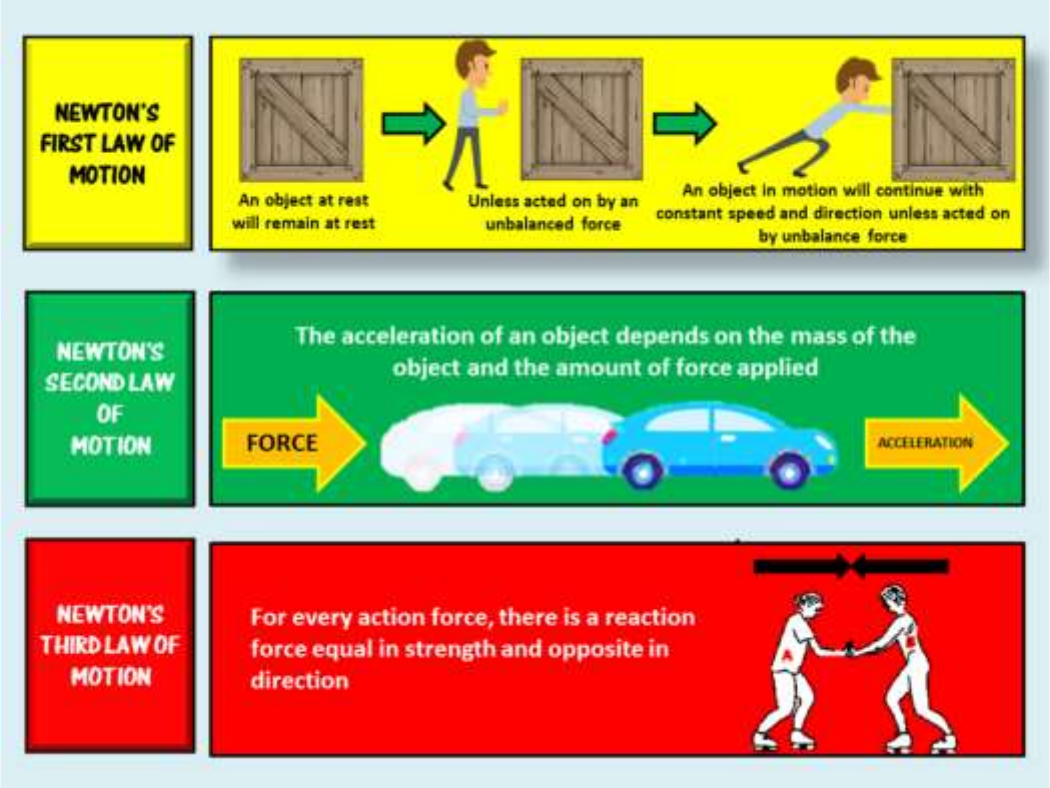
As physics revision

...

Newton's laws



Conservation of momentum

Principle of **conservation of linear momentum:** when bodies in a system interact, total momentum remains constant provided no external force acts on the system.

Ps: In inelastic collisions, total energy is conserved but E(k)may be converted into other forms of energy e.g. heat

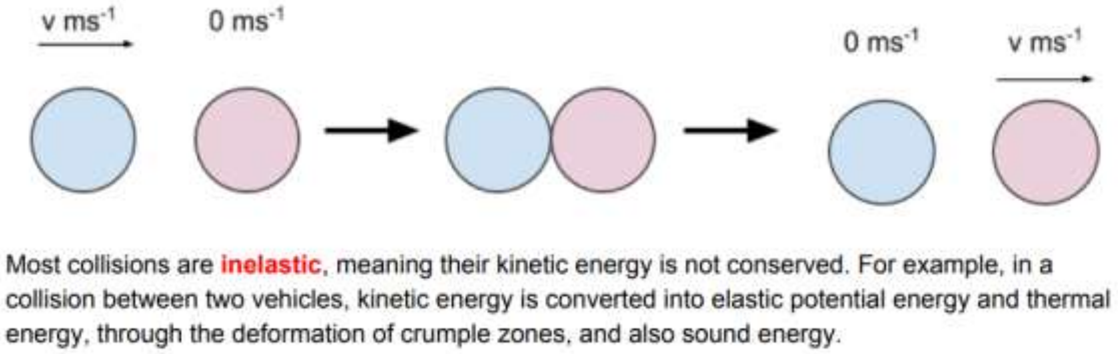
	Momentum	**Kinetic Energy**	**Total Energy**
Elastic Collision	Conserved	Conserved	Conserved
Inelastic Collision	Conserved	Not conserved	Conserved

Equations

P=mv

Δp=mΔv=m(v−u)

F=Δp/t



Only for elastic collisions!

(relative velocity before collision)=−(relative velocity after collision)

U(a)-U(b)=V(b)-V(a)

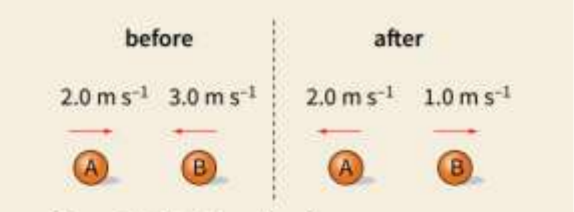


Figure 6.6 For Question 3.

Two-dimensional collisions

For a collision where objects will be moving in 2 dimensions (e.g. x and y), the momentum will be conserved in each direction independently (as long as there's no external impulse in that direction).

$\Sigma p_{xi} = \Sigma p_{xf}$ / $\Sigma p_{yi} = \Sigma p_{yf}$

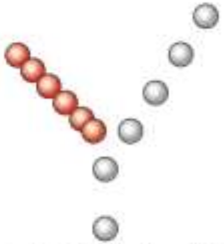


Figure 6.14 The white ball strikes the red ball a glancing blow. The two balls move off in different directions.

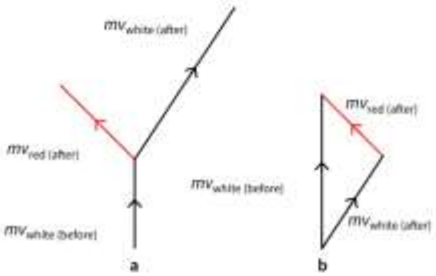
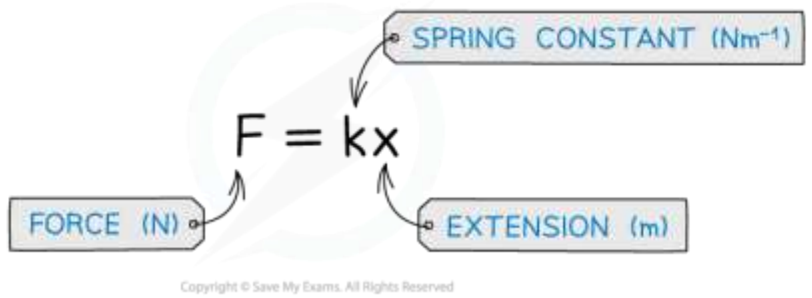
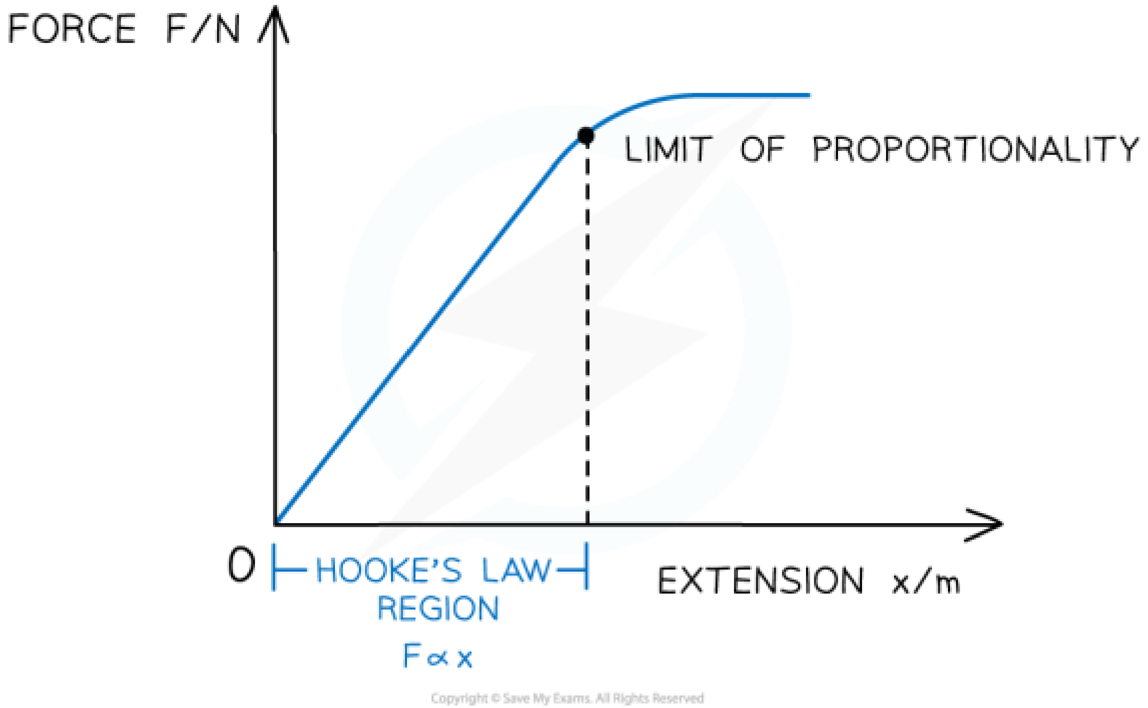


Figure 6.15 **a** These vectors represent the momenta of the colliding balls shown in Figure 6.14. **b** The closed vector triangle shows that momentum is conserved in the collision.

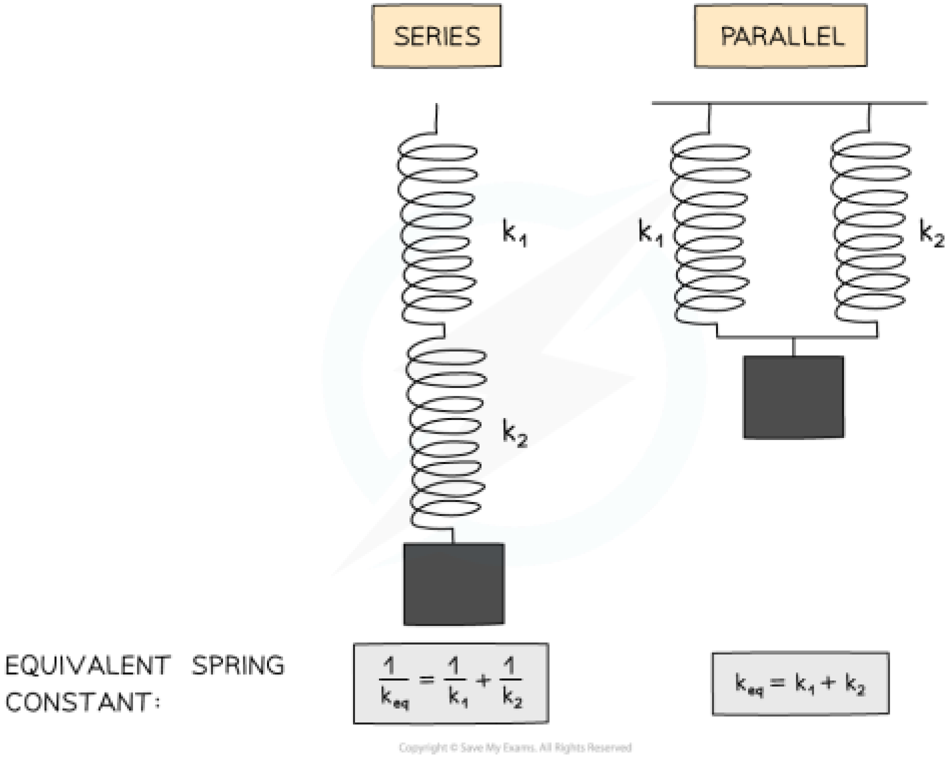
Deformation of solids

Hooke's law


SPRING CONSTANT (Nm⁻¹)
F = kx
FORCE (N)
EXTENSION (m)
Copyright © Save My Exams. All Rights Reserved

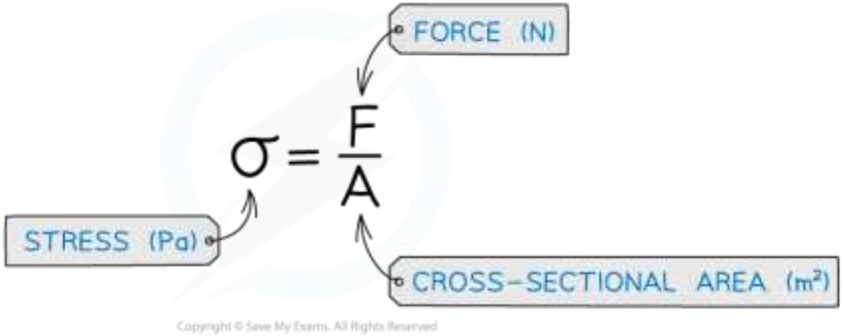

FORCE F/N
LIMIT OF PROPORTIONALITY
0
HOOKE'S LAW REGION
F ∝ x
EXTENSION x/m
Copyright © Save My Exams. All Rights Reserved

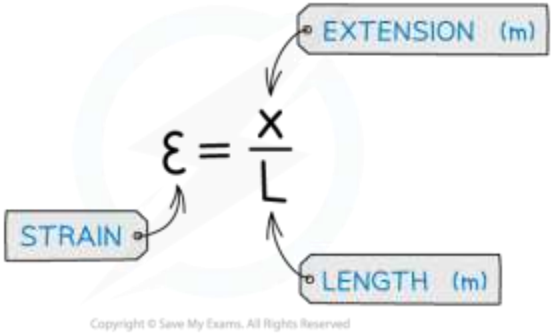
Combination of springs



Stress and strain

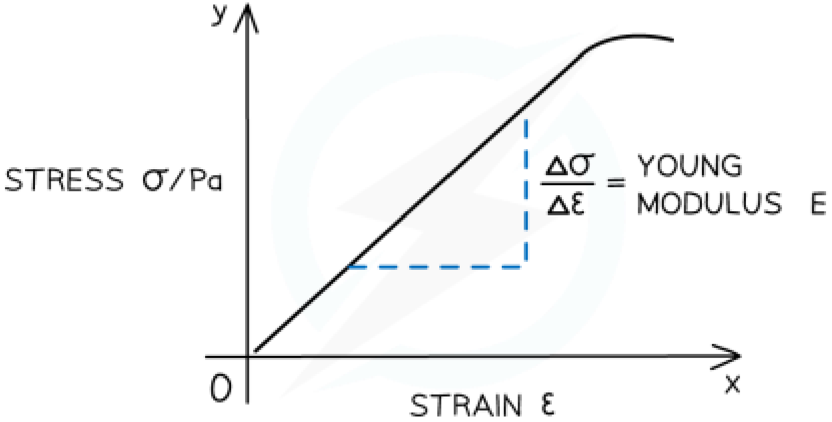
The ultimate tensile stress is the maximum force per original cross-sectional area a wire is able to support until it breaks





Young's modulus

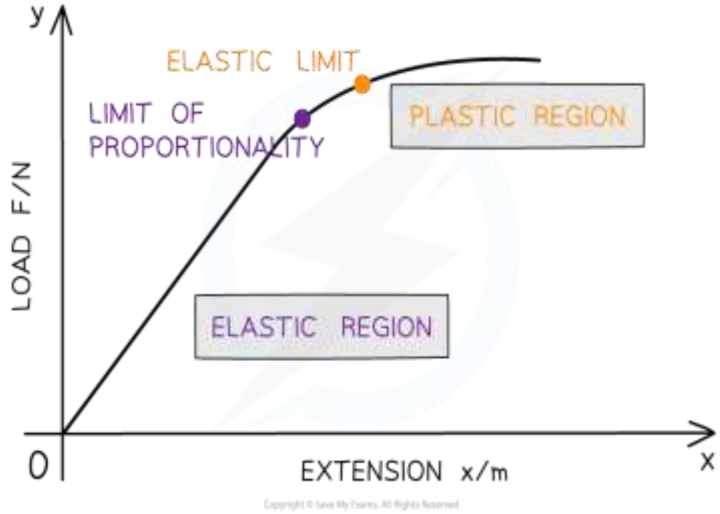
- The Young modulus is the measure of the ability of a material to withstand changes in length with an added load ie. how stiff a material is
- This gives information about the elasticity of a material

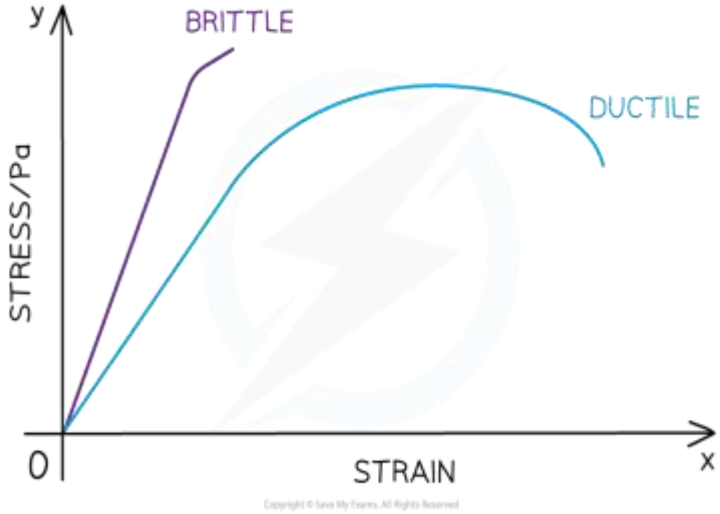


$$\text{YOUNG MODULUS } E = \frac{\text{STRESS } \sigma}{\text{STRAIN } \varepsilon} = \frac{FL}{Ax}$$

(Pa)

Elastic and plastic deformation



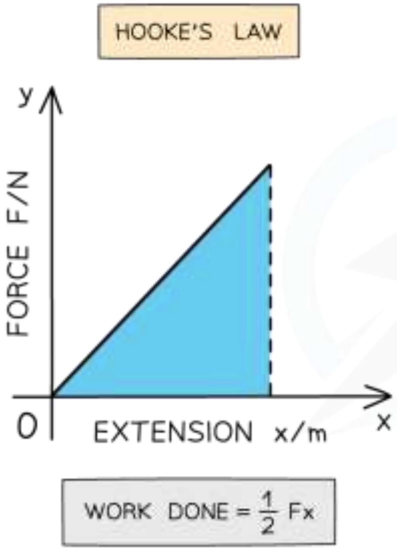


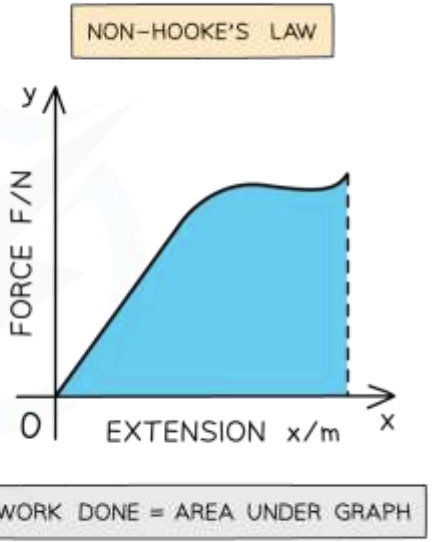
- Brittle materials have very **little to no plastic** region e.g. glass, concrete. The material breaks with little elastic and insignificant plastic deformation
- Ductile materials have a **larger plastic region** e.g. rubber, copper. The material stretches into a new shape before breaking

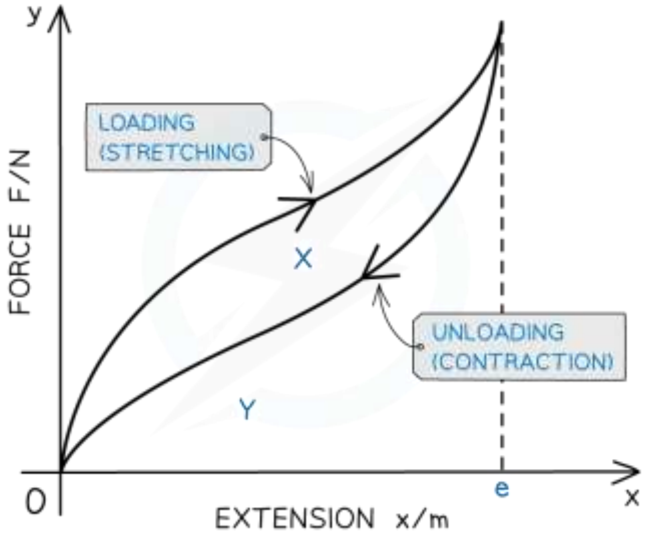
Limit of proportionality and elastic limit

The **limit of proportionality** is the point beyond which the material is no longer defined by Hooke’s law. **The elastic limit** is the furthest point a material can be stretched whilst still able to return to its previous shape. This is at a slightly higher extension than the limit of proportionality.

Work







- The force-extension curve for stretching and contraction of a material that has exceeded its elastic limit, but is not plastically deformed is shown below.
- The area X represents the net work done or the thermal energy dissipated in the material.
- The area X + Y is the minimum energy required to stretch the material to extension e.

Elastic potential energy

HOOKE'S LAW: $F = kx$

$$EPE = \frac{1}{2}Fx = \frac{1}{2}(kx)x$$

$$\boxed{\text{ELASTIC POTENTIAL ENERGY} = \frac{1}{2}kx^2}$$

The formula for EPE = ½ kx2 is only the area under the force-extension graph when it is a straight line i.e. when the material obeys Hooke's law and is within its elastic limit.

RADIOACTIVITY

Rutherford scattering

The majority of α-particles went straight through (A)

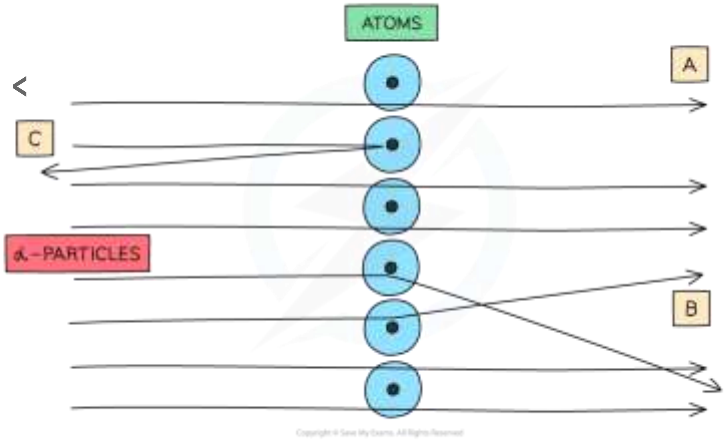
- This suggested the atom is mainly empty space

Some α-particles deflected through small angles of < 10o

- This suggested there is a positive nucleus at the centre (since two positive charges would repel)

Only a small number of α-particles deflected straight back at angles of > 90o (C)

- This suggested the nucleus is extremely small and this is where the mass and charge of the atom is concentrated
- It was therefore concluded that atoms consist of small dense positively charged nuclei, surrounded by negatively charged electrons



Matters and antimatters

The unified atomic mass unit (u) is roughly equal to the mass of one proton or neutron:

1 u = 1.66 × 10-27 kg

MATTER		CHARGE	ANTIMATTER		CHARGE
ELECTRON	e^-	−1	POSITRON	e^+	+1
PROTON	p	+1	ANTI−PROTON	$\bar{p}$	−1
NEUTRON	n	0	ANTI−NEUTRON	$\bar{n}$	0

Alpha, Beta & Gamma Particles

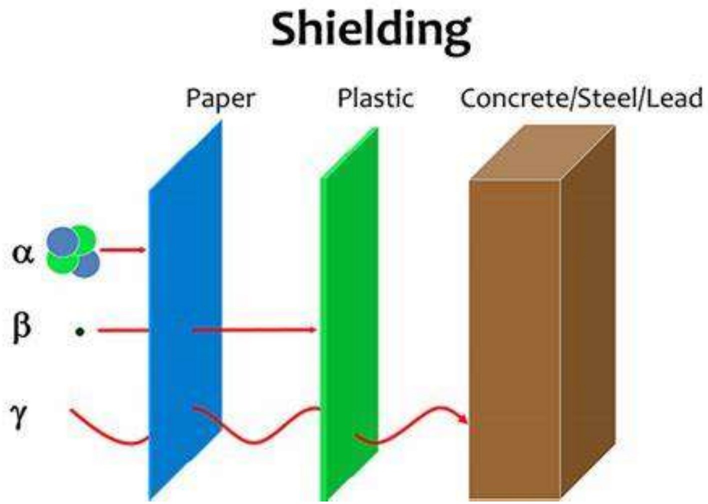
In order to become more stable, they emit particles and/or electromagnetic radiation (Thes nuclei are said to be radioactive)

Alpha (α) particles are high energy particles, usually emitted from nuclei that are too large.

Beta (β-) particles are high energy electrons, emitted by nuclei that have too many neutrons.

Gamma (γ) rays are high energy electromagnetic waves

They are emitted by nuclei that need to lose some energy



PROPERTIES OF THE DIFFERENT TYPES OF RADIATION

Particle	Composition	Mass / u	Charge / e	Speed / c
Alpha (α)	2 protons + 2 neutrons	4	+2	0.05
Beta minus (β^-)	Electron (e^-)	0.0005	−1	> 0.99
Beta plus (β^+)	Positron (e^+)	0.0005	+1	> 0.99
Gamma (γ)	Electromagnetic wave	0	0	1

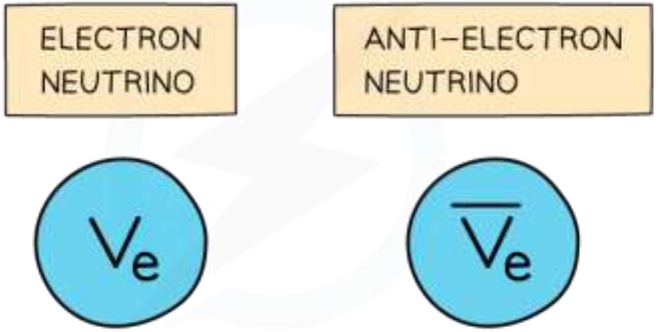
u is the atomic mass unit (see “Atomic Mass Unit (u)”)
e is the charge of the electron: 1.60 × 10-19 C
c is the speed of light: 3 × 108 m s-1

Neutrino and antineutrino

An electron neutrino is a type of subatomic particle with no charge and negligible mass which is also emitted from the nucleus.

The anti-neutrino is the antiparticle of a neutrino

- Electron anti-neutrinos are produced during β- decay
- Electron neutrinos are produced during β+ decay

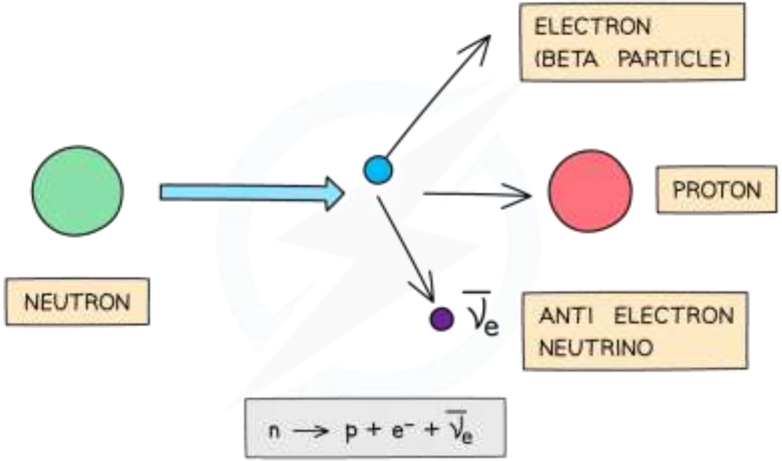


Alpha decay

$$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}\alpha$$

e.g. $$^{212}_{84}Po \longrightarrow {}^{208}_{82}Y + {}^{4}_{2}\alpha$$

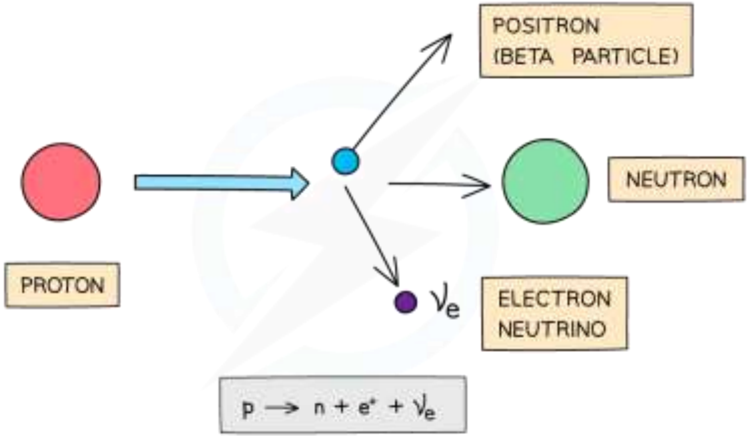
Beta (-) decay



$$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu}_e$$

e.g. $$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu}_e$$

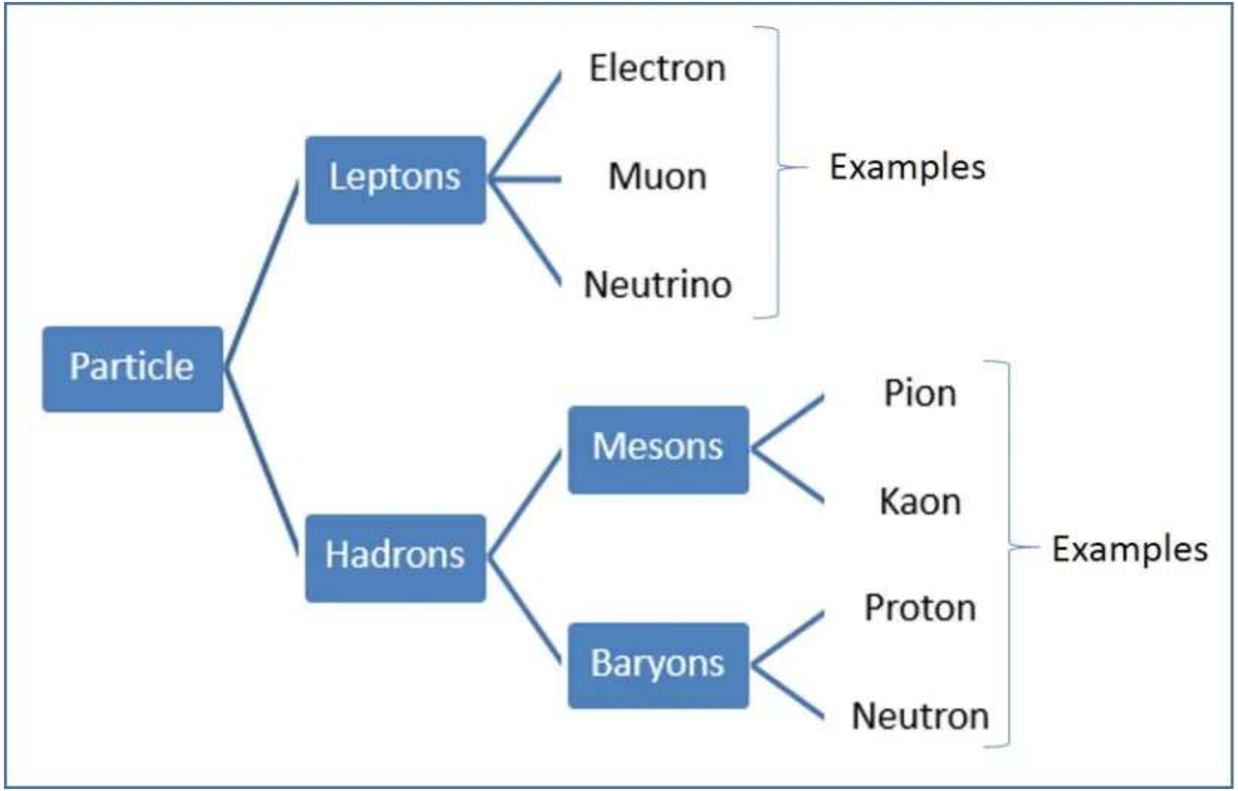
Beta (+) decay



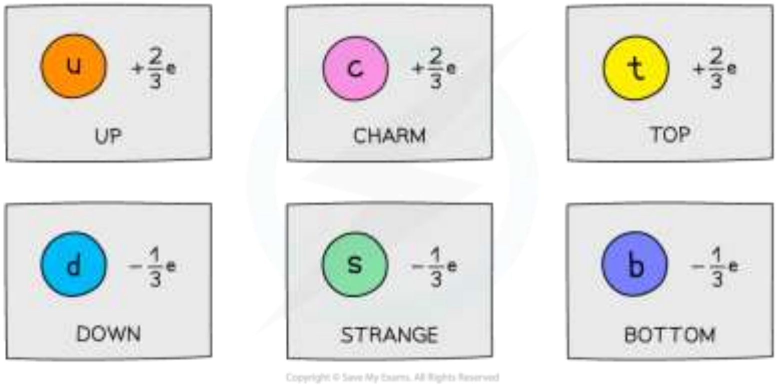
$$^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}\beta + {}^{0}_{0}\nu_e$$

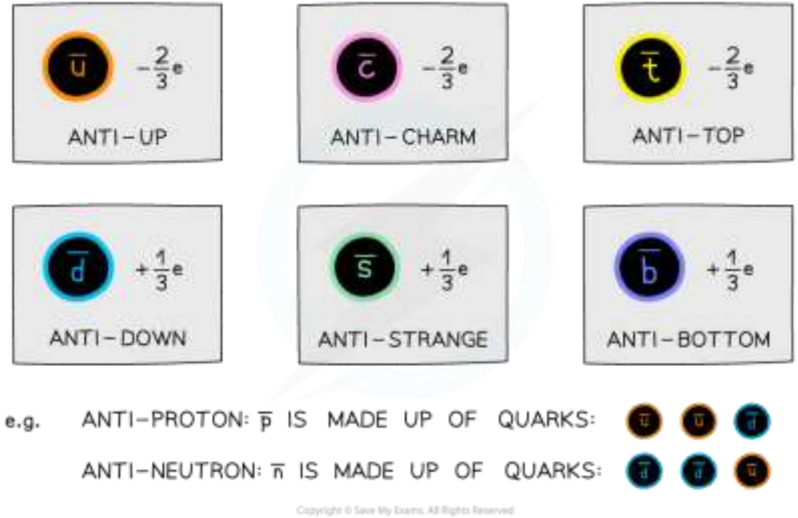
e.g. $$^{6}_{6}C \longrightarrow {}^{6}_{5}B + {}^{0}_{+1}\beta + {}^{0}_{0}\nu_e$$

CLASSIFICATION



Fundamental Particles: hadrons ⇔ Quarks

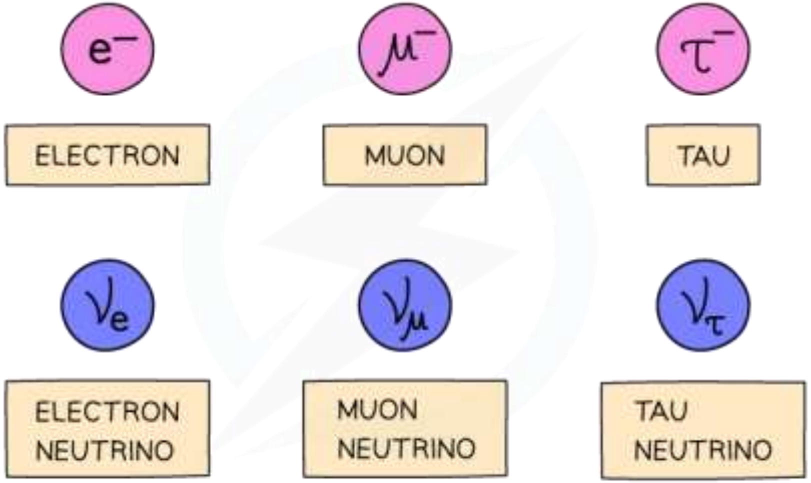




- Protons and neutrons are in a category of particles called **hadrons**
- **Hadrons** are defined as any particle made up of **quarks**

LEPTONS

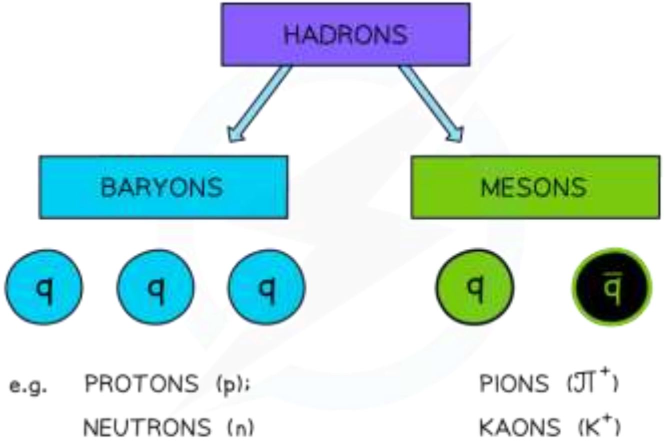
Leptons are a group of fundamental (elementary) particles. This means they are not made up of any other particles (no quarks)



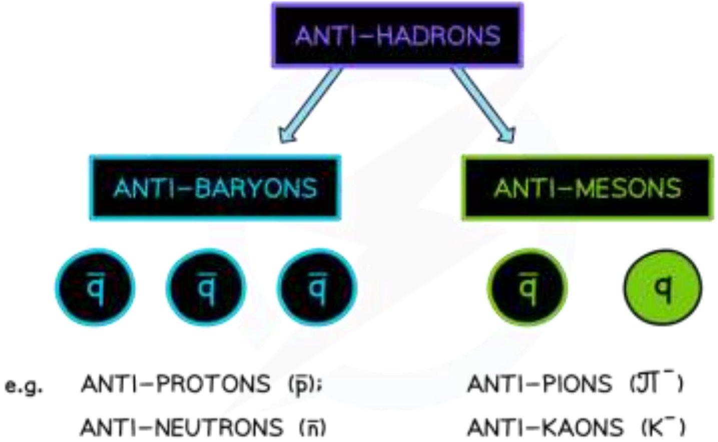
Leptons

- The muon and tau particle are very similar to the electron but with slightly larger mass
- Electrons, muon and tau particles all have a charge of -1e and a mass of 0.0005u
- There are three flavours (types) of neutrinos (electron, muon, tau)
- Neutrinos are the most abundant leptons in the universe
- They have no charge and negligible mass (almost 0)
- Leptons interact with the weak interaction, electromagnetic and gravitational forces
- However, they do not interact with the strong force
- Although quarks are fundamental particles too, they are not classed as leptons
- Leptons do not interact with the strong force, whilst quarks do

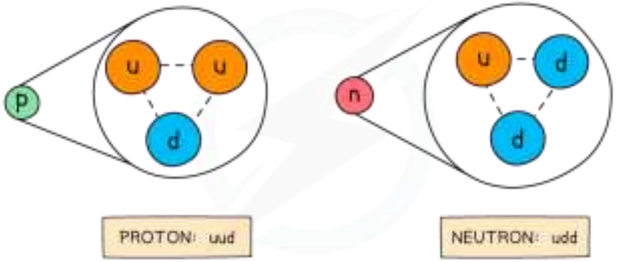
HADRONS



HADRONS
BARYONS
MESONS
q q q
q $\bar{q}$
e.g. PROTONS (p);
NEUTRONS (n)
PIONS (π^+)
KAONS (K^+)



ANTI–HADRONS
ANTI–BARYONS
ANTI–MESONS
$\bar{q}$ $\bar{q}$ $\bar{q}$
$\bar{q}$ q
e.g. ANTI–PROTONS ($\bar{p}$);
ANTI–NEUTRONS ($\bar{n}$)
ANTI–PIONS (π^-)
ANTI–KAONS (K^-)



p
u u d
n
u d d
PROTON: uud
NEUTRON: udd