GCSE Physics
Additional Topics 1-8 Revision Guide

Bassaleg
SCHOOL

Name

Additional Physics - Topic 1 Radioactivity

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Key Topics	Page
1. know that radioactive emissions from unstable atomic nuclei arise **because of an imbalance between the numbers of protons and neutrons.**	
2. use secondary sources, e.g. the website of the Health Protection Agency, to investigate the sources of background radiation.	
3. be aware of the dangers associated with radon in the home and use secondary sources to investigate the geographical distribution of radon-affected houses, and the measures that can be taken against radon	
4. investigate experimentally, or use secondary sources to investigate the penetrating power of nuclear radiation and to determine the types of radiation emitted by a radioactive material	
5. know how the different penetrating powers of alpha, beta and gamma radiation relate to the dangers of external and internal exposure to radioactive sources	
6. discuss the health risks associated with exposure to radioactive emissions, and describe the precautions needed to protect medical staff and patients from over-exposure to radioactivity.	

Areas you wish to focus on when revising:

1. Radioactivity is a totally random process

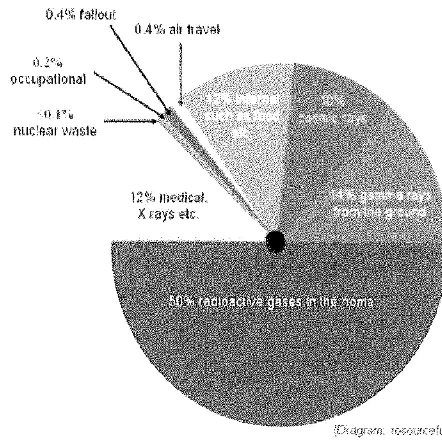
Unstable nuclei in atoms will decay and in the process will give out radiation.
This process is entirely random.
Eg. If you have 1000 unstable nuclei, you can't say when any one of them will decay, and neither can you do anything at all to make a decay happen.
Each nucleus will just decay quite spontaneously in it's own good time. It's completely unaffected by physical conditions like temperature or by any sort of chemical bonding etc.

2. Background radiation comes from many sources

Natural background radiation comes from:
Radioactivity of naturally occurring unstable isotopes which are all around us - in the air, in food, in building materials, and in the rocks under our feet.

Radiation from space, which is known as cosmic rays and come mostly from the Sun.

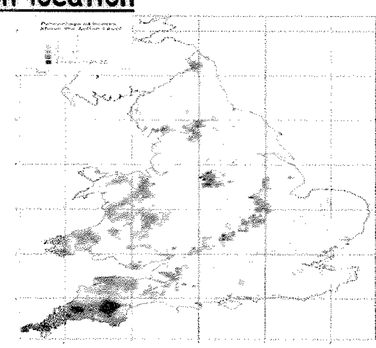
Radiation due to human activity. i.e. fallout from nuclear explosions or dumped nuclear waste. But this represents a tiny proportion of the total background radiation.



(Diagram: resourcefulphysics.org)

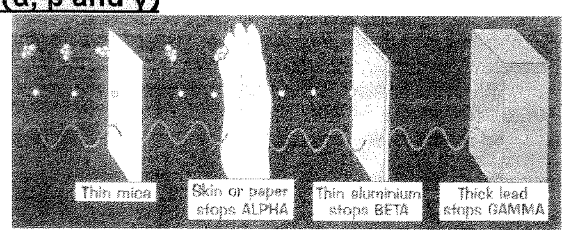
3. The level of background radiation changes depending on location

Certain underground rocks can cause high levels of radiation at the surface, especially if they release radioactive Radon gas. This gas tends to get trapped inside peoples houses. This varies widely across the UK depending on the rock type.
Houses are routinely tested in areas of high Radon gas. The gas can be pumped away through ventilation and floors sealed to prevent the gas entering homes.



4. Types of radiation: Alpha, Beta, Gamma (α, β and γ)

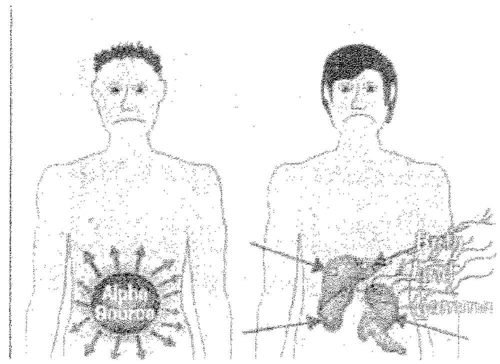
Alpha: Is a Helium nucleus comprised of 2 protons and 2 neutrons
Beta: Is a free electron
Gamma: Is a ray of pure energy
What blocks the 3 types of radiation:
Alpha: blocked by skin or paper
Beta: blocked by a few mm of foil
Gamma: blocked by thick lead or concrete



5. Radiation harms living cells

Outside the body (irradiation) Beta and Gamma sources are the most dangerous.
This is because they can penetrate the skin to the delicate organs whereas alpha is much less dangerous because it is blocked by the skin and clothing.

Inside the body (contamination) alpha sources do all the damage in a very localised area. Beta and Gamma sources on the other hand are less dangerous inside the body because they mostly pass straight out without doing much damage.



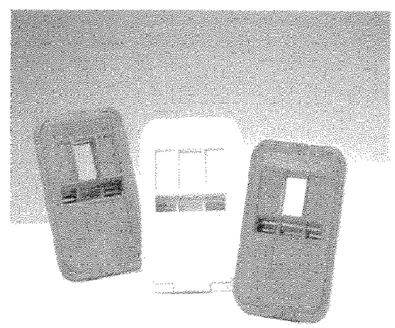
6. Radiation hazards and safety

Alpha, Beta and Gamma radiation will cheerfully enter living cells and collide with molecules.
These collisions cause ionisation, which damages or destroys the molecules.
Lower doses tend to cause minor damage without killing the cell.
This can give rise to mutant cells which multiply uncontrollably. This is called cancer.

Safety Precautions

Use of lead-lined suits and lead/concrete barriers and thick lead screens to prevent exposure to x-rays from highly contaminated areas.

Workers in the nuclear industry or those using x-ray equipment such as dentists and radiographers wear badges which have a bit of photographic flim in them.
The film is checked regularly to see if it's tarnished too quickly. This would mean the person is getting too much exposure to radiation.



Additional Physics - Topic 2 & 3 Radioactivity

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Key Topics	
1. Investigate using secondary sources, the decay of a short-lived radioactive material and determine its half life.	
2. Perform simple calculations involving the activity and half life of radioactive materials	
3. Use physics knowledge to respond to information describing contemporary uses of radioactive materials, relating to the half life, penetrating power and biological effects of the radiation e.g. *radioactive tracers, carbon dating, thickness monitoring and* a. *cancer treatment.*	
4. Discuss the scientific and ethical problems associated with the long-term disposal of radioactive waste materials and appreciate the problems posed by the uncertainties in the behaviour of these materials and their containers over thousands of years.	

Areas you wish to focus on when revising

1. Radioactive Half life

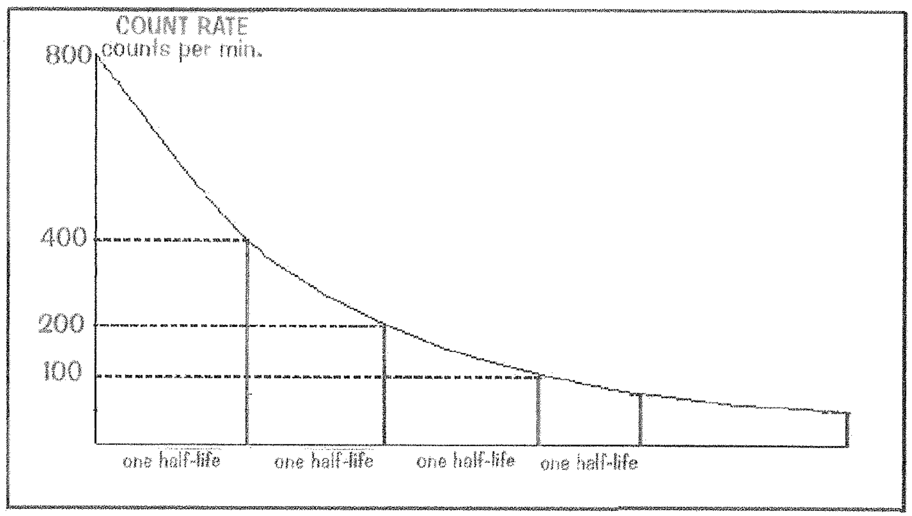
HALF-LIFE is the TIME TAKEN for HALF of the radioactive atoms now present to DECAY

"The time taken for the activity (or count rate) to fall by half".

A short half-life means the activity falls quickly, because lots of the nuclei decay quickly.
A long half-life means the activity falls more slowly

Measuring half life of a sample using a graph

1) This can only be done by taking several readings of count rate using a G-M tube and counter.
2) The results can then be plotted as a graph, which will always be shaped like the one below.
3) The half-life is found from the graph, by finding the time interval on the bottom axis corresponding *to* halving of the activity on the vertical axis. Easy peasy really.



2. Half life calculations: Step by Step

The basic idea of half-life is maybe a little confusing, but Exam calculations are pretty straightforward so long as you do them slowly, STEP BY STEP. Like this one:

A VERY SIMPLE EXAMPLE: The activity of a radio-isotope is 640cpm (counts per minute). Two hours later it has fallen to 40 cpm. Find the half life of the sample.

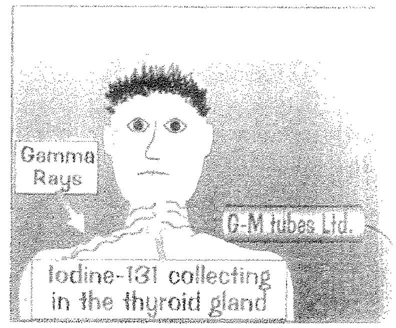
ANSWER: You must go through it in short simple steps like this:

INITIAL count:		after ONE half-life:		after TWO half-lives:		after THREE half-lives:		after FOUR half-lives:
640	(÷2)→	320	(÷2)→	160	(÷2)→	80	(÷2)→	40

Notice the careful step by step method, which tells us it takes four half-lives for the activity to fall from 640 to 40. Hence two hours represents four half-lives so the half-life is 30 minutes.

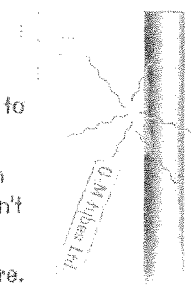
3. The uses of radiation

Tracers in medicine – Always short half lives



1) Certain radioactive isotopes can be injected into people (or they can just swallow them) and their progress around the body can be followed using a detector (such as a G-M tube) which will show where the strongest reading is coming from.
2) A good example is radioactive Iodine-131 which is used to check that the thyroid gland in the throat is working properly.
3) All isotopes which are taken into the body must be GAMMA or BETA (never alpha), so that the radiation passes out of the body and they should only last a few hours, so that the radioactivity inside the patient quickly disappears. (i.e. they should have a short half-life.)

Tracers in industry – Finding leaks

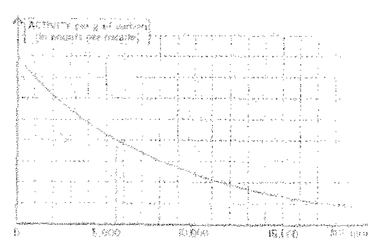


1) Radio-isotopes can be used to detect leaks in pipes.
2) You just squirt it in, and then go along the outside of the pipe with a detector to find places of extra high radioactivity, which shows the stuff is leaking out. This is really useful for concealed or underground pipes, to save you digging up half the road trying to find the leak.
3) The isotope used must be a gamma emitter, so that the radiation can be detected even through metal or earth which may be surrounding the pipe. Alpha and beta rays wouldn't be much use because they are easily blocked by any surrounding material.
4) It should also have a short half-life so as not to cause a hazard if it collects somewhere.

Radiotherapy – Treatment of cancer using Gamma rays

1) Since high doses of gamma rays will kill all living cells they can be used to treat cancers.
2) The gamma rays have to be directed carefully and at just the right dosage so as to kill the cancer cells without damaging too many normal cells.
3) However, a fair bit of damage is inevitably done to normal cells which makes the patient feel very ill. But if the cancer is successfully killed off in the end, then it's worth it.

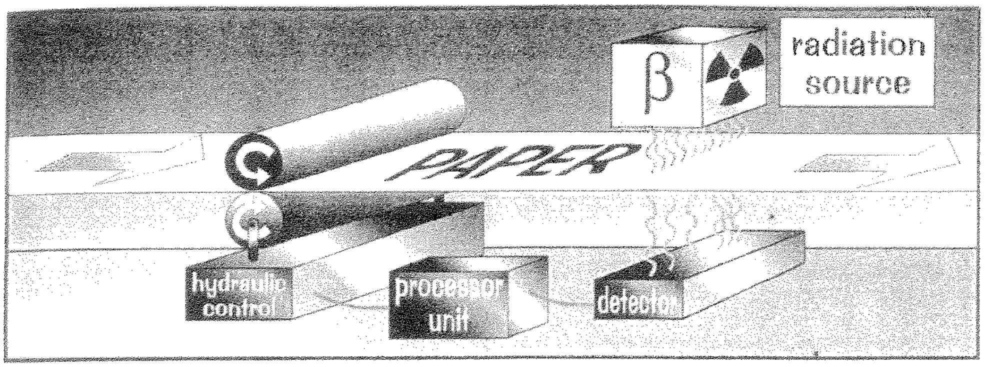
Radioactive Dating of rocks and archaeological specimens



1) The discovery of radioactivity and the idea of half-life gave scientists their first chance to accurately work out the age of rocks and fossils and archaeological specimens.
2) By measuring the amount of a radioactive isotope left in a sample, and knowing its half-life, you can work out how long the thing has been around (see P. 85).

Thickness control in manufacturing

1) You have a radioactive source and you direct it through the stuff being made, usually a continuous sheet of paper or cardboard or metal etc.



2) The detector is on the other side and is connected to control unit.

3) When the amount of radiation detected goes down, it means the stuff is coming out too thick and so the control unit pinches the rollers up a bit to make it thinner again.

4) If the reading goes up, it means it's too thin, so the control unit opens the rollers out a bit. It's all clever stuff, but the most important thing, as usual, is the choice of isotope.

5) First of all it must have a nice long half-life (of several years at least!), otherwise the strength would gradually decline and the silly control unit would keep pinching up the rollers trying to compensate.

6) Secondly, the source must be a beta source for paper and cardboard, or a gamma source for metal sheets. This is because the stuff being made must partly block the radiation. If it all goes through (or none of it does), then the reading won't change at all as the thickness changes. Alpha particles are no use for this since they would all be stopped.

4. Disposal of radioactive waste

Radioactive waste can stay radioactive for thousands of years.
Because the waste can be very dangerous it must be kept safe for a wery long time.
We can keep the waste safe by burying it deep underground in thick containers and sealed in concrete bunkers.
However we aren't really sure what might happen to that area over a long time.
Other suggested methods include simply dumping it into the sea and launching it into space. These pose the real threat of contaminating large areas of the globe should the rockets or containers fail.

Additional Physics - Topic 4 Electricity

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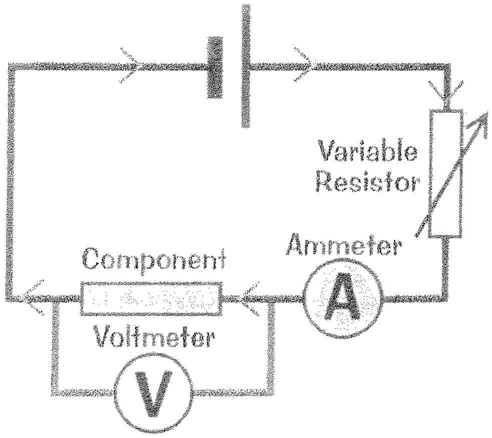
Key Topics	
1. Know how to use voltmeters and ammeters to measure the voltage across and current through electrical components.	
2. Understand the relationship between current, voltage and resistance.	
3. Select and use the equation: Voltage = current x resistance	
4. Know how current changes with voltage for a resistor (or wire) at constant temperature, a filament lamp and a diode.	

Areas you wish to focus on when revising

1. Connecting Voltmeters and Ammeters in electrical circuits



The Ammeter

1) Measures the current (in Amps) flowing through the component.
2) Must be placed in series.
3) Can be put anywhere in series in the main circuit, but never in parallel like the voltme

The Voltmeter

1) Measures the voltage (in Volts) across the component.
2) Must be placed in parallel around the component under test — NOT around the variable resistor or the battery!

2. Relationship between Voltage, Current and Resistance – Ohm's law

Ohm's law states that

*"The electrical current **(I)** flowing in a circuit is proportional to the voltage **(V)** and inversely proportional to the resistance **(R)**."*

e.g. For a given Voltage, the bigger the resistance the smaller the current in the circuit.

e.g. For a given Resistance, the bigger the voltage the bigger the current.

3. Ohm's law equation

Voltage = Current x Resistance

(Volts) = (Amps) (Ohms)

e.g.

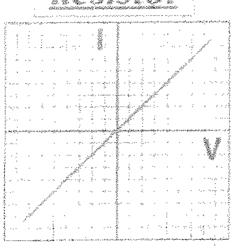
For a 30Ω resistor carrying a current of 0.12A the voltage is:

Voltage = 0.12A x 30 Ω

Voltage = 3.6Volts

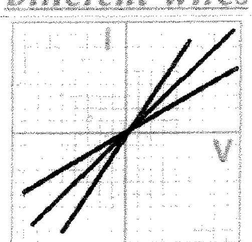
4. How current behaves in common electrical components

Resistor



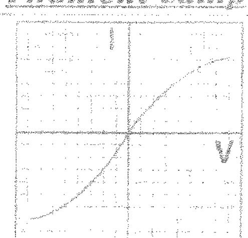
The current through a resistor (at constant temperature) is proportional to voltage.

Different Wires



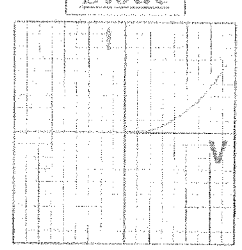
Different wires have different resistances, hence the different slopes.

Filament Lamp



As the temperature of the filament increases, the resistance increases, hence the curve.

Diode



Current will only flow through a diode in one direction, as shown.

Additional Physics - Topic 5 Electrical Safety

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At the end of this topic, indicate the areas that you understand well with green, areas that you are very uncertain about in red and colour orange the ones that you are not sure about. Make sure that you are familiar with the skill areas that you need to cover

Do you

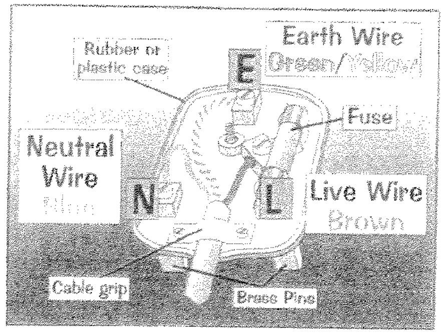
Key Topics	Self-evaluation box
1. Understand the roles of the live, neutral and earth leads and insulation in domestic electrical circuits.	
2. Know how the earth lead and fuse operate to protect consumers against fire and electrical shocks.	
3. Select and use the equation: Power = Voltage x Current to calculate the current taken by an appliance and hence the correct fuse required to protect the cable to the appliance.	
4. Explain the roles of miniature circuit breakers (m.c.b.) and residual current devices (r.c.d.) and compare their actions to those of fuses.	
5. Discuss how ideas of risk and cost play a part in deciding what voltage domestic electricity supplies should use and appreciate that different countries have adopted different voltages.	

Areas you wish to focus on when revising

1. Connecting plugs and cables

Get the Wiring Right:

1) The right coloured wire is connected to each pin, and firmly screwed in.
2) No bare wires showing inside the plug.
3) Cable grip tightly fastened over the cable outer layer.



Plug Features:

1) The metal parts are made of copper or brass because these are very good conductors.
2) The case, cable grip and cable insulation are all made of plastic because this is a really good insulator and is flexible too.
3) This all keeps the electricity flowing where it should.

2. Earth wires and fuses - Prevent electrical shocks and fires

Earth Wires

1) If a fault develops in which the live somehow touches the metal case, then because the case is earthed, a big current flows in through the live, through the case and out down the earth wire.
2) This surge in current blows the fuse (or trips the circuit breaker), which cuts off the live supply.

Fuses

1) The fuse has a rating printed on the outside in amps.
2) If the current going through the fuse rises above its rated value, then the fuse "blows" (it melts) which turns off the appliance.

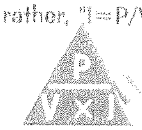
3. Calculating fuse ratings - Always use Power = Voltage x Current

Power	=	Current	x	Voltage
(Watts)	=	(Amps)		(Volts)

Most electrical goods indicate their power rating and voltage rating. To work out the fuse needed, you need to work out the current that the item will normally use. That means using "P=VI", or rather, "I=P/V".

Example: *A hairdrier is rated at 240 V, 1.1 kW. Find the fuse needed.*

Answer: *I = P/V = 1100/240 = 4.6 A. Normally, the fuse should be rated just a little higher than the normal current, so a 5 amp fuse is ideal for this one.*



4. The roles of m.c.b's and r.c.d's

Minature circuit breakers:
Act like a fuse,
They prevent fires
They disconnect the power supply if too much current flows

Residual current devices:
Act like an Earth wire
They prevent electrical shocks
They switch off the circuit if there is a difference between the current in the live and neutral wires.

Both m.c.b's and r.c.d's are advantageous as they are very fast acting and can be reset

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Additional Physics - Topic 6 Distance, Speed and Acceleration & Topic 7 Forces

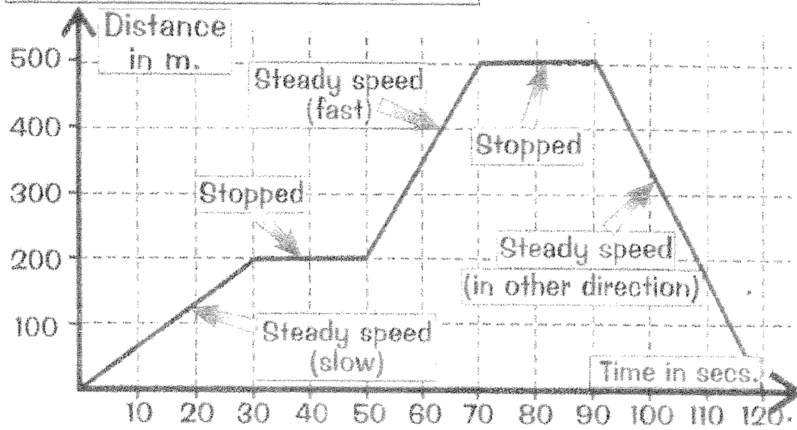
Key Topics	
1. describe motion using speed, acceleration, speed-time and distance-time graphs.	
2. select and use the equations: speed = distance / time acceleration [or deceleration] = change in speed / time in the context of the motion of objects	
3. investigate experimentally, e.g. using an air track and data logger, or computer simulation, the effect of balanced and unbalanced forces on an object.	
4. select and use the equation: resultant force = mass x acceleration	
5. distinguish between the weight and mass of an object **and use the approximation that the weight of an object of mass 1 kg is 10 N.**	
6. use knowledge of forces and their effects to explain the behaviour of objects moving through the air, including the concept of terminal speed.	

Areas you wish to focus on when revising

1. Distance-Time and Speed-Time graphs

Make sure you learn all these details real good. Make sure you can distinguish between the two, too.

Distance-Time Graphs



Four Very Important Notes:

1) Flat sections are where it's stopped.
2) The steeper the graph, the faster it's going.
3) Uphill sections (↗) mean it's travelling away from its starting point.
4) Downhill sections (↘) mean it's coming back toward its starting point.

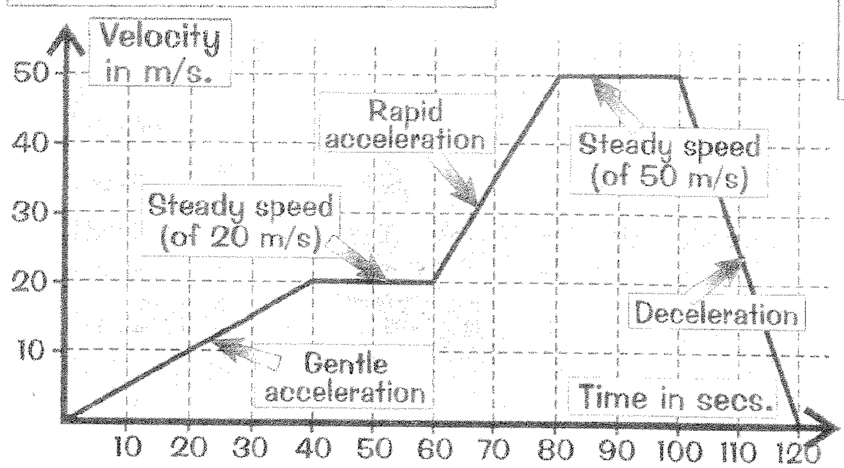
Calculating Speed from a Distance-Time Graph

For example the speed of the return section of the graph is:

$$\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}} = \frac{500}{30} = 16.7 \text{ m/s}$$

Don't forget that you have to use the scales of the axes to work out the gradient. Don't measure in cm.

Speed-Time Graphs



Four Very Important Notes:

1) Flat sections represent steady speed.
2) The steeper the graph, the greater the acceleration or deceleration.
3) Uphill sections (↗) are acceleration.
4) Downhill sections (↘) are deceleration.

Calculating Acceleration and Speed from a Velocity-time Graph

1) The acceleration represented by the first section of the graph is:

$$\text{Acceleration} = \frac{\text{change in speed}}{\text{time interval}} = \frac{20}{40} = 0.5 \text{ m/s}^2$$

2) The speed at any point is simply found by reading the value off the speed axis.

2. Selecting motion equations

Speed = Distance / Time
(m/s) = (m) (s)

Acceleration = (final speed - initial speed) / Time
(m/s^2) = (m/s) (s)

3. Balanced and Unbalanced forces

Balanced forces - Stationary object remains at rest.
Moving object continues at steady speed.

Unbalanced forces - Stationary object begin to move.
Moving object changes speed and/or direction.

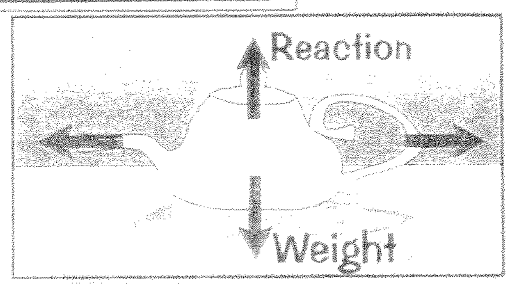
A force is simply a push or a pull. There are only six different forces for you to know about:

1) GRAVITY or WEIGHT always acting straight downwards.
2) REACTION FORCE from a surface, usually acting straight upwards.
3) THRUST or PUSH or PULL due to an engine or rocket speeding something up.
4) DRAG or AIR RESISTANCE or FRICTION which is slowing the thing down.
5) LIFT due to an aeroplane wing.
6) TENSION in a rope or cable.

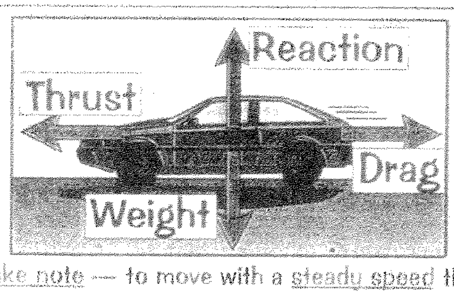
And there are basically only five different force diagrams you can get:

1) Stationary Object — All Forces in Balance

1) The force of Gravity (or weight) is acting downwards.
2) This causes a reaction force from the surface pushing the object back up.
3) This is the only way it can be in balance.
4) Without a reaction force, it would accelerate downwards due to the pull of gravity.
5) The two horizontal forces must be equal and opposite otherwise the object will accelerate sideways.

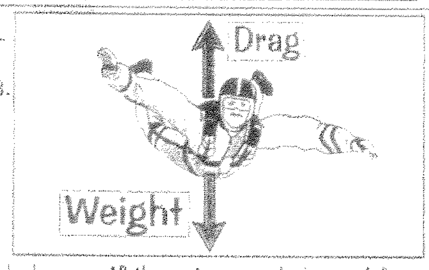


2) Steady Horizontal Velocity — All Forces in Balance!



3) Steady Vertical Velocity — All Forces in Balance!

This skydiver is free-falling at 'terminal velocity' — see P.28.



Take note — to move with a steady speed the forces must be in balance. If there is an unbalanced force then you get acceleration, not steady speed. That's rrrreally important so don't forget it.