Highsted Knowledge Organiser Physics : Radioactivity

What I need to know

The development of the model of the atom
3 types of radiation and their features
Half life calculations

Key Vocabulary:

The **atomic number** is the number of protons.
The **mass number** is the total number of protons and neutrons (number of things in the nucleus).
Isotopes are atoms of the same element that have different numbers of neutrons.

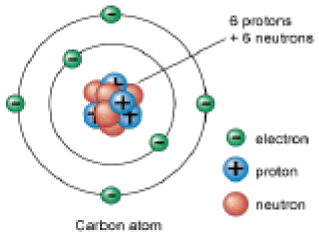
The half-life is the time it takes for the count rate, activity, or number of radioactive nuclei of an isotope to fall to half its initial value.

Equations

Student reference point

Atomic Structure: The Nuclear Model

Atoms are very small, with a radius of about 1×10^{-10}m. The structure of an atom is:



The centre of the atom is called the **nucleus**.

Most of the mass is in the nucleus.
The radius of the nucleus is 1 / 10000th the radius of the atom.

The electrons are arranged at different distances from the nucleus, in energy levels.

Electrons can move away from the nucleus (higher energy level) by absorption of electromagnetic radiation.
Electrons can move closer to the nucleus (lower energy level) by emission of electromagnetic radiation.

Atoms can be represented as:

Mass Number $^{12}_{6}C$
Atomic Number

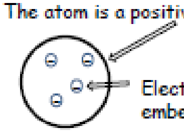
In an atom there are the same number of protons and electrons, so atoms have no overall charge.
Atoms can lose electrons to become positive **ions**.

The Development of the Model of the Atom

Before the discovery of the electron, atoms were thought to be tiny spheres that couldn't be divided.

After the discovery of the electron, scientists suggested the **plum pudding model**. The atom is a positive ball.

Can you describe differences with the nuclear model?



Electrons are embedded in it

The results from the alpha particle scattering experiment led to the discovery of the nucleus. This led to a new model, the **nuclear model**. All the mass and positive charge is thought to be in the nucleus.

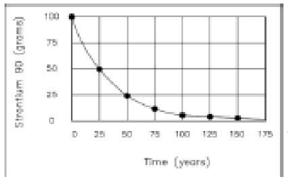
Niels Bohr adapted the nuclear model by adding electron **orbits**. Bohr's calculations agreed with experiments.

20 years after the nucleus was accepted as an idea, James Chadwick discovered **neutrons** within it.

New experimental evidence may lead to a scientific model being changed or replaced.

Half Life

Radioactive decay is **random**



The half-life for this isotope is 25 years.

The count rate or number of nuclei remaining after **n** half-lives can be calculated by dividing the initial value by 2^n. **(Higher Tier Only)**

Nuclear Radiation

Four types of radiation can be emitted from the nucleus: **Alpha, beta, gamma and neutrons.**

	What is it?	Absorbed By	Range in air	Ionising Power	Example Decay
Alpha α	2 protons, 2 neutrons (helium nucleus)	Skin Paper	About 5cm	High	$^{219}_{86}Ra \rightarrow ^{215}_{84}Po + ^{4}_{2}He$ Alpha decay causes the mass and charge of the nucleus to decrease.
Beta β	High speed electron	Thin aluminium	About 1m	Medium	$^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$ Beta decay doesn't change the mass but the charge of the nucleus increases
Gamma γ	Electromagnetic radiation	Thick lead	Infinite	Low	Gamma ray emission does not change the mass or charge of the nucleus

Half-Life and Hazards

Radioactive isotopes have a very wide range of half life values.
For example Uranium-238 has a half-life of 4.5 billion years but Oxygen-22 has a half-life of 2 seconds (you don't need to know these examples).

The hazards associated with radioactive materials differ according to their half-life values.

Short Half-Life
Isotopes with a short half-life have a high activity as they emit more radiation per second. This makes them dangerous as they can provide a high dose.

Long Half-Life
Isotopes with a long half-life emit less radiation per second but will stay radioactive for a long time. Some of the radioactive waste products from nuclear power stations need to be stored for hundreds of years before they become safe.

Hazards
Alpha, Beta and Gamma are **ionizing**, which means they can remove electrons from atoms. In our cells this increases the risk of cancer.
Irradiation is the process of exposing an object to nuclear radiation. **Radioactive contamination** is the unwanted presence of radioactive substances on other materials.

Challenge question: Is alpha or beta radiation more dangerous. (6marks)

Suggested reading: Chernobyl: what happened, and the long-term impact | National Geographic

Highsted Knowledge Organiser Physics : Radioactivity

What I need to know

Define fission
Define Fusion
Medical Uses of Radiation

Key Vocabulary:

Nuclear fission is the splitting of a **large** and **unstable** **nucleus.**

Nuclear fusion is the joining of two **light** **nuclei** to form a heavier one.

Equations

Student reference point

Background Radiation

Background Radiation is around us all the time. It comes from:

- Natural sources such as rocks and cosmic rays from space
- Man-made sources such as the fallout from nuclear weapons tests and nuclear accidents

The level of background radiation and radiation dose may be affected by occupation (e.g. a miner might have a higher dose) and location.

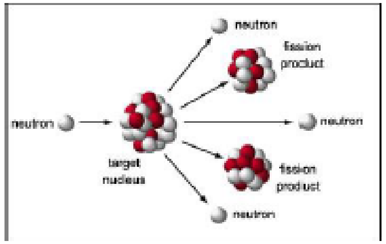
Radiation dose is measured in Sieverts (Sv). You do not need to remember this unit, but you may be asked to answer questions about dose.

Dose is often given in millisieverts (mSv).
1000 millisievert (mSv) = 1 sievert (Sv)

Fission

Spontaneous fission is rare. Usually the unstable nucleus must **absorb** a **neutron**.

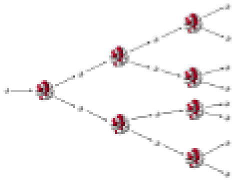
$${}^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{energy}$$



The nucleus undergoing fission splits into **two smaller nuclei**, roughly equal in size, and emits two or three **neutrons** plus gamma rays. **Energy** is released by the fission reaction.

Chain Reactions

All the fission products have **kinetic energy**.
The neutrons may go on to start a **chain reaction**.



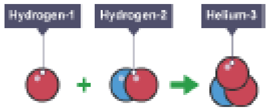
A chain reaction is where each fission goes on to cause at least one more fission.

The explosion of a nuclear weapon is an example of an **uncontrolled** chain reaction.

The chain reaction in a nuclear reactor is **controlled** to control the energy release.

Fusion

$${}^{1}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + energy$$



In this process some of the **mass** is converted into **energy** in the form of radiation.

Medical Uses of Nuclear Radiation

Exploration of Internal Organs

Radioactive isotopes are taken into the body, and the radiation they emit can be detected outside the body.
Benefit: doctors can investigate internal organs without surgery (which is higher risk)
Risk: increased danger of developing cancers

Control or Destruction of Unwanted Tissue

A beam of high energy radiation (usually gamma) is fired at a tumour.
Benefit: cancerous tumours can be destroyed or diminished
Risk: increased danger of developing new cancers

In medical treatments the benefit of using nuclear radiation outweighs the risk.

Challenge question: Is alpha or beta radiation more dangerous (6marks)

Suggested reading: [Chernobyl: what happened, and the long-term impact | National Geographic]

Highsted Knowledge Organiser Physics: Forces in Balance

What I need to know

Examples of scalars and vectors
Be able to draw free body diagrams
Calculate resultant force with the use of parallelogram
Resolve forces using horizontal or vertical components.

Key Vocabulary:

Physical quantities that have magnitude (size) and NO specific direction are called SCALARS

Physical quantities that have both magnitude (size) and direction VECTORS

Contact forces -These require the objects to be physically touching.

Non-contact forces - the objects are physically separated and do not need to touch each other.

Equations

Moment = force x perpendicular distance from the line of action of the force to the pivot

$M = F \times d$

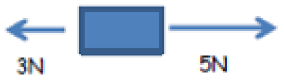
Student reference point

We can draw **free body diagrams** to show the forces acting on an object

Resultant Forces

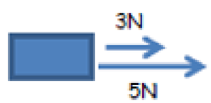
When two or more forces act on an object , the resultant force is the overall effect of those forces

1) When forces act in opposite directions, take the smaller force away from the bigger force to find the resultant
2) When forces act in the same direction add the forces together to find the resultant force



Resultant force =

5 - 3 = 2N to the right



Resultant force =

5 + 3 = 8N to the right

Resultant forces cause objects to **accelerate** in the direction of the resultant force

Newton's First law states that if the forces acting on an object are balanced (the resultant force is 0) , the object is either

- Stationary (not moving)
- Moving at a constant speed and in the same direction.

Newton's Third law states that when two objects interact with each other, they exert equal and opposite forces on each other

E.g The boys weight pushes down on the chair which applies an upward support force on the boy .

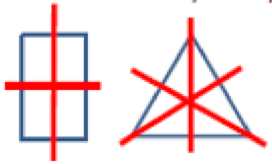
The weight and support force are equal in size but opposite in direction

Without this support force he would fall to the around

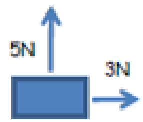
The **centre of mass** of an object is the point at which its mass can be thought of as being concentrated

The weight of the object may be considered to act at the centre of mass.

For a symmetrical object the centre of mass is located in the middle of the object where the axes of symmetry meet.

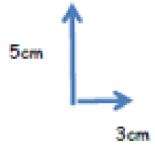


HIGHER ONLY: Sometimes we might have to calculate the resultant force when forces aren't acting along the same line (as shown below.

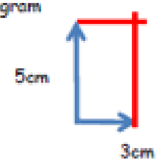


To calculate the resultant force in this scenario we need to use the **parallelogram of forces**

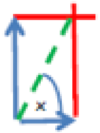
Step 1: Draw a scale diagram of the forces. This is a diagram that shows the direction of the forces and uses a scale to show the size of the forces using lengths. E.g if our scale is 1N = 1cm



Step 2: Complete the shape to form a parallelogram



Step 3: Draw a line connecting the bottom corner to the top corner. Measure the length of the line and convert it into a force using your scale.



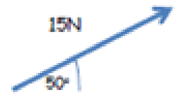
E.g line is measured to be 6cm

Using our scale 6cm = 6N
Therefore the resultant force is 6N

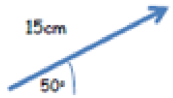
The direction is angle x.

HIGHER ONLY: Sometimes we might have the resultant force and we may need to calculate the forces which made it. This is called **resolving forces**

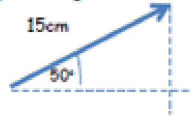
E.g Resolve the force below



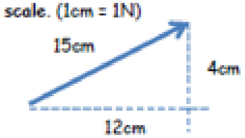
Step 1: Draw a scale diagram of the forces. This is a diagram that accurately shows the direction of the force and uses a scale to show the size of the forces using lengths. E.g if our scale is 1N = 1cm



Step 2: Complete the shape to form a right angled triangle



Step 3: Measure the length of the new lines and convert back into a force **using your scale**. (1cm = 1N)



Horizontal component = 12N

Vertical component = 4N

Challenge question: A force of 3N and 4N act on a point. Determine the magnitude and direction of the Resultant forces if the angle between their lines of action is 45 degrees.

Suggested reading: [AQA GCSE Physics Topic 5: Forces Revision - PMT (physicsandmathstutor.com)]

Highsted Knowledge Organiser Physics : Forces in Balance

What I need to know
Be able to calculate moments for a given situation
Apply the principle of moments.
Levers at as force multipliers
Gears multiply the turning effect of a force.

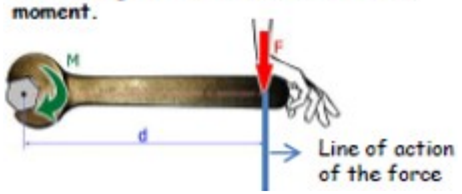
Key Vocabulary:
Inertia is the tendency for objects to continue in their state of rest or of uniform motion

Equations
Moment = force x perpendicular distance from the line of action of the force to the pivot

M = F x d

Student reference point

The turning effect of a force is called a **moment**.



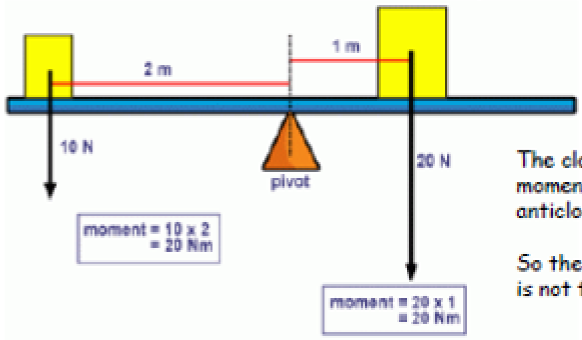
Note: The line of action of a force is a line along which a force may be considered to act.

Moment = force x perpendicular distance from the line of action of the force to the pivot

M = F x d

The principle of moments

The principle of moments states that for an object that is not turning, the sum of all the clockwise moments about any point = the sum of the anti-clockwise moments about that point

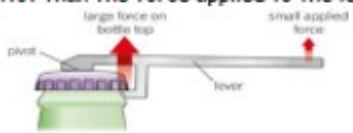


The clockwise moments = the anticlockwise

So the see saw is not turning

Gears and levers

Levers act as force multipliers. They can increase the size of a force acting on an object because the force applied by the lever is closer to the pivot than the force applied to the lever



Gears can also multiply the turning effect of a force

Low gear: A force applied to a small gear creates a large moment in the bigger gear. This gives a low speed but high turning effect

High gear: A force applied to a large gear creates a smaller moment in the smaller gear. Since the smaller gear rotates faster this gives a high speed but low turning effect.

Challenge question: The driving wheel or cog connected to the pedals has a radius of 45mm. If the cyclist pedals with a force of 360N what is the turning moment?

Suggested reading: AQA GCSE Physics Topic 5: Forces Revision - PMT (physicsandmathstutor.com)