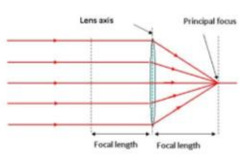
(focal length in metres)



Beyond the focal length, the image will be inverted, real and start to get smaller.

Sign convention: Focus to the left of the lens is negative (–ve) and to the right it is positive (+ve):

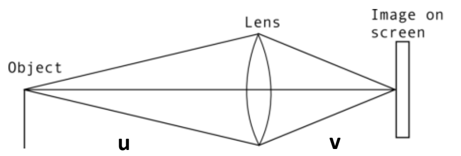




P3 Topic 1

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

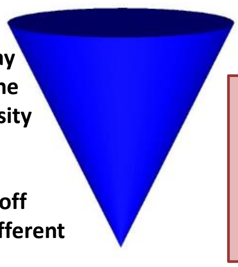
f = focal length
u = object distance
v = image distance



Only works when image rays are not parallel.

The further away from a point, the lower the intensity of radiation.

Intensity drops off differently in different media.

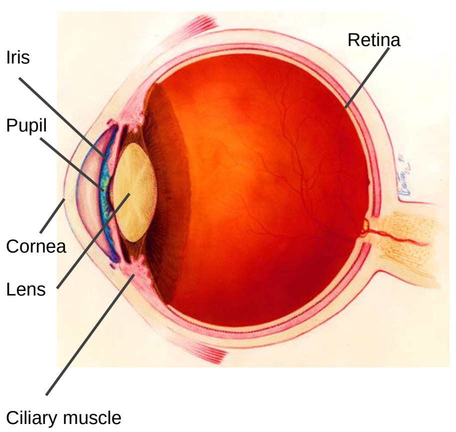


Intensity = $\frac{\text{power of incident radiation}}{\text{area}}$

$$I = \frac{P}{A}$$

P3 Topic 1

Diagram of the eye



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

*** The average human adult has a near point of 25 cm and a far point of infinity.**

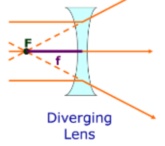
P3 Topic 1

*** Short sighted:**

Caused by too long an eye or an unevenly curved cornea causing the image to be formed in front of the retina.

Can see near objects.

Corrected by a concave/diverging lens

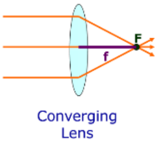


*** Long sighted:**

Caused by too short an eye or an unevenly curved cornea causing the image to be formed behind the retina.

Can see distant objects.

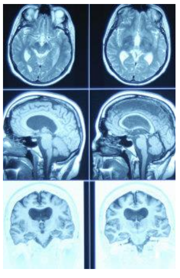
Corrected by a convex/converging lens



Laser surgery can be used to correct both defects by reshaping the cornea

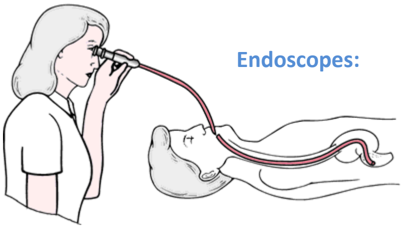
P3 Topic 1

Medical Physics



CAT scan:

Low level x-ray slices through sections of the body.



Endoscopes:

Using the Total Internal Reflection of light passing down fibre optics to view inside the body.

Ionising radiation:

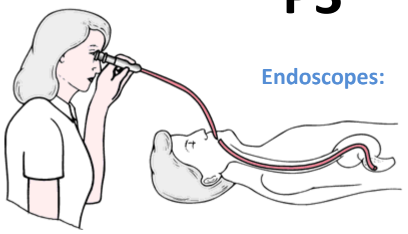
For treatment and detection of cancers

Ultrasound:

Low energy sound waves used to 'look' inside the body

Radiation includes energy in the form of waves or particles originating from a source

P3 Topic 1



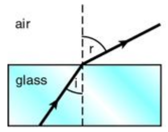
Endoscopes:

Using the Total Internal Reflection. Light passes down fibres, illuminating the subject, and is retuned along other fibres to the eyepiece / monitor.

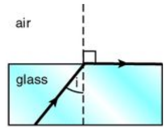
Snell's Law:

Refractive Index (n) = $\frac{\sin i}{\sin r}$

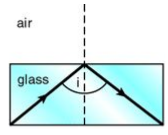
Sin critical angle = $\frac{1}{\text{Refractive Index}}$



At incident angles less than the critical, light is refracted.
Refraction is a change in direction due to a change in speed



At the critical angle light passes out at 90° to the 'normal'.



At angles greater than the critical, light undergoes Total Internal Reflection

Angle of incidence = angle of reflection

P3 Topic 1

Ultrasound: (Diagnosis)

Sound waves, with frequencies greater than 20,000Hz, linked to a computer to generate pictures of inside the body.

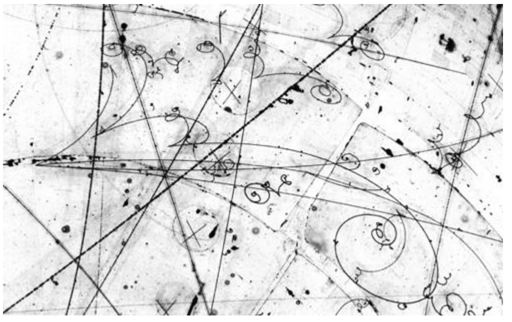
Ultrasound is not just used for foetal scanning.

Ultrasound: (Treatment)

Ultrasound is also used to treat pain and promote tissue healing.

It is used for beauty treatment but ……

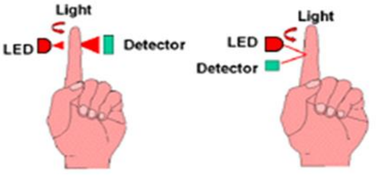
P3 Topic 2

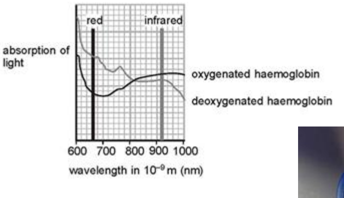


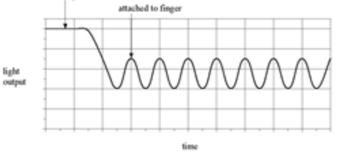
Physics

P3 Topic 2

Pulse oximeters compare the levels of absorption of different wavelengths of red and infra red light by oxygenated and deoxygenated blood and can be used to give values for the % oxygen and pulse rate.



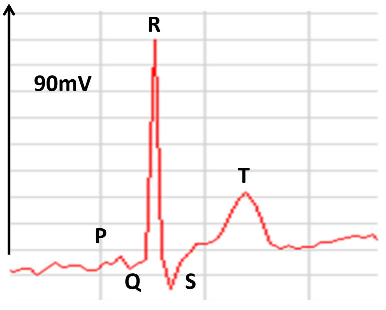




P3 Topic 2

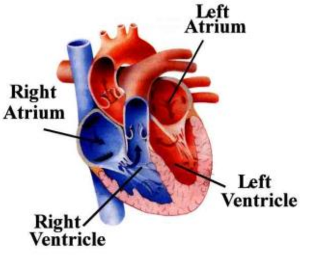
The heart beat is triggered by an electrical impulse / rhythm from the pacemaker or Sinoatrial (SA) Node.

An ECG measures the potential of the cardiac cells at the surface of the skin (usually a maximum of around 90mV):



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

Frequency (Hz)
time (secs)



P wave:
Depolarization of the left and right atria (the smaller chambers)

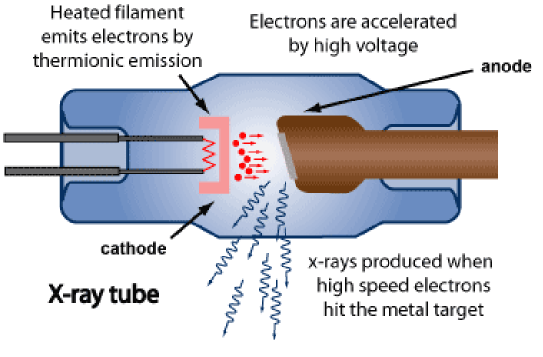
QRS wave:
Ventricular depolarisation (larger chambers)

T wave:
Ventricular repolarisation (recovery)

P3 Topic 2

Collisions take place in an evacuated tube to avoid collisions with unwanted particles.

The higher the frequency of the X-rays, the greater the energy and the greater the ionising ability



$KE = \frac{1}{2} mv^2 = eV$

K.E. = Kinetic Energy
m = mass (kg)
v = velocity (m/s)
e = charge on electron (C)
V = accelerating pd (volts)

$I = N q$

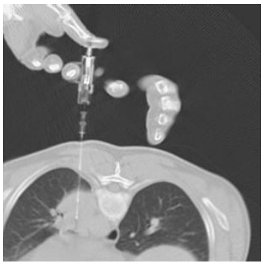
I = Current (amps)
N = Number of particles per second
q = charge on each particle

The beam of electrons travelling from cathode to anode is a flow of charges over time (rate) and therefore represents a current (flowing in the opposite direction).

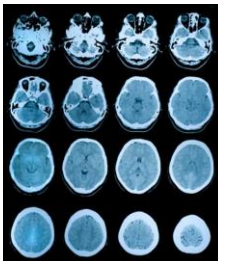
P3 Topic 2

X-rays

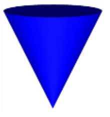
**Fluoroscopy:
(Dynamic x-rays)**



**CAT Scan
(Multiple slices)**

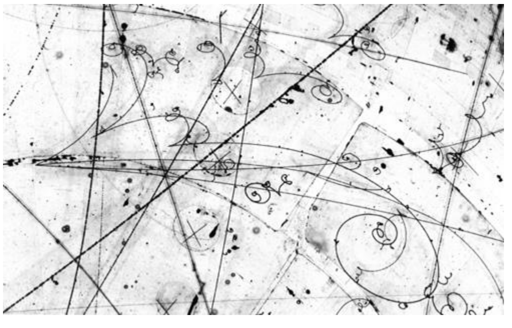


X-rays are absorbed by different materials. Usually the thicker the material, the more that the waves are absorbed.



Double the distance from a source and the power falls by 1/4 . This is the inverse square law.

P3 Topic 3



Physics

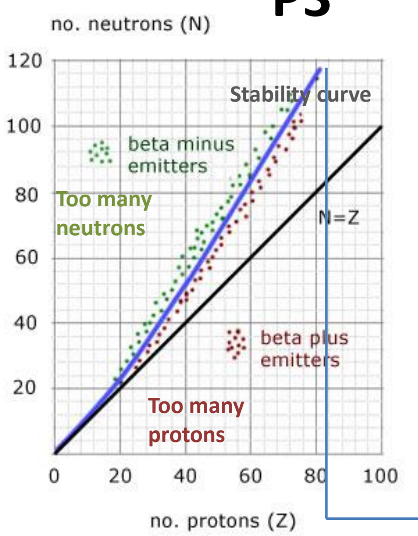
P3 Topic 3

	Name	Mass (amu)	Charge	Damage
$^{4}_{2}\alpha$	Alpha particle	4	+2	Damage to surface cells
$^{0}_{-1}B^{-}$	Beta - (electron)	1/2000	-1	Damage few cm below the skin
$^{0}_{+1}B^{+}$	Beta + (positron)	1/2000	+1	Cause mutations
$^{0}_{0}\gamma$	Gamma ray	0	0	Kill cells in sufficient intensity
$^{1}_{0}n$	Neutron	1	0	Stopped by water
$^{1}_{1}p$	Protons	1	+1	N/A

In a neutral atom, the number of protons equals the number of electrons.

α decay	$^{228}_{90}Th \rightarrow {}^{224}_{88}Ra + {}^{4}_{2}\alpha$	**all can be accompanied**
β^{-} decay	$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta^{-}$	**by γ decay as the nucleus**
β^{+} decay	$^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + {}^{0}_{+1}\beta^{+}$	**re-arranges**
n capture	$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{90}_{36}Kr + 2{}^{1}_{0}n$	**(Nuclear fission)**

P3 Topic 3



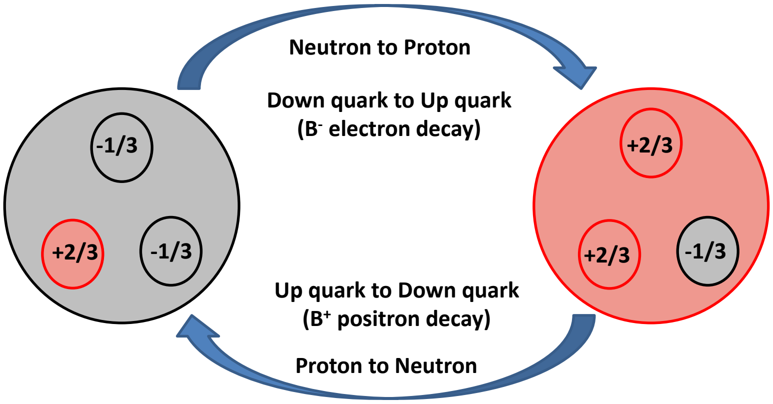
In a neutral atom, the number of protons equals the number of electrons.

Isotopes of an element contain the same number of protons but differing numbers of neutrons

Isotopes outside of the stability curve will be radioactive.

All atoms with a Z number greater than 82 will undergo α decay.

P3 Topic 3



	Up Quark	mass = 1/3 amu	charge = +2/3
	Down Quark	mass = 1/3 amu	charge = -1/3

P3 Topic 3

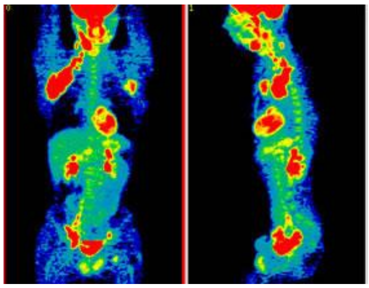
Palliative care:

Treatment of pain and symptoms with no chance of recovery. This may include radiation therapy.

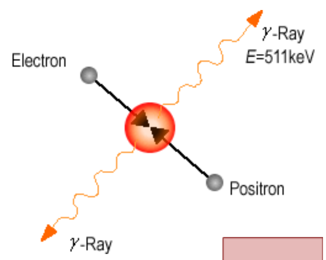
The dose of ionising radiation has to be limited for both the patient and the medical personnel

P3 Topic 3

PET Scan
(Positron Emission Tomography)



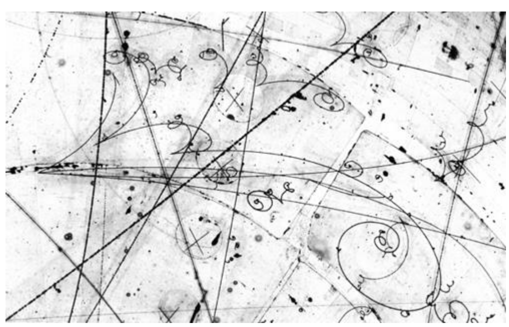
Because positron emitting isotopes are placed inside the body they need to have short half-lives and therefore need to be produced locally in cyclotrons.



Positron emitting isotopes are carried to highly metabolising parts of the body, these include cancers. Positrons collide with electrons in the body (annihilation). The gamma photons emitted are detected outside of the body using a gamma camera.

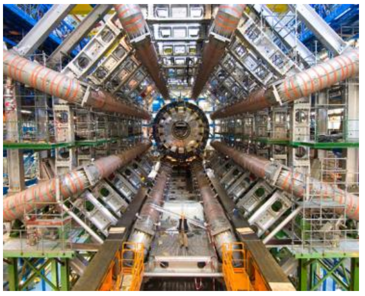
$E = mc^2$

P3 Topic 4

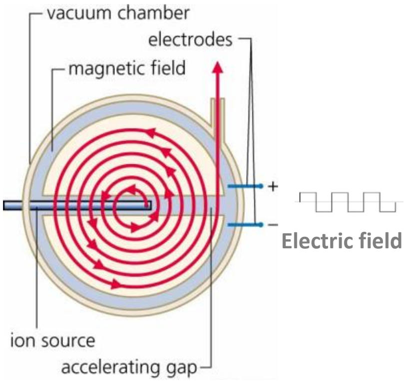


Physics

P3 Topic 4

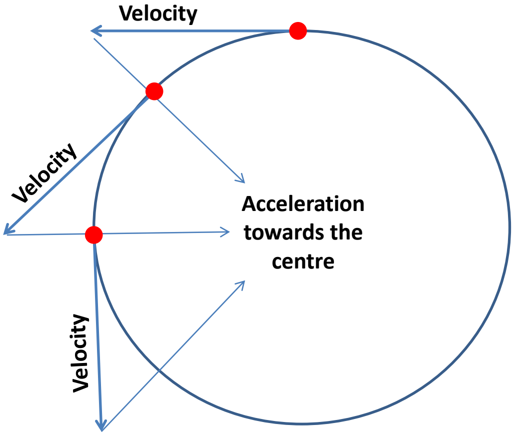


Accelerators where charged particles are bent by magnetic fields and accelerated by electric fields, such as in the cyclotron shown, are used to bombard isotopes with protons to produce radioactive isotopes for medical purposes:



With the increasing costs and complexity of scientific research, international co-operation (such as takes place at CERN in Switzerland) is becoming more usual. Collisions at the end of these accelerators allow scientist to understand the particles and forces that make up matter.

P3 Topic 4



Centripetal force acting towards the centre

The red ball is travelling in a circle at a constant speed.

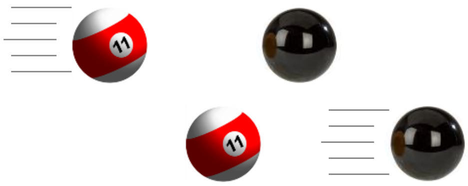
The direction in which the ball is travelling is constantly changing over time. In other words it's velocity is changing constantly.

Acceleration is the *rate of change in velocity*. The ball is constantly accelerating (towards the centre).

The mass of the red ball is accelerating towards the centre. F = ma means that there is also a Force acting towards the centre. This is *centripetal* force.

P3 Topic 4

Elastic collision:
(bounce off)



Momentum is conserved

Kinetic Energy is conserved

KE = ½ mv^2

momentum = mass x velocity

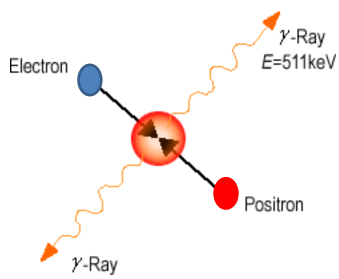
Inelastic collision:
(stick together)

Momentum is conserved

Kinetic Energy is <u>not</u> conserved
(total KE is decreased)

P3 Topic 4

Conservation of momentum:



Both the positron and the colliding electron will have momentum. In the simplest case, with both particles travelling at the same speed, these momentums will disappear after collision.

The resulting gamma rays (photons) have energy and (because of mass-energy equivalence) they too have momentum.

The two gamma photons produced have the same energy and are travelling in exactly opposite directions therefore momentum is again conserved.

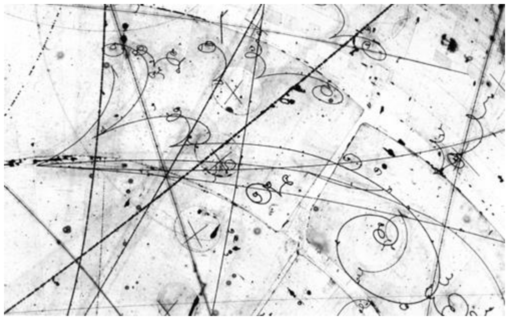
Conservation of charge:

When a - ve electron collides with a +ve positron uncharged light photons are produced. Charge is conserved.

E = mc2

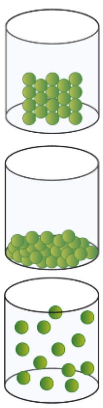
(where c is the speed of light)

P3 Topic 5



Physics

P3 Topic 5



Solid: The particles are held closely together by strong forces. They can vibrate but not move freely

Liquid: Bonds between particles are not as strong and they can slide past each other. The particles are still close together hence liquids are difficult to compress.

Gas: Particles are far apart and fast moving.

Pressure: Caused by the forces of collision with the walls of a container. Unit pascal (Pa)

0 K = -273°C

0°C = 273 K

To convert from Celsius to Kelvin, add 273

Temperature: Is a measure of the *average kinetic energy* of the particles in a substance. As the temperature of a gas increases so does the speed of the particles. When the particles don't move, this is called absolute zero (-273K) Unit kelvin (K)

The average kinetic energy is proportional to the kelvin temperature.

P3 Topic 5

Be able to use the relationship:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Pressure in pascal (Pa)
Volume in m^3
Temperature in kelvin (K)

Or in its other forms:

$$V_1 = \frac{T_1 V_2}{T_2}$$

(For a gas at constant pressure)

$$V_1 P_1 = V_2 P_2$$

(For a gas at constant temperature)