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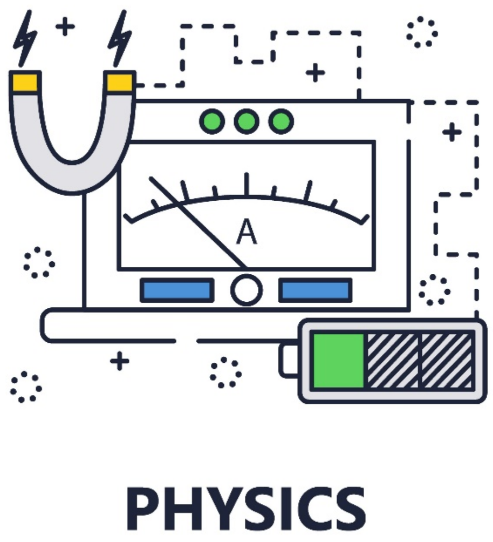

PHYSICS ULTIMATE GUIDE

HIGHER

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Contents

When objects/food cools down the heat is transferred to the surroundings. If the object is cold they gain heat from their surroundings.

How a radiator warms the room – the radiator has hot water inside. Heat transfers to the outside surface by the process of **conduction**. Air touching the radiator warms up and spreads around the room by **convection**. This is because the **air expands** and becomes **less dense**, **rises** and is replaced by **cold air**.

Heat is lost through:

the roof - fit loft insulation
windows - fit double glazing and curtains
gaps around the door - fit draught excluders
the walls - fit cavity wall insulation
the floor - fit a carpet
Heat loss through windows can be reduced using double glazing. There may be air or a *vacuum* between the two panes of glass. Air is a poor conductor of heat, while a vacuum can only transfer heat energy by radiation.

Heat loss through walls can be reduced using cavity wall insulation. This involves blowing insulating material into the gap between the brick and the inside wall, which reduces the heat loss by conduction. The material also prevents air circulating inside the cavity, therefore reducing heat loss by convection.

Heat loss through the roof can be reduced by laying loft insulation. This works in a similar way to cavity wall insulation. **Remember: all these methods rely on air being a poor conductor of heat!!**

You can also put foil behind radiators – this reflects heat/radiation back into the room.

Specific heat capacity

The **specific heat capacity** of a substance is a measure of how much heat energy it can hold. It is the energy needed to increase the temperature of 1 kg of the substance by 1 °C. Different substances have different specific heat capacities. Water has a particularly high specific heat capacity. This makes water useful for storing heat energy, and for transporting it around the home using central heating pipes.

energy (J) = mass (kg) × specific heat capacity (J/kg/°C) × temperature change (°C)

The efficiency of a device such as a lamp can be calculated using this equation:

efficiency = (useful energy transferred ÷ energy supplied) × 100

The efficiency of the filament lamp is (10 ÷ 100) × 100 = 10%.

This means that 10% of the electrical energy supplied is transferred as light energy (90% is transferred as heat energy).

The efficiency of the energy-saving lamp is (75 ÷ 100) × 100 = 75%. This means that 75% of the electrical energy supplied is transferred as light energy (25% is transferred as heat energy).

The main types of electromagnetic radiation and their typical use

frequency	type of electromagnetic radiation	typical use	wavelength
highest	gamma radiation	killing cancer cells	shortest
	x-rays	medical images of bones	

	ultraviolet radiation	sunbeds	
	visible light	seeing	
	infrared radiation	optical fibre communication	
	microwaves	cooking	
lowest	radio waves	television signals	longest

Infrared radiation

Some surfaces are better than others at absorbing and reflecting infrared radiation:

black surfaces are good absorbers
shiny surfaces are good reflectors
When an object absorbs infrared radiation, its temperature increases. Food, for instance, begins to cook when its surface absorbs infrared radiation.

Cooking

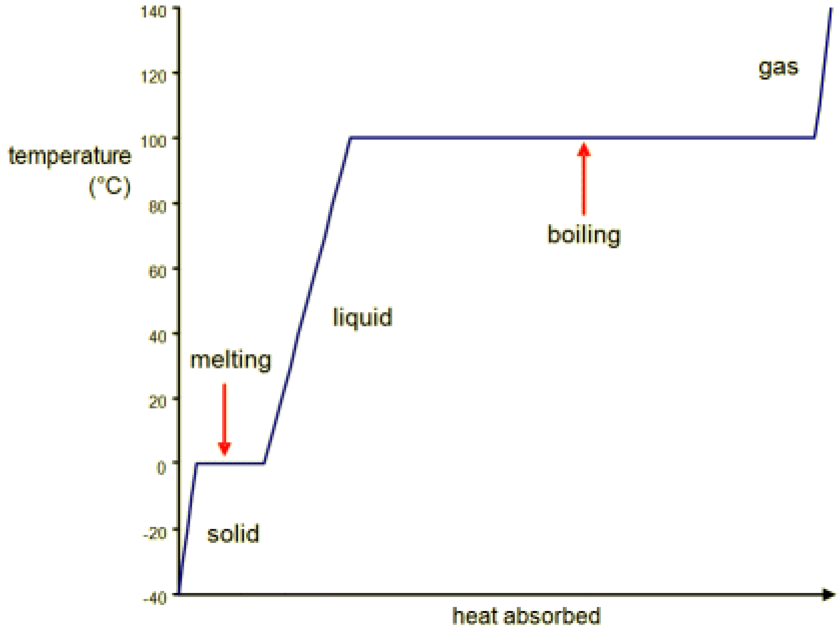
In each case, the **kinetic energy** of particles is increased when the radiation is absorbed:

infrared radiation is absorbed by all particles on the surface. This increases the kinetic energy of the particles. The energy is then transferred to the rest of the food by conduction.
microwave radiation is absorbed by water particles, both on the **surface** and up to about 1cm deep into the food. This gives the particles kinetic energy and they vibrate more. Heat is then transferred by conduction.

Microwave design – the walls are metal and the door is made of a special glass that has a metal mesh to reflect the microwave radiation. Food can be put in a glass bowl when cooking as the microwaves can pass through to the food.

Changing state

A substance must absorb heat energy so that it can melt or boil. The temperature of the substance does not change during melting, boiling or freezing, even though energy is still being transferred.



A heating curve for ice

The **specific latent heat** of a substance is a measure of how much heat energy is needed to melt or boil it. It is the energy needed to melt or boil 1 kg of the substance.

Lasers

Lasers - 'Light Amplification by Stimulated Emission of Radiation' - produces an intense narrow beam of light. A typical laser beam might only spread out by 1m when shone onto a surface 1km away. The light waves in a laser beam are:

the same frequency
in phase with each other
When light waves are in the same phase, their crests all line up, as do their troughs.

Earthquakes can be detected with a seismometer.

Feature of a wave	P-waves	S-waves
Speed	Faster	Slower
Travel through	Solids and liquids	Solids
Type	Transverse	Longitudinal

Global warming

Carbon dioxide is a **greenhouse gas**. It absorbs heat energy that is radiated from the Earth's surface and prevents it from escaping into space. This keeps the Earth warmer than it would otherwise be. But human activities are increasing the amount of carbon dioxide in the atmosphere. This increases the **greenhouse effect** and leads to **global warming**.

Human activities leading to global warming include:

- increased use of energy
- deforestation - cutting down trees

Increased use of energy

Most of the energy we use comes from burning fossil fuels. These release carbon dioxide when they burn. So the increasing use of energy is leading to increasing amounts of carbon dioxide in the atmosphere.

Deforestation

When land is cleared for timber and farms, there are fewer trees to remove carbon dioxide from the atmosphere by photosynthesis. Also, if the fallen trees are burned or left to rot, additional carbon dioxide is released into the atmosphere.

Ozone layer

Absorbs ultraviolet radiation, preventing most of it reaching the ground. This is important because UV radiation can lead to skin cancer. Chlorofluorocarbons, or CFCs, are chemicals that were once used in aerosol spray cans. These break down ozone and damage the ozone layer. CFCs have now been almost completely replaced by chemicals that do not destroy ozone.

Ultraviolet radiation

Ultraviolet radiation is found naturally in sunlight. Exposure to ultraviolet radiation can cause: our skin to tan, sunburn and skin cancer. We cannot see or feel ultraviolet radiation, but our skin responds to it by turning darker. This happens in an attempt to reduce the amount of ultraviolet radiation that reaches deeper skin tissues. Inside the skin there are cells that produce melanin – this causes the skin to tan.

Darker skins absorb more ultraviolet light, so less ultraviolet radiation reaches the deeper tissues. This is important because ultraviolet radiation can cause normal cells to become cancerous.

Sunblocks

Sunblocks can reduce the damage caused by ultraviolet radiation. They contain chemicals that absorb a lot of the radiation and prevent it from reaching our skin. They may also contain chemicals that reflect some of the radiation away from the skin.

Manufacturers of sunblocks make products with different sun protection **factors**:

the higher the factor, the longer you can stay out in the sun without burning
high factor sunblocks reduce the risks from ultraviolet radiation more than low factor sunblocks
If, for example, you would get sunburnt after ten minutes in the sun, with Factor 5 applied you could stay in the sun for 50 minutes - or for 1500 minutes with Factor 150 applied. But the real time is usually lower, because some of the sunblock gets absorbed by the skin, and some gets rubbed off.

You could also sit in the shade or cover up.

Communication

Electromagnetic radiation can be used for wireless communications. For example:

- radio waves are used to transmit television and radio programmes
- microwaves are used to transmit mobile phone calls

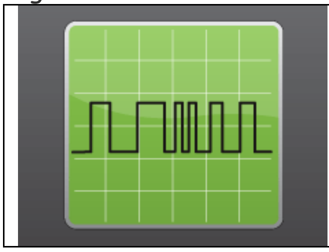
Radio stations with similar transmission frequencies can interfere with each other's signals.

Microwaves are also used to network computers together, especially laptop computers.

Wireless communications can be available all of the time, almost anywhere. They have several advantages over wired communications. These include:

- no wires need to be run through buildings, over ground or underground

- wireless devices can be portable

Analogue		Digital	
	Can **vary** in frequency, amplitude, or both. You may have heard of FM radio and AM radio - Frequency		Series of pulses consisting of just two states: ON (1) or OFF (0). There are no values in between.

Digital radio signals maintain their quality better than analogue signals. They are less prone to interference. All signals become weaker as they travel long distances, and they may also pick up random extra signals. This is called noise, and it is heard as crackles and hiss on radio programmes.

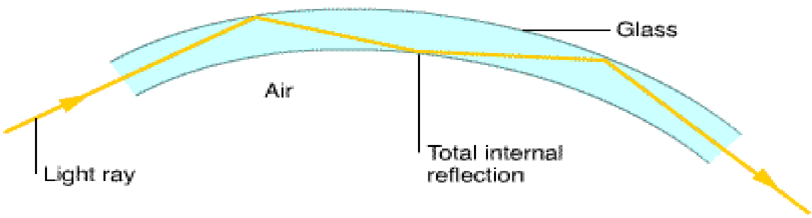
Noise adds extra random information to analogue signals. Each time the signal is amplified, the noise is also amplified. Gradually, the signal becomes less and less like the original signal. Eventually, it may be impossible to make out the music in a radio broadcast against the background noise, for example.

Noise also adds extra random information to digital signals. However, this noise is usually lower in amplitude than the amplitude of the ON states. As a result, the electronics in the amplifiers can ignore the noise, and it does not get passed along.

Reflection

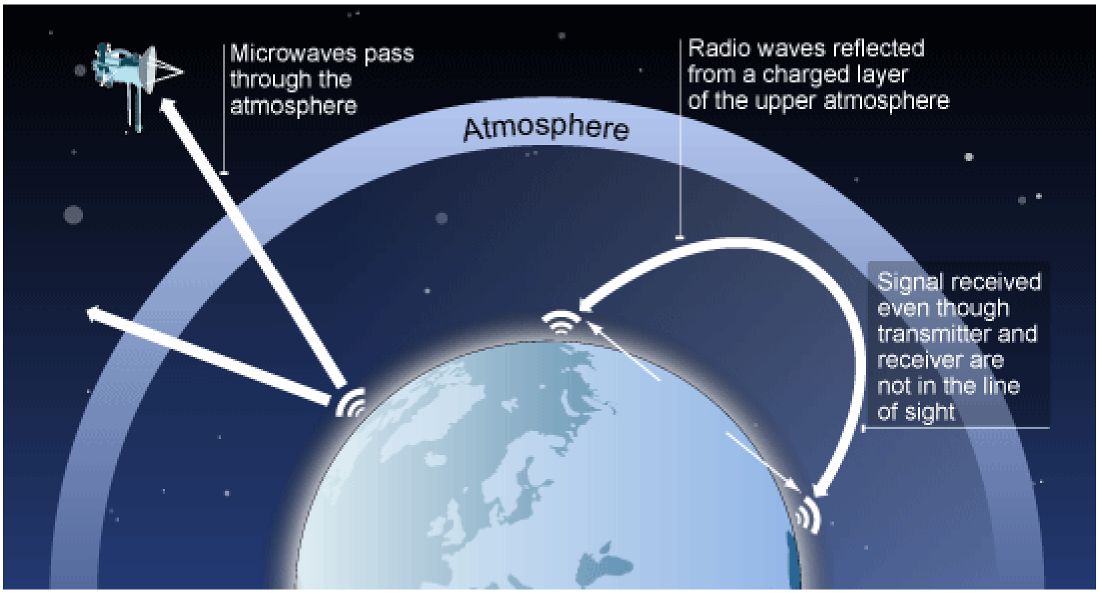
Wireless signals can be reflected off buildings and other large objects. This means that signals may be received even if the receiver is not in direct sight of the transmitter. But it can also cause 'ghosting' on television pictures, for example.

Reflection is also important in wired communications. An optical fibre is a thin rod of high-quality glass that absorbs very little light. Even when the fibre is bent, light getting in at one end undergoes repeated total internal reflection and emerges at the other end.



Refraction

Radio waves are refracted by different layers in the Earth's atmosphere. This leads to a reduction in the signal, making it difficult for them to be received over long distances. Unlike radio waves, microwaves are not refracted, so they are used for satellite communications.



Radio waves and microwaves

A radio receiver does not need to be directly in view of the transmitter to receive programme signals. The lowest frequency radio waves are **reflected** from an electrically charged layer of the upper atmosphere, called the ionosphere. This means they can reach receivers that are not in the line of sight, because of the curvature of the Earth's surface.

Microwaves and radio waves in the atmosphere

Signals are **diffracted** as they leave a transmitter dish. This causes them to spread out. Diffraction can be reduced by using larger dishes.

Photocells

- light) energy / photons absorbed by photocell
- electrons knocked loose from silicon / atoms / particles in photocell
- electrons flow / idea of current if linked to electrons
- Produce DC (direct current) – like a battery

<u>Wind</u>

Advantages	Disadvantages
Renewable, no pollution, no fuel needed.	Kills birds, depends on wind speed, space needed

<u>Power stations</u>

- Fuel (coal, oil or gas) is burnt and the heat energy heats water which produces steam (happened in the **boiler**)
- Steam turns the blades of a **turbine**
- Turns a **generator** and electricity is generated

* Renewable fuel that can be burned in power station - wood

AC (Alternating current) is produced – mains electricity ((constantly) reversing direction / going from positive to negative / flowing to and fro / swapping directions around circuit)

The national grid is system of pylons and cables that take electricity to the consumer. Consumers include – hospitals, schools, homes, shops and businesses.

Step up transformers - high voltage produced / current is reduced - reduces energy loss / waste

Power:	**Energy used:**
Power (W) = voltage x current	Energy used = Power x time Cost (pence) = energy x cost per kWh

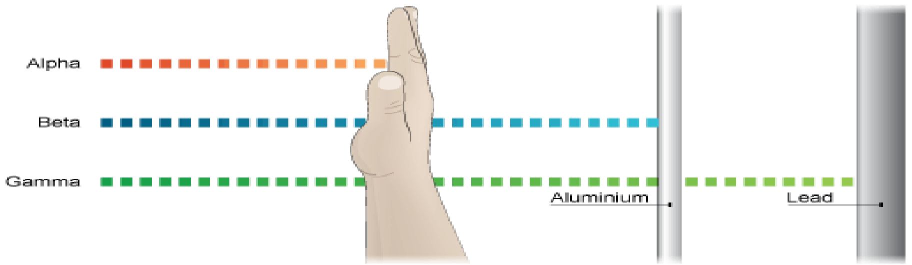
Magnetism

Magnetic field surround the magnet.
The ends are called **the North and South Poles**
A **compass** shows the **direction** of the magnetic field
Earth has a magnetic field due to the **Iron** in the core.

To make **a bigger current** flow through a coil, you could do the following:

- more coils
- stronger magnet
- move the magnet faster

Radiation – alpha, beta and gamma



Dangers of radiation	**Precautions**
- mutations - Cancer	Use tongs, store in a labelled lead lined box, keep exposure time short, arms length

Uses of radiation	**Background radiation**
Alpha – smoke alarms **Beta** – thickness gauges (paper) **Gamma** – treat cancer, sterilise medical equipment	Is radiation that is all around us Sources include: rocks and soil, food and drink, cosmic rays from the sun, industry

Disposal
Diluted in water and dumped at sea, stored in steel drums and buried underground. The problem with burying the waste is that it can get into the water supply, remains radioactive for a long time and remains a terrorist risk. High level waste is encased or reprocessed.

The **Big bang theory** describes how the universe began. The universe started with a big explosion. Universe is expanding.
Stars – started as a cloud of gas
Asteroids – are rocks. Left over when the solar system was formed. When an asteroid hits Earth a crater is formed. Dust is thrown up in the air,
Asteroid belt – is between Mars and Jupiter
Comets – made of ice and dust. Speed increases as they get nearer the sun due to increased gravity.
NEOs – Near Earth Objects e.g. comets and asteroids
Telescope – used to observe NEOs
Moon is the Earths natural satellite. Could have formed when two planets collided.
Artificial satellites – monitor weather, take photographs, spying

Solar system – planets orbiting the sun

My	Mercury
Very	Venus
Easy	Earth
Method	Mars
Just	Jupiter
Speeds	Saturn
Up	Uranus
Naming	Neptune
Planets	(Pluto)

	Advantages	**Disadvantages**
Manned	Can carry out repairs if something goes wrong	Risk – could die. Can't travel to certain areas
Unmanned	No risk, can travel to areas that are too dangerous to humans	Can't carry out repairs.

Red shift

You may have noticed that when an ambulance or police car goes past, its siren is high-pitched as it comes towards you, then becomes low-pitched as it goes away. This effect, where there is a change in frequency and wavelength, is called the Doppler effect. It happens with any wave source that moves relative to an observer.

This happens with light, too, and is called 'red shift'. Our Sun contains helium. We know this because there are black lines in the spectrum of the light from the Sun where helium has absorbed light. These lines form the absorption spectrum for helium.

When we look at the spectrum of a distant star, the absorption spectrum is there, but the pattern of lines has moved towards the red end of the spectrum, as you can see below:

This is called **red shift**. It is a change in frequency of the position of the lines.

Astronomers have found that the further from us a star is, the more its light is red-shifted. This tells us that distant galaxies are moving away from us, and that the further away a galaxy is, the faster it is moving away.

Since we cannot assume that we have a special place in the Universe, this is evidence for a generally expanding universe. It suggests that everything is moving away from everything else. The Big Bang theory says this expansion started 13.6 billion years ago with an explosion. (SEE GCSE BITESIZE)

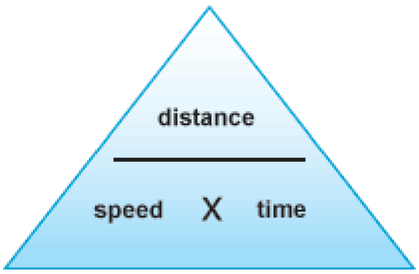
Speed

To measure speed you need a **timer** and a **measuring tape or trundle wheel**

Speed = distance/time

distance = speed x time

time = distance / speed

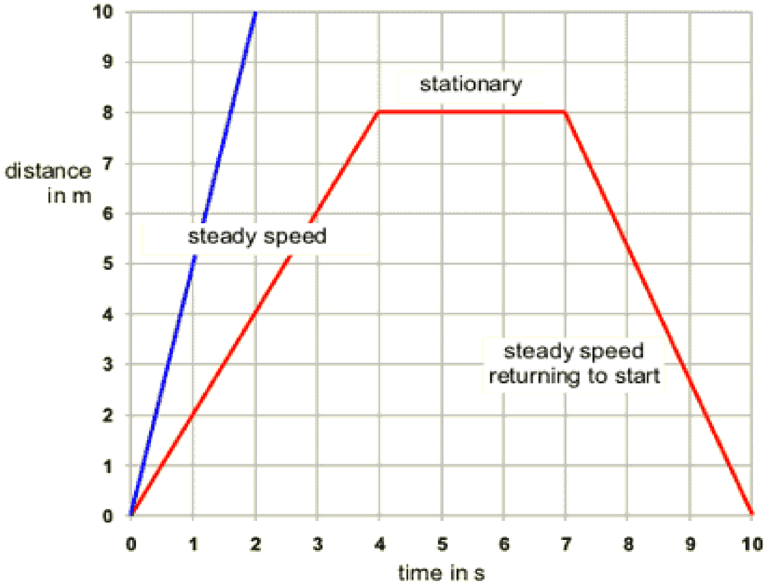


Speed cameras

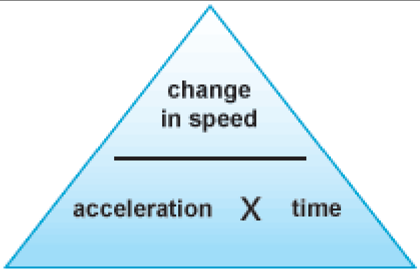
- As a speeding car passes a camera a photograph is taken
- A second photograph is taken 5 seconds later. There are white line on the road at a distance of 1.5m. They show how far the car travels in 0.5 seconds.
- E.g. if a car passes over 6 lines it travels 1.5m x 6 = 9m in 0.5 seconds

  This means the speed of the car was 18 m/s (9m / 0.5 = 18 m/s)

  Speed – distance graph (check **axis** before answering question)



Acceleration

	**Acceleration = change in speed/time taken** **change in speed = acceleration x time taken** **time taken = change in speed / acceleration**

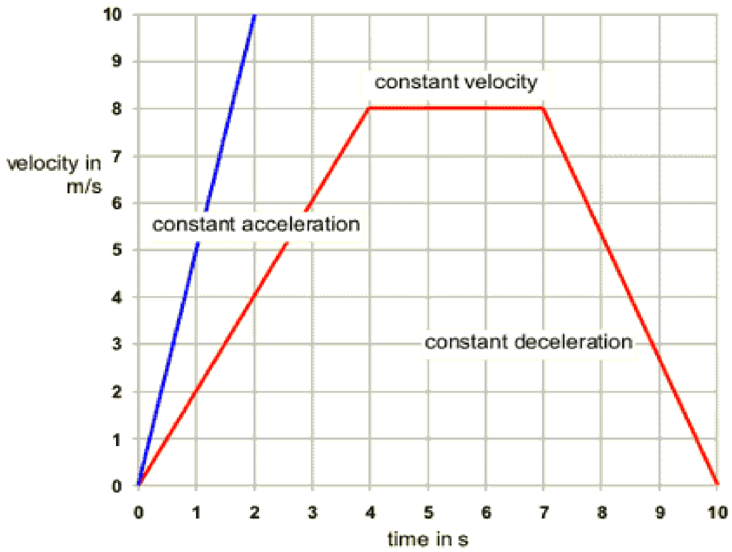
Example

A bus accelerates from 5 m/s to 25 m/s in 10s. To calculate its acceleration, first find the change in speed.

This is 25m/s - 5m/s = 20m/s

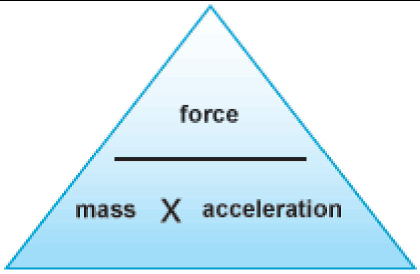
Acceleration = 20m/s ÷ 10s = 2m/s^2

Speed – time graph **(Check the axis before answering the question)**



Remember – the steeper the graph the larger the acceleration

Forces and motion

Force = mass x acceleration N = Kg x m/s^2	

More mass = more acceleration

More force = more acceleration

More Mass needs a large forward force

Forces always occur in **pairs**.

Stopping distance

Stopping distance = Thinking **distance** + braking **distance**

Always leave a space between you and the car in front so that you are not within their stopping distance. You would crash otherwise!

Thinking distance

The **thinking distance** is the distance travelled in between the driver **realising** he needs to brake and actually braking.

It is increased by:

- greater speed
- tiredness
- alcohol and drugs
- distractions

Braking distance

Braking distance - The braking distance is the distance taken to **stop** once the brakes are applied. It is increased by:

- greater speed
- poor road conditions (icy, wet)
- car conditions (bald tyres, poor brakes, full of people)

Calculations

Speed of car m/s	Thinking distance in m	Braking distance in metres
8	6	7
16	12	28
32	24	112

To calculate stopping distance – add the thinking and braking distance together

e.g. for 8 m/s the stopping distance is 13 m (6 +7 = 13)

To calculate **thinking time** for this driver **(refer to speed equation/ triangle)**

Time = distance / speed

Look at thinking distance – 6 / 8 = 0.75 s **or** 12/16 = 0.75 s **or** 24 / 32 = 0.75s

Relationship between speed and braking distance.

This bit always comes up!

As speed or kinetic energy (movement energy) increases the braking distance increases

When speed doubles Kinetic energy quadruples.

Kinetic energy is absorbed when braking – but as your speed doubles the braking distance also quadruples.

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

Car safety

Active car safety features	Passive car safety
- ABS brakes - Traction control - Safety cage	- electric windows - cruise control - paddle shift controls (on the steering wheel) - adjustable seating

Moving cars have kinetic energy. As energy cannot be created or destroyed, when a car **brakes** its kinetic energy changes into heat energy. The brakes heat up and then transfer the energy to the surroundings. Modern cars also have **safety features** that absorb kinetic energy in **collisions**. These typically include:

- seat belts
- air bags
- crumple zones

All these features reduce injuries to the people in the car by absorbing energy when they change shape.

As they **deform** they increase the amount of **time** the person takes to come to a stop. This reduces the **acceleration and force** on the person, so reducing injury.

<u>Ie:</u> they change shape, absorb energy, increase stopping time / collision time, increased stopping distance / increased collision distance

e.g. Drivers energy is **<u>absorbed</u>** by the airbag, collision time is **<u>increased</u>**, stopping distance is **<u>increased</u>**, acceleration time is **<u>reduced.</u>**

<u>Seatbelts</u>

Seatbelts must be replaced after an accident in case they have been damaged or stretched (length increases)

Seatbelts absorb energy.

<u>Electric cars</u>

Most cars use **fossil fuels** such as petrol or diesel as an **energy source**. These are **non-renewable** and so will run out in the future.

Unlike cars powered by fossil fuels, battery-driven cars don't have an exhaust pipe and so **<u>don't pollute the air around them.</u>**

They do, however have to be **recharged** using electricity generated at a **power station**. <u>This means it causes pollution at the power station.</u>

<u>Fuel consumption</u>

Car	Miles per gallon
Renault Megane	32
Land Rover	24

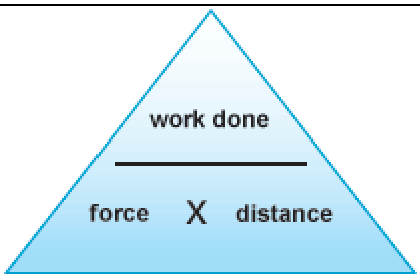
To calculate how far a car will travel e.g. how far will the land rover travel on 2 gallons:

24 x 2 =24 miles

However, most drivers will not get the full miles per gallon e.g. land Rover will rarely travel 24 miles per gallon due to driving at different speeds, different driving styles, different road conditions, different loads, different use of heater / radio / air conditioning.

<u>Work and power</u>

<u>Work</u>



Work = Force x distance

Distance = work / force

Force = Work / distance

Remember – if the object is not moving then no work is done!

Power

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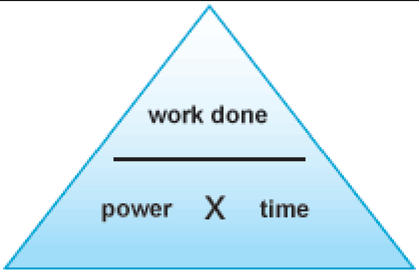
<td>
</td>
<td>Power = Work done / time

work done = power x time taken

time taken = work done / power</td>
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Gravitational potential energy (GPE)

On Earth we always have the force of **gravity** acting on us. When we're above the Earth's surface we have **potential** (stored) energy. This is called **gravitational potential energy**. The amount of gravitational potential energy an object on Earth has depends on its:

- mass
- height above the ground

GPE = m x g x h

The higher the object the more gravitational potential energy it has. As it falls it loses gravitational potential energy.

GPE and KE

A rollercoaster car converts GPE to KE when it rolls down the track

When an object falls it converts **gravitational potential energy** (GPE) to **kinetic energy** (KE). This is what happens when a...

- book falls off a shelf
- rollercoaster rolls down the track
- skydiver jumps out of a plane

Parachute

Before the parachute opens

1. When the skydiver jumps out of the plane he **accelerates** due to the force of **gravity** pulling him down.

2. As he speeds up the upwards **air resistance** force increases. He carries on accelerating as long as the air resistance is less than his **weight**.

3. Eventually, he reaches his **terminal speed** when the air resistance and weight become **equal**. They're said to be **balanced**.

After the parachute opens

4. When the canopy opens it has a large **surface area** which increases the **air resistance.** This **unbalances** the forces and causes the parachutist to **slow down**.

5. As the parachutist slows down, his air resistance gets **less** until eventually it **equals** the downward force of gravity on him (his weight). Once again the two forces **balance** and he falls at **terminal speed**. This time it's a much **slower** terminal speed than before.

Note: terminal speed weight = drag/ forces are balanced. The kinetic energy remains constant.

Streamline

The classic shuttlecock/ tennis ball question.

The shuttle cock slows down quicker than the tennis ball as there is more air resistance.

The forces on the shuttlecock reach terminal speed because the drag/air resistance and weight are balanced.

Cutting the feathers on the shuttlecock increases terminal speed as there is less air resistance.

<u>Static electricity</u> - There are two charges positive protons and negative electrons. - When an object is rubbed (friction) the **negative electrons** move (The way to remember it is – in a classroom the negative (naughtiest) child moves. - **Like** charges **repel, opposites attract**	**Safety measures** In a factory, machinery operators stand on insulating mats or wear shoes with insulating soles. This stops any charge flowing through them to the Earth. Lorries containing inflammable gases, liquids and powders are connected to the Earth by an earth wire before being unloaded. This means charge immediately flows down the earth wire preventing a spark causing an explosion.

Static electricity is a **nuisance** when: - Attracting dust - Shocks from door handles - Makes clothing cling Anti-static sprays, liquids and cloths prevent the build up of charge by allowing it to conduct away	Static electricity is **dangerous** when: - Charge can build up on clothes – dangerous if there is a **spark near inflammable gases or fuel fumes.** - Grain chutes, paper rollers, fuel filling – needs earthing.

<u>Uses of static electricity:</u>

- **<u>Paint spraying</u>** – the paint is charged (-) and the car is given the opposite charge (+). Paint is then attracted to the car.
- **<u>Dust precipitators</u>** – remove particles from smoke. As the smoke rises they meet a wire a grid with a negative charge – the smoke is given a negative charge. As it rises further up the chimney, it is attracted to positively charged metal plates. This causes the smoke particles to stick together. When heavy enough the lumps fall off or are knocked off.

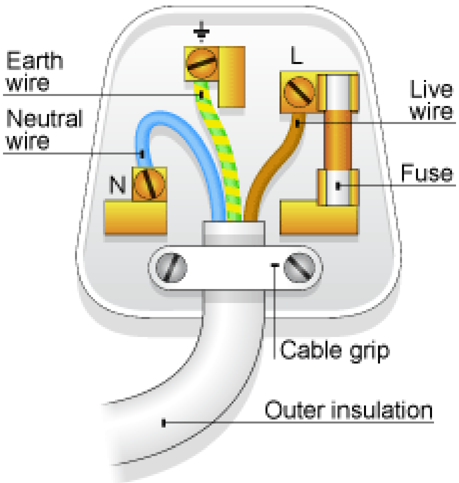
- **Defibrillators**- restarts the heart. Operators stand back so they don't get a shock. The handles are insulated so only the patient gets the shock.

Resistance – anything in the circuit that slows the flow of current down.

Resistance (Ohms) = Potential difference(v) / Current (amps)

Note: you won't need to remember the equation, just use it,

Plugs



Wire	Colour	Job
Neutral	Blue	Carries voltage to the house
Earth	Green and yellow	Safety wire – normally current flows through it.
Live	Brown	Provides a return path to the sub-station

Appliances such as hairdryers are said to be 'double insulated' and there's no need for an earth wire because the case is made of a non conducting plastic. If a faulty live wire touches the inside of the plastic case there's little risk as the case is an **insulator**.

Fuses – safety device.

The fuse contains a thin piece of wire – if the current is too high the wire gets hot, melts and breaks. This then breaks the circuit.

Ultrasound

- sound with too high a frequency for humans to hear

Longitudinal waves

All sound is produced by vibrating particles that form **longitudinal waves**. In this kind of wave the vibrations of the particles are in the **same direction** as the wave.

Uses

- monitoring the foetus (reflects/echoes from layers / tissues / baby, time taken for wave to return varies and is measured, time taken indicates depth /different parts of the baby
- breaking down kidney stones
- investigate heart and liver problems

Advantage

- does not damage living cells

Alpha radiation - used in smoke alarms

Uses of Gamma radiation

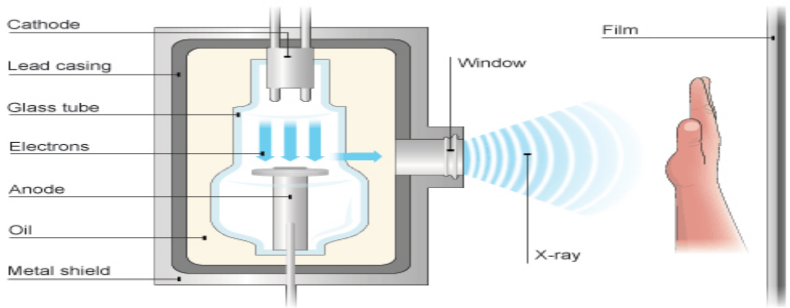
- sterilising medical equipment
- treating cancer
- tracer (alpha is not used as it would not pass through the skin)

RADIOGRAPHER

- person who carries out procedures using x-rays and nuclear radiation

X-rays

X-rays are manufactured by an X-ray machine. A hot cathode emits electrons that are attracted to a tungsten anode. When the fast-moving electrons hit the target, most of their kinetic energy is transferred to heat but some is transferred to X-rays.



This machine allows the energy and intensity of the X-rays to be controlled. Gamma rays, on the other hand, are given out by the nucleus of an unstable atom. This process is totally random and so cannot be **controlled** as easily as X-rays.

X-rays are some times better to use than gamma radiation as it can be controlled and easier to focus on the cancer.

When treated for cancer using gamma radiation the gun is moved around the person's head to reduce the damage caused to healthy tissue.

Radiation	Description
Alpha	Helium nuclei
Beta	Electron
Gamma	Wave

Decay

It is the **NUCLEUS** that decays (as in **NUCLEAR** radiation). It decays because it is unstable.

The nucleus of an atom can be represented as:

$${}^{A}_{Z}X$$

Where:

A = atomic mass (number of protons + neutrons)

Z = atomic number (number of protons)

X = chemical symbol (as shown on the Periodic Table)

Fission

- URANIUM is the fuel used in a nuclear power station

Power station

- The fission (splitting of a large nucleus) of uranium in a nuclear reactor produces heat.
- The heat is used to boil water to produce steam
- The pressure of the steam acts on the turbine blades which turn
- Rotating blades turns the generator to produce electricity.

Control rods are also lowered into the core. These absorb neutrons and control the rate of the **chain reaction**. They are raised to speed it up, or lowered to slow it down

Chain reaction

- is a reaction that goes further and faster
- A nuclear bomb is a chain reaction that has gone out of control

Artificial radioactivity

- materials can be made radioactive by putting them in a reactor. This is because they absorb neutrons.

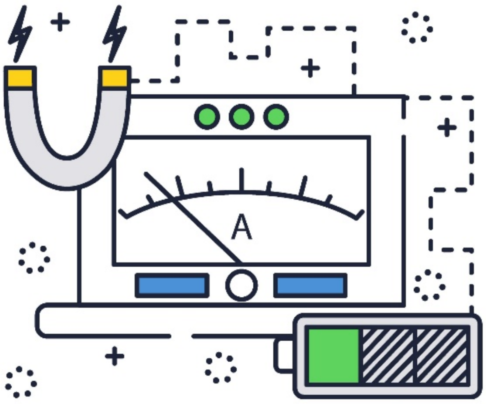
Radioactive waste

- **Low level** waste can be buried or imbedded in glass and buried in the sea
- **High level** – can be reprocessed to make radioactive materials for reuse

Nitrogen cycle

Denitrifying bacteria	Convert nitrogen compounds/ nitrates/ ammonium compounds in nitrogen gas
Nitrifying Bacteria	Converts nitrogen compounds/ammonia/ nitrites into nitrates
Nitrogen fixing bacteria	Converts nitrogen (gas) or atmospheric nitrogen

Adept
Tuition



PHYSICS

PHYSICS ULTIMATE GUIDE

FOUNDATION

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Contents

When objects/food cools down the heat is transferred to the surroundings. If the object is cold they gain heat from their surroundings. Thermograms are images that show hotter and cooler areas.

How a radiator warms the room – the radiator has hot water inside. Heat transfers to the outside surface by the process of **conduction (through solids)**. Air touching the radiator warms up and spreads around the room by **convection (heat transfer in liquids and gases)**. This is because the **air expands** and becomes **less dense**, **rises** and is replaced by **cold air**.

Heat is lost through:

the roof - fit loft insulation
windows - fit double glazing and curtains
gaps around the door - fit draught excluders
the walls - fit cavity wall insulation
the floor - fit a carpet
Heat loss through windows can be reduced using double glazing. There may be air or a *vacuum* between the two panes of glass. Air is a poor conductor of heat, while a vacuum can only transfer heat energy by radiation.

Heat loss through walls can be reduced using cavity wall insulation. This involves blowing insulating material into the gap between the brick and the inside wall, which reduces the heat loss by conduction. The material also prevents air circulating inside the cavity, therefore reducing heat loss by convection.

Heat loss through the roof can be reduced by laying loft insulation. This works in a similar way to cavity wall insulation. **Remember: all these methods rely on air being a poor conductor of heat!!**

You can also put foil behind radiators – this reflects heat/radiation back into the room.

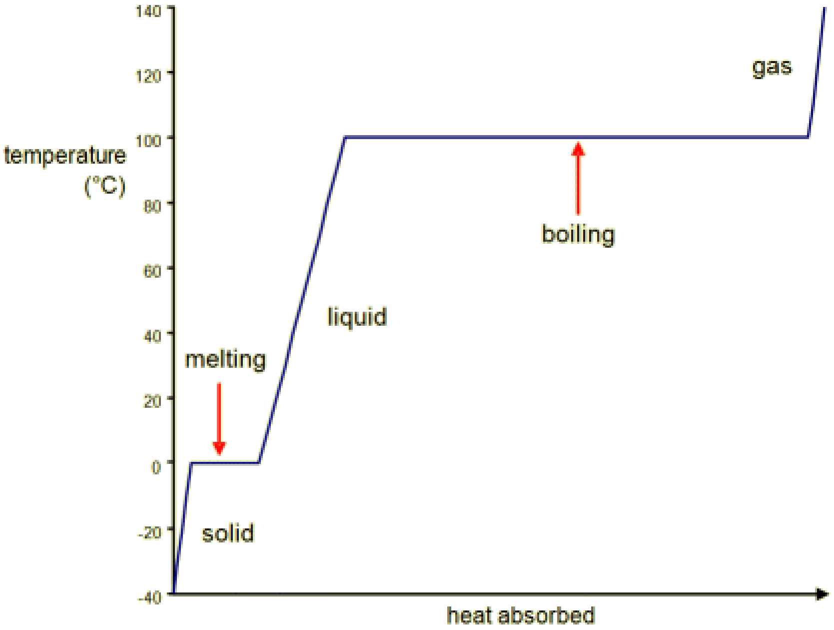
Specific heat capacity

The **specific heat capacity** of a substance is a measure of how much heat energy it can hold. It is the energy needed to increase the temperature of 1 kg of the substance by 1 °C. Different substances have different specific heat capacities. Water has a particularly high specific heat capacity. This makes water useful for storing heat energy, and for transporting it around the home using central heating pipes.

energy (J) = mass (kg) × specific heat capacity (J/kg/°C) × temperature change (°C)

Changing state

A substance must absorb heat energy so that it can melt or boil. The temperature of the substance does not change during melting, boiling or freezing, even though energy is still being transferred.



A heating curve for ice

The **specific latent heat** of a substance is a measure of how much heat energy is needed to melt or boil it. It is the energy needed to melt or boil 1 kg of the substance.

The efficiency of a device such as a lamp can be calculated using this equation:

efficiency = (useful energy transferred ÷ energy supplied) × 100

The efficiency of the filament lamp is (10 ÷ 100) × 100 = 10%.

This means that 10% of the electrical energy supplied is transferred as light energy (90% is transferred as heat energy).

The efficiency of the energy-saving lamp is (75 ÷ 100) × 100 = 75%. This means that 75% of the electrical energy supplied is transferred as light energy (25% is transferred as heat energy).

The main types of electromagnetic radiation and their typical use

frequency	type of electromagnetic radiation	typical use	wavelength
highest	gamma radiation	killing cancer cells	shortest
	x-rays	medical images of bones	
	ultraviolet radiation	sunbeds	
	visible light	seeing	
	infrared radiation	optical fibre communication	
	microwaves	cooking	
lowest	radio waves	television signals	longest

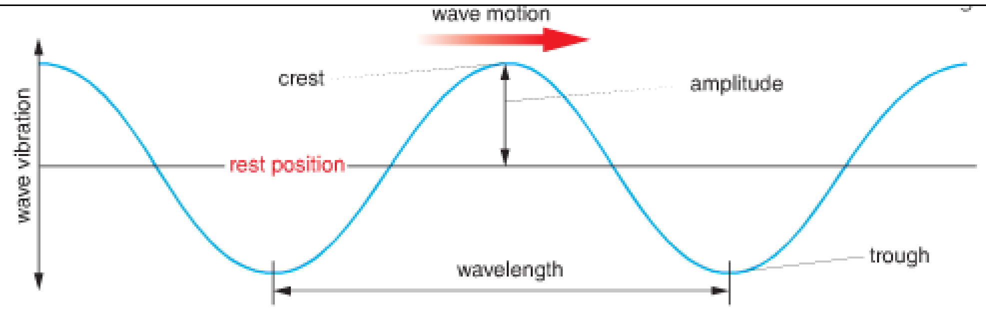
Infrared radiation

Some surfaces are better than others at absorbing and reflecting infrared radiation:

black surfaces are good absorbers

shiny surfaces are good reflectors

When an object absorbs infrared radiation, its temperature increases. Food, for instance, begins to cook when its surface absorbs infrared radiation.



Wave speed = frequency x wavelength

Cooking

In each case, the **kinetic energy** of particles is increased when the radiation is absorbed:

infrared radiation is absorbed by all particles on the surface. This increases the kinetic energy of the particles. The energy is then transferred to the rest of the food by conduction.

microwave radiation is absorbed by water particles, both on the **surface** and up to about 1cm deep into the food. This gives the particles kinetic energy and they vibrate more. Heat is then transferred by conduction.

Microwave design – the walls are metal and the door is made of a special glass that has a metal mesh to reflect the microwave radiation. Food can be put in a glass bowl when cooking as the microwaves can pass through to the food.

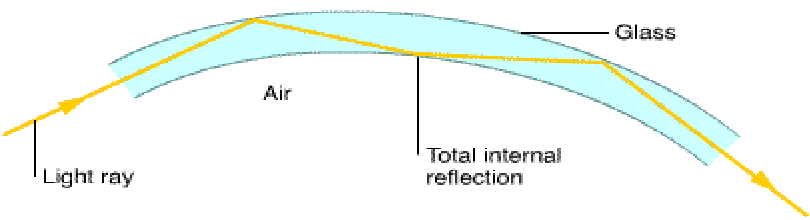
Lasers

Used for communication, dental treatment, surgery and bar code readers.

Morse code

Messages consisting of dots and dashes.

Total internal reflection - all light is reflected.



Communication

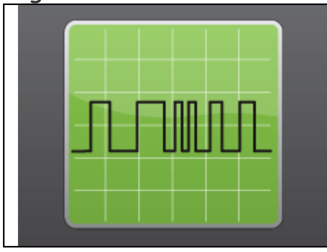
Wireless communications can be available all of the time, almost anywhere. They have several advantages over wired communications. These include:

- no wires need to be run through buildings, over ground or underground
- wireless devices can be portable

Analogue

Can **vary** in frequency, amplitude, or both. You may have heard of FM radio and AM radio - Frequency

Digital



Series of pulses consisting of just two states: ON (1) or OFF (0). There are no values in between.

Earthquakes can be detected with a **seismometer.**

Feature of a wave	**P-waves**	**S-waves**
Speed	Faster	Slower
Travel through	Solids and liquids	Solids
Type	Transverse	Longitudinal

Ozone layer

Absorbs ultraviolet radiation, preventing most of it reaching the ground. This is important because UV radiation can lead to skin cancer. Chlorofluorocarbons, or CFCs, are chemicals that were once used in aerosol spray cans. These break down ozone and damage the ozone layer. CFCs have now been almost completely replaced by chemicals that do not destroy ozone.

Ultraviolet radiation

Ultraviolet radiation is found naturally in sunlight. Exposure to ultraviolet radiation can cause: our skin to tan, sunburn and skin cancer. We cannot see or feel ultraviolet radiation, but our skin responds to it by turning darker. This happens in an attempt to reduce the amount of ultraviolet radiation that reaches deeper skin tissues. Inside the skin there are cells that produce melanin – this causes the skin to tan.

Darker skins absorb more ultraviolet light, so less ultraviolet radiation reaches the deeper tissues. This is important because ultraviolet radiation can cause normal cells to become cancerous.

Sunblocks

Sunblocks can reduce the damage caused by ultraviolet radiation. They contain chemicals that absorb a lot of the radiation and prevent it from reaching our skin. They may also contain chemicals that reflect some of the radiation away from the skin.

Manufacturers of sunblocks make products with different sun protection **factors**:

the higher the factor, the longer you can stay out in the sun without burning
high factor sunblocks reduce the risks from ultraviolet radiation more than low factor sunblocks
If, for example, you would get sunburnt after ten minutes in the sun, with Factor 5 applied you could stay in the sun for 50 minutes - or for 1500 minutes with Factor 150 applied. But the real time is usually lower, because some of the sunblock gets absorbed by the skin, and some gets rubbed off.

You could also sit in the shade or cover up.

Photocells

- convert light energy into electrical energy.
- Produce **DC (direct current)** – like a battery

Advantage of solar	Disadvantages of solar
No wires, can be used in remote areas, reduces your bills	No sun, no energy!

WIND – blades turn due to **convection currents**. Wind has kinetic energy which it transfers to electrical energy.

Power stations

- Fuel (coal, oil or gas) is burnt and the heat energy heats water which produces steam (happened in the **boiler**)
- Steam turns the blades of a **turbine**
- Turns a **generator** and electricity is generated

Transformers- step up transformer increases voltage, a step down transformer decreases voltage.

* Renewable fuel that can be burned in power station - wood

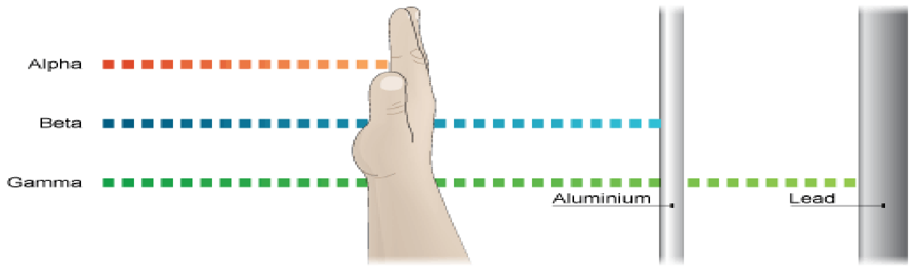
AC (Alternating current) is produced – mains electricity

The **national grid** is system of **pylons and cables** that take electricity to the consumer. **Consumers** include – hospitals, schools, homes, shops and businesses.

Power:	**Energy used:**
Power (W) = voltage x current	Energy used = Power x time Cost (pence) = energy x cost per kWh

Global warming – caused by carbon dioxide.
However, dust and smoke from factories reflect radiation from the town back to Earth - temperature rises.
Ash from volcanoes reflects radiation from the sun back to space. The temperature falls as a result.

Radiation – alpha, beta and gamma



Dangers of radiation	Precautions
- mutations - Cancer	Use tongs, store in a labelled lead lined box, keep exposure time short, arms length
Uses of radiation **Alpha** – smoke alarms **Beta** – thickness gauges (paper) **Gamma** – treat cancer, sterilise	**Disposal** - Diluted in water and dumped at sea, stored in steel drums and buried underground. Fuel rods in a nuclear power station release energy in the form of heat and produce

medical equipment	plutonium. Plutonium can be used to make nuclear weapons.

The **Big bang theory** describes how the universe began. The universe started with a big explosion. Universe is expanding.
Stars – started as a cloud of gas
Asteroids – are rocks. Left over when the solar system was formed.
When an asteroid hits Earth a crater is formed. Dust is thrown up in the air,
Asteroid belt – is between Mars and Jupiter
Comets – made of ice and dust.
NEOs – Near Earth Objects e.g. comets and asteroids
Telescope – used to observe NEOs
Moon is the Earths natural satellite. Could have formed when two planets collided.
Artificial satellites – monitor weather, take photographs, spying

Solar system – planets orbiting the sun

My	Mercury
Very	Venus
Easy	Earth
Method	Mars
Just	Jupiter
Speeds	Saturn
Up	Uranus
Naming	Neptune
Planets	(Pluto)

	Advantages	**Disadvantages**
Manned	Can carry out repairs if something goes wrong	Risk – could die. Can't travel to certain areas
Unmanned	No risk, can travel to areas that are too dangerous to humans	Can't carry out repairs.

Astronauts need food, water and oxygen.

Speed, distance and time

The speed of an object tells you how **fast** or **slow** it's moving.

Calculating speed

To work out speed the following two things must be known:

- The **distance** travelled (use a trundle wheel)
- The **time taken** to travel that distance (use a timer)

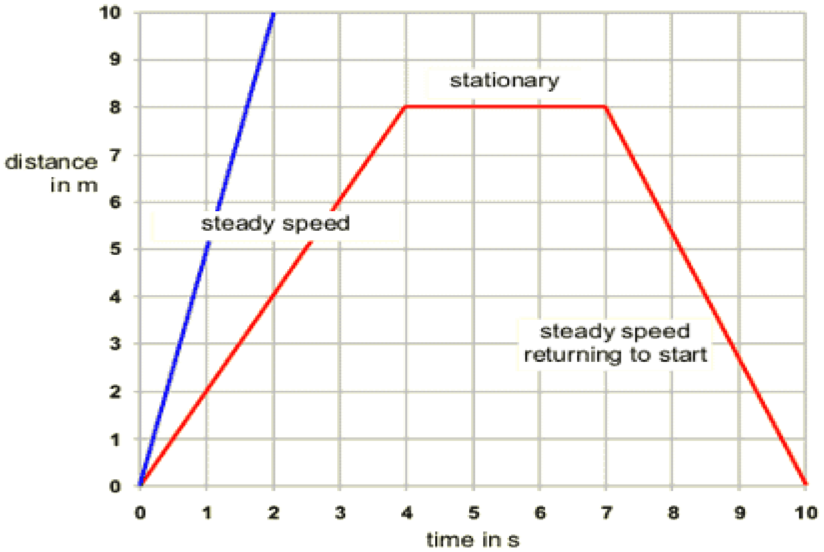
Equation

This equation shows the relationship between speed, distance and time.

speed (metres per second, m/s) = distance (metre, m) / time (seconds, s)

Distance-time graphs

Distance-time graphs are a useful way of describing the motion of an object. They show how the distance moved from a starting point **changes** over time.



Changing speed

Acceleration is the rate at which an object changes its speed. It's calculated using the equation: acceleration = change in speed / time taken.

Speed-time graphs illustrate how the speed of an object changes over time. The steeper the gradient of the line, the greater the acceleration.

Acceleration

In everyday language we use 'accelerate' to mean speeding up and 'decelerate' to mean slowing down. In scientific terms 'acceleration' is the rate at which something **changes** its speed - faster or slower.

Acceleration depends on two things:

- How much the **speed** changes

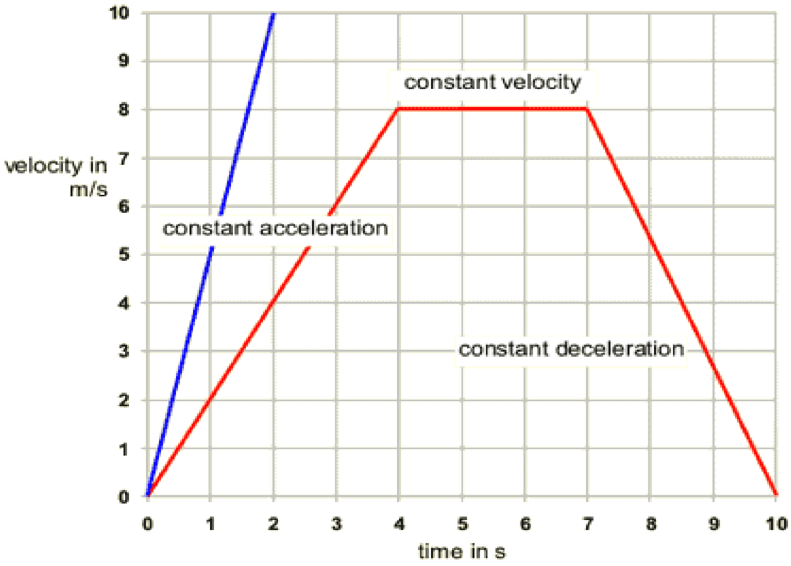
- How much **time** the change in speed takes

Calculating acceleration

acceleration = change in speed / time taken

Speed-time graphs

A speed-time graph tells us how the **speed** of an object **changes** over **time**.



Work and power (ALWAYS COMES UP)

Whenever 'work' is done energy is transferred from one place to another. If an object does not move, then no work is done. **Work is done whenever a force moves something.** The amount of work done is expressed in the equation: work done = force x distance. The unit for work is joules. The amount of work done depends on:

- the size of the **force** on the object
- the **distance** the object moves

Power is a measure of how quickly work is being done. Power is expressed in the equation:

power = work done / time taken.

Energy on the move

The amount of **'kinetic energy'** that all moving objects have depends on their **speed and mass**. When a car brakes the kinetic energy is changed into heat energy.

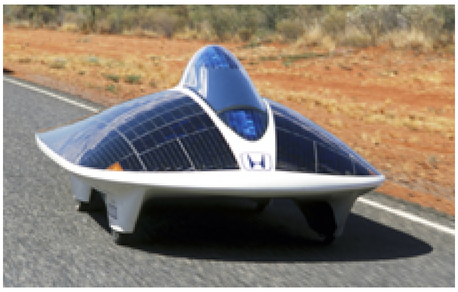
Kinetic energy and braking distance

When a car **brakes**, its kinetic energy is changed into **heat energy**.

Work done by brakes = loss in kinetic energy

If the speed of the car **doubles**, the kinetic energy and braking distance **quadruple**.

Fuels for transport



A solar-powered car

Most cars use **fossil fuels** such as petrol or diesel as an **energy source**. These are **non-renewable** and so will run out in the future.

However, electricity can be used for example in battery-driven or solar-powered cars.

Electric vehicles

- don't pollute the air around them.

- They do, however have to be **recharged** using electricity generated at a **power station**. This means it causes pollution at the power station.

Thinking, braking and stopping distance (ALWAYS COMES UP – MAKE SURE YOU KNOW THE DEFINITION OF THINKING DISTANCE, BRAKING DISTANCE AND STOPPING DISTANCE. Also what affects them)

stopping distance = thinking distance + braking distance

The stopping distance depends on two factors:

- **Thinking distance** - The **thinking distance** is the **distance** travelled in between the driver **realising** he needs to brake and actually braking.

Thinking distance can be increased by:

- greater speed
- tiredness
- alcohol and drugs
- distractions

- **Braking distance** - The braking distance is the **distance** taken to **stop** once the brakes are applied.

Braking distance can be increased by:

- greater speed
- poor road conditions (icy, wet)
- car conditions (bald tyres, poor brakes, full of people)

The stopping distance is much **further** for **faster** speeds, which is why you should:

- Keep your **distance** from the car in front, especially if the road conditions are poor.
- Keep to the speed limit.

Crumple zones

Moving cars have kinetic energy, which is changed into heat energy when they brake. Safety features in modern cars, such as seat belts and crumple zones, are designed to absorb kinetic energy in a crash.

Car safety features

Moving cars have kinetic energy. As energy cannot be created or destroyed, when a car **brakes** its kinetic energy changes into heat energy. The brakes heat up and then transfer the energy to the surroundings. Modern cars also have **safety features** that absorb kinetic energy in **collisions**. These typically include:

- seat belts
- air bags
- crumple zones

All these features reduce injuries to the people in the car by absorbing energy when they change shape.

REMEMBER: Seat belts have to be replaced after a crash because the large forces may damage them (stretched or torn)

Active safety features

These are designed to help you survive a crash with as little injury as possible. They include:

- **Anti-lock braking system (ABS)** – prevents skidding allowing the driver to remain in control. The vehicle stops more quickly as there's more friction between the road and tyres.
- **Traction control** - prevents skidding while accelerating so the car can quickly escape a dangerous situation.
- **Safety cage** – strengthens the cabin section to protect people in a roll-over accident.

Passive safety features

These are designed to help prevent accidents by reducing distractions while driving. They include:

- **Electric windows** – make it easier to open and close windows
- **Cruise control** – helps reduce accidental speeding
- **Paddle shift controls** – allows the driver to keep both hands on the steering wheel while changing gear or radio stations
- **Adjustable seats** – makes the driver more comfortable

Falling objects

When an object is dropped it gets faster and faster as it falls. This happens because their weight (the force of gravity) pulls them down towards the centre of the Earth.

As they fall through the air, they also experience an upward force called air resistance (drag).

Objects with large surface areas, such as parachutes or shuttlecocks fall more slowly because they experience more air resistance.

Frictional forces such as air resistance, friction and drag act **against** the direction of motion, so tend to **slow** the object down.

The size of frictional forces can be reduced by **streamlining** the object or lubricating any moving parts.

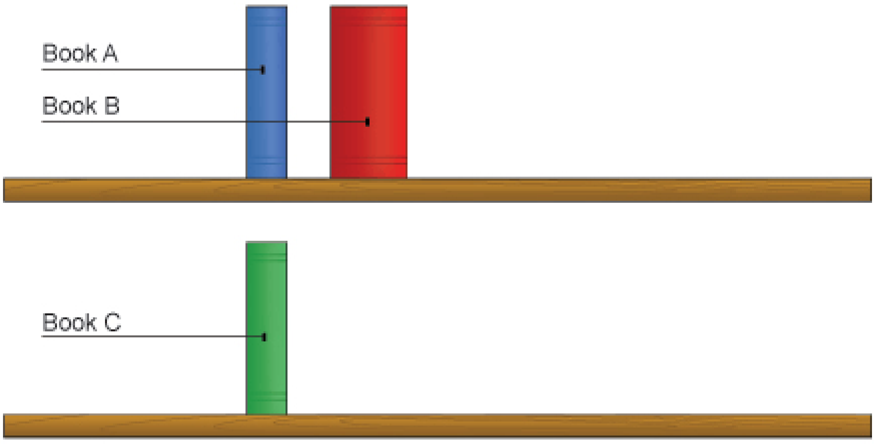
Terminal speed

When objects fall through the Earth's atmosphere they get faster and faster until they reach a speed where the upwards force (air resistance) and downwards force (weight) **equal** each other. At this point the object travels at its fastest speed called **terminal speed**.

Gravitational potential energy (GPE)

On Earth we always have the force of **gravity** acting on us. When we're above the Earth's surface we have **potential** (stored) energy. This is called **gravitational potential energy**. The amount of gravitational potential energy an object on Earth has depends on its:

- mass
- height above the ground



Books on a shelf have gravitational potential energy.

Book A has more than book C as it's **higher**.

Book B has more than book A because it has a greater **mass**.

GPE and KE

A rollercoaster car converts GPE to KE when it rolls down the track

When an object falls it converts **gravitational potential energy** (GPE) to **kinetic energy** (KE). This is what happens when a...

- book falls off a shelf
- rollercoaster rolls down the track
- skydiver jumps out of a plane

Remember objects that **are high up have more gravitational potential energy**. If objects move **higher they gain more gravitational potential energy**. When they **fall** they **lose gravitational potential energy.**

Objects that are **moving** have **Kinetic energy.**

Static electricity	Safety measures
- There are two charges positive protons and negative electrons. - When an object (insulators) are rubbed (friction) the **negative electrons** move (The way to remember it is – in a classroom the negative (naughtiest) child moves. - **Like** charges **repel, opposites attract**	In a factory, machinery operators stand on insulating mats or wear shoes with insulating soles. This stops any charge flowing through them to the Earth. Lorries containing inflammable gases, liquids and powders are connected to the Earth by an earth wire before being unloaded. This means charge immediately flows down the earth wire preventing a spark causing an explosion.

Static electricity is a **nuisance** when:	Static electricity is **dangerous** when:
- Attracting dust - Shocks from door handles - Makes clothing cling Anti-static sprays, liquids and cloths prevent the build up of charge by allowing it to conduct away	- Charge can build up on clothes – dangerous if there is a **spark near inflammable gases or fuel fumes.** - Grain chutes, paper rollers, fuel filling – needs Earthing.

Uses of static electricity:

- **Paint spraying** – the paint is charged (-) and the car is given the opposite charge (+). Paint is then attracted to the car. Even coverage and paint is not wasted
- **Dust precipitators** – remove particles from smoke. As the smoke rises they meet a wire a grid with a negative charge – the smoke is given a negative charge. As it rises further up the chimney, it is attracted to positively charged metal plates. This causes the smoke particles to stick together. When heavy enough the lumps fall off or are knocked off.
- **Defibrillators**- restarts the heart. Operators stand back so they don't get a shock. The handles are insulated so only the patient gets the shock.

Resistance – anything in the circuit that slows the flow of current down.

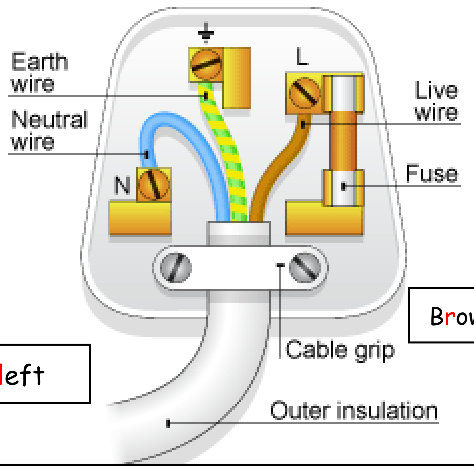
$$\text{Resistance (Ohms)} = \frac{\text{Potential difference(v)}}{\text{Current (amps)}}$$

Note: you won't need to remember the equation, just use it,

Plugs

Striped - top

Wire	Colour	Job
Neutral	Blue	Carries voltage to the house
Earth	Green and yellow	Safety wire – normally current flows through it.
Live	Brown	Provides a return path to the sub-station



Blue - left

Brown - right

Appliances such as hairdryers are said to be 'double insulated' and there's no need for an Earth wire because the case is made of a non conducting plastic. If a faulty live wire touches the inside of the plastic case there's little risk as the case is an **insulator**.

Wires – clockwise from left: Neutral, Earth, Live
Never Eat Liver

Fuses – safety device.
The fuse contains a thin piece of wire – if the current is too high the wire gets hot, melts and breaks. This then breaks the circuit.

Ultrasound

- sound with too high a frequency for humans to hear

Longitudinal waves

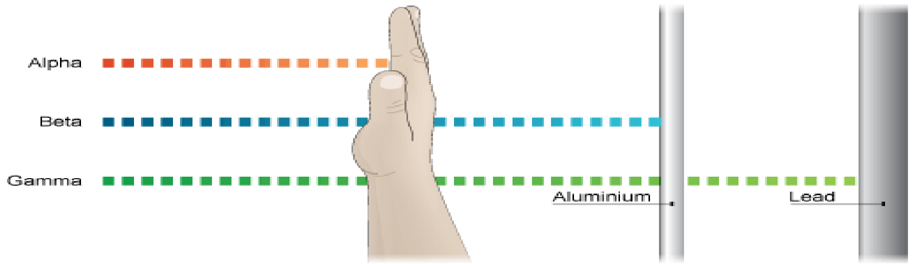
Uses

- monitoring the foetus
- breaking down kidney stones
- investigate heart and liver problems

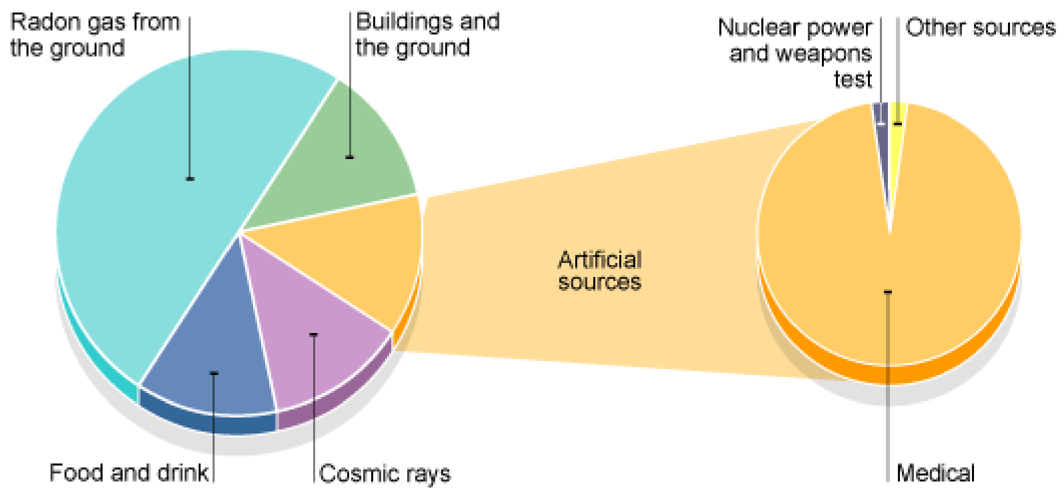
Advantage

- does not damage living cells

Nuclear Radiation – from the nucleus of the atom.



Background radiation – radiation that is all around us



Average contribution of different sources to natural background radiation

Alpha radiation - used in smoke alarms

Uses of Gamma radiation

- sterilising medical equipment
- treating cancer
- tracer (alpha is not used as it would not pass through the skin)

RADIOGRAPHER

- person who carries out procedures using x-rays and nuclear radiation

Radiation	Description
Alpha	Helium nuclei
Beta	Electron
Gamma	Wave

Decay

It is the **NUCLEUS** that decays (as in **NUCLEAR** radiation). It decays because it is unstable.

Fission

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Power station

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Chain reaction

- is a reaction that goes further and faster
- A nuclear bomb is a chain reaction that has gone out of control

Artificial radioactivity

- materials can be made radioactive by putting them in a reactor. This is because they absorb neutrons.

Radioactive waste

- **Low level** waste can be buried or imbedded in glass and buried in the sea
- **High level** – can be reprocessed to make radioactive materials for reuse