Conduction and Convection

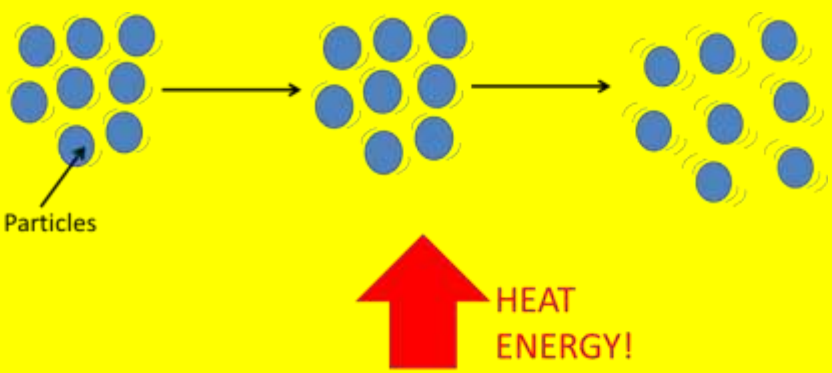
Convection Currents

Definition

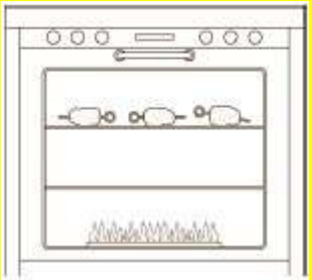
Convection is the transfer of heat in liquids and gases.

The hotter the liquid/gas the particles move faster and spread out. This means the gas/liquid becomes less dense.

The less dense gas/liquid rises and the more dense gas/liquid sinks.



Because the particles have to rise and fall for convection to occur it can only happen in liquids and gases, where the particles are free to move.



Model Question (3)

Explain how heat is transferred by the process of convection from the gas flame at the bottom of the oven to the potatoes at the top of the oven.

Model Answer

The air particles are heated by the gas flame and gain energy. This causes the particles to move faster and spread out. Because the particles are spread out the hot air becomes less dense and rises.

Real world Examples

A lava lamp – The light bulb heats the wax causing it heat up and rise. The wax cools at the top and sinks again.

Conduction and Convection

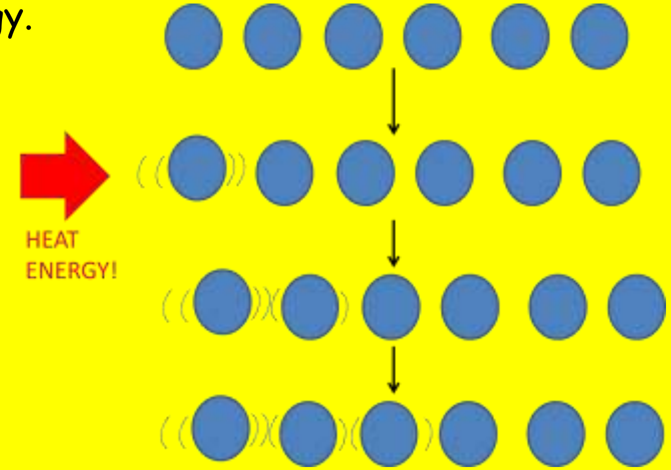
Conduction

Definition

Conduction is how heat energy is transferred through solids when they are heated. Heat energy can also be passed from one solid to another by conduction.

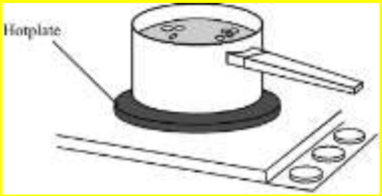
Conductors are materials which transfer energy more easily. Insulators are materials which don't transfer heat as well for example, Glass and plastics.

As the conductor is heated the atoms gain more energy and vibrate more. This causes them to collide with other atoms transferring the heat energy.



Model Question

Explain in terms of particles how heat is transferred through the base of the ban?



Model Answer

Atoms in the base of the saucepan gain thermal energy from the hob.
This causes the atoms in the saucepan to vibrate. Due to the vibration the atoms will collide with other atoms and pass on their thermal energy.

Why are metals good conductors?

In a metal lattice electrons from the outer shell are freed from their atoms. This causes those atoms to become positively charged ions. Heating the metal causes these ions to vibrate more. This extra energy is transferred from hotter to colder parts of the metal by the free electrons colliding with other ions and transferring their energy

Infra Red and Rate of Heat transfer

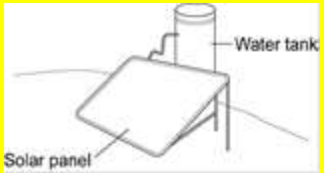
<u>Definition</u>
All objects emit (give out) and absorb (take in) infra red radiation. The hotter an object is the more infra red radiation it gives out.

<u>Absorption, emission and reflection</u>

Black (Dark, matt) surfaces are both good absorbers and good emitters of infra red radiation.

Light shiny surfaces are both poor absorbers and poor emitters of infra red radiation.

Light, Shiny Surfaces are good reflectors of infra red radiation



Water from the tank is slowly through copper pipes inside the solar panel where the water is heated by energy from the Sun.

Question – Explain why the copper pipes inside the solar panel are painted black.

Model Answer – Black is a good absorber of radiation therefore, more of the energy from the Sun is transferred into heating the water.

<u>Infra Red emission and surface area</u>
The larger a surface area an object has the more infra red radiation it will emit. Examples of this are car engines having cooling fins to allow for a better cooling system. In nature you can see the application of this with African elephants having larger ears than Indian elephants to help with cooling and arctic foxes having smaller ears to prevent heat loss.

P1.1.3/P1.1.1

<u>Difference in temperature</u>

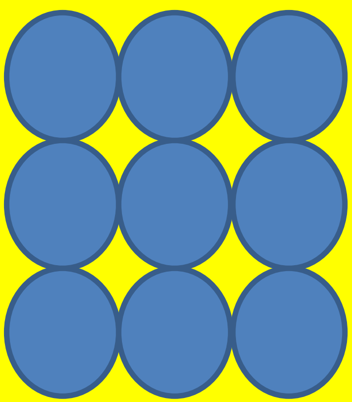
The bigger the temperature difference between an object and its surroundings the faster the rate at which heat is transferred

Evaporation

Solids liquids and gases

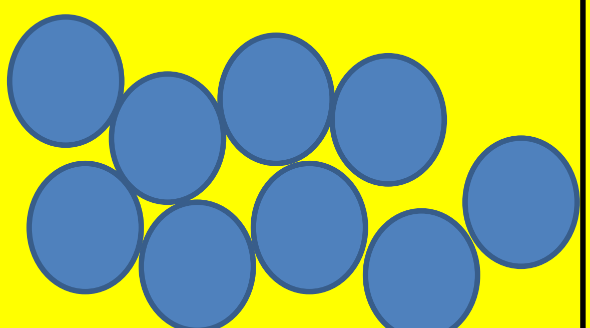
Solids

Solid is the lowest energy state of matter.
There are strong bonds between atoms and atoms are in a rigid and ordered structure.
Solid substances retain their shape.



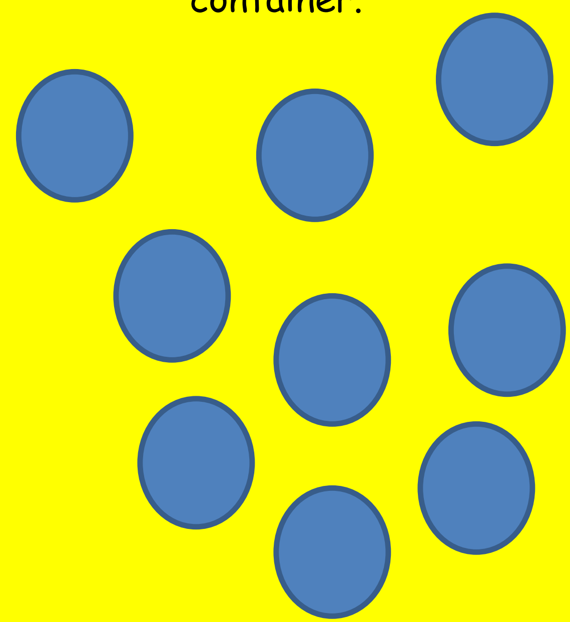
Liquids

Liquids are in a higher energy state than solids. There still exist bonds between atoms but they are no longer in a ordered structure and can move position. Liquids will take on the shape of the container they are in



Gases

Gases are the highest energy a substance can be. There are no bonds holding atoms together and therefor the atoms move freely and expand to fill a container.



Evaporation

Evaporation

Evaporation is when a liquid changes to a gas but it is not the same as boiling. Boiling only happens when a liquid is at its boiling point and every atom has the energy needed to change to a gas. Evaporation happens when an object is below its boiling point.

Liquids evaporate quickly when;
-**It is warm** The average energy is higher and more particles have the energy to break the bonds.

-**The liquid is spread out** The liquids larger surface area mean there are more particles at the surface

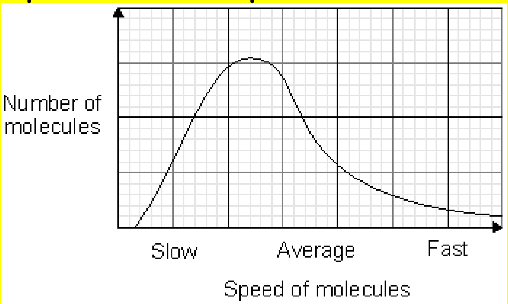
-**It is windy** Air can only hold a certain number of liquid particles before it is saturated (full up) if it is windy the air above the liquid will be blown away and there is room for more liquid particles.

Condensation

Condensation is when a gas turns back into a liquid state and can occur at the boiling point or lower. Condensation occurs better on objects that will conduct the heat energy away from the gas better.

Evaporation and Energy

Particles in a liquid have a range of energies. Some particles have more energy than the average some have less.
The bonds between the particles hold it together as a liquid. To evaporate the particles must have enough energy to break these bonds. This means only the most energetic particles escape. The average energy decreases as a result and the overall temperature drops



Heating and Insulating buildings

U-Values

U values measure how effective a material is an insulator.
The lower a U-Value is the better the insulator it is.

Solar Panels

Solar panels may contain water that is heated by radiation from the sun. This water may then be used to heat buildings or provide domestic hot water.

Specific heat capacity

The specific heat Capacity of a substance is the amount of energy required to change the temperature of the substance by one degree Celsius.

$$E = M \times c \times \theta$$

- E: Energy transferred in Joules (J)
- M: Mass measured in kilograms (Kg)
- c: Specific heat capacity measured in J/Kg°C
- θ: Temperature change in degrees Celsius (°C)

Payback time

This is the time it takes for something like double glazing, loft insulation or draught proofing to save as much money as it cost to install

$$\text{Payback time (Years)} = \frac{\text{Initial Cost (£)}}{\text{Savings per year (£)}}$$

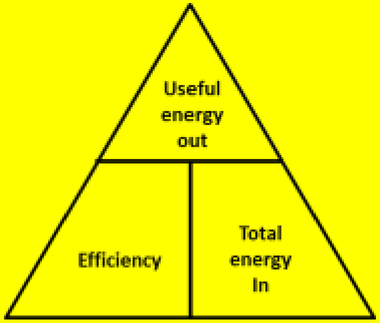
Energy transfers and efficiency

Energy can be transferred usefully, stored or dissipated but cannot be created or destroyed. When energy is transferred only part of it may be usefully transferred, the rest is “wasted”. Wasted energy is eventually transferred to the surroundings which become warmer. The wasted energy becomes increasingly spread out so becomes less useful.

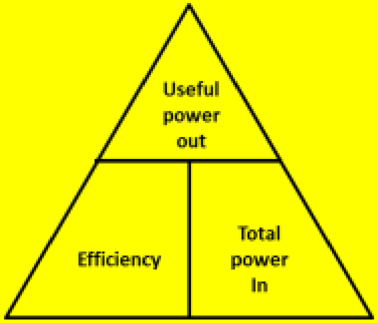
<u>Efficiency</u>

Efficiency is a measure of how much wasted energy is produced compared to useful energy. An efficient object is one which produces more useful energy than wasted.

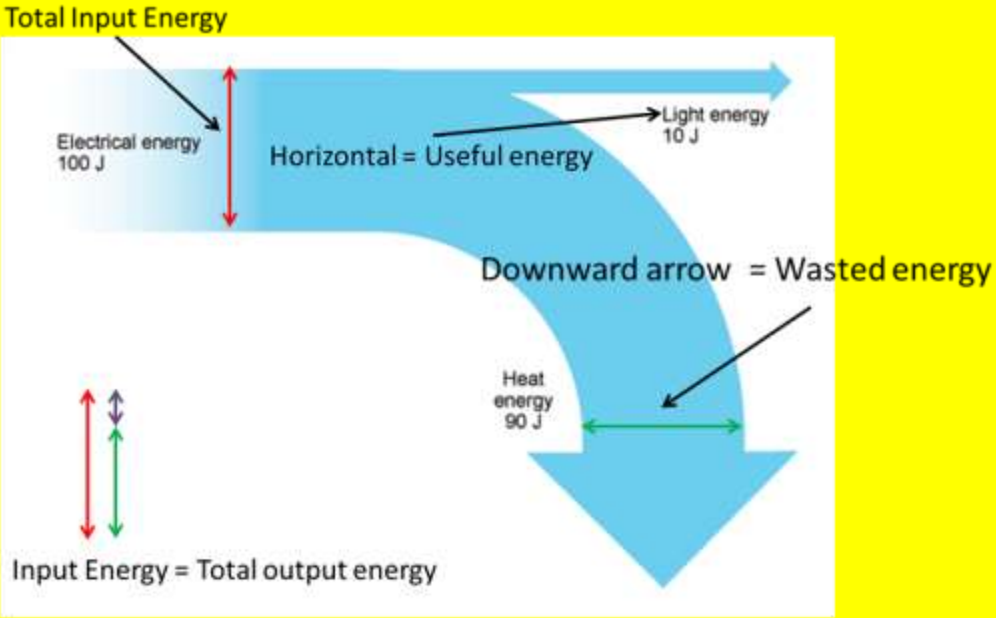
$$\text{Efficiency} = \frac{\text{Useful energy out}}{\text{Total energy in}}$$



$$\text{Efficiency} = \frac{\text{Useful power out}}{\text{Total power in}}$$



Energy transfers and efficiency



Sankey Diagrams

Sankey diagrams are a visual representation of how much energy is input into a system and what proportion is useful or wasted.

It is the width of the arrows that tell us how much energy is useful or wasted.

Transferring electrical energy

Energy Transfers

Electricity →

→ Heat (Useful energy)
→ Kinetic (Useful Energy)
→ Sound (Wasted Energy)

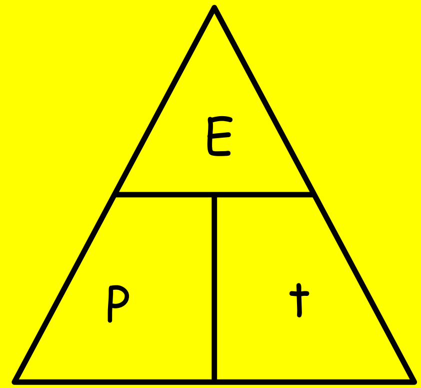
Electricity →

→ Light (Useful energy)
→ Sound (Useful Energy)
→ Kinetic (Wasted Energy)

Electricity →

→ Heat (Useful energy)
→ Kinetic (Useful Energy)
→ Sound (Wasted Energy)

The amount of energy an appliance transfers depends on how long the appliance is switched on for and the power it draws.



Energy transferred = Power x Time

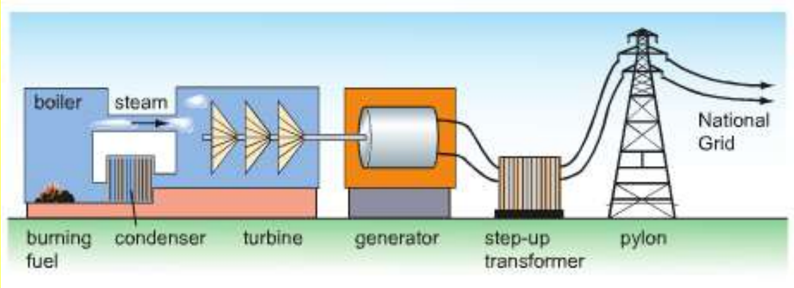
E	P	t
kWh	kW	hrs
J	W	s

The units may be given as kilowatthours, kilowatts and hours, or Joules, watts and seconds

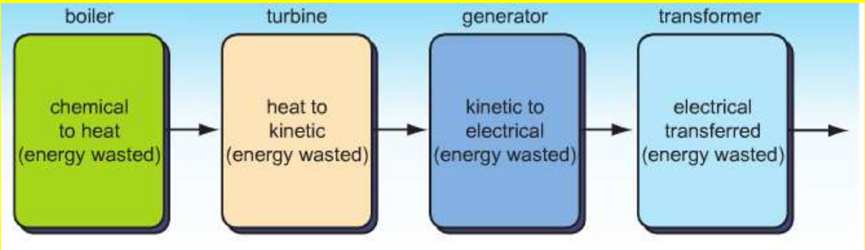
Generating electricity

In most power stations an energy source is used to heat water. The steam produced drives a turbine that is coupled to an electrical generator.

Energy sources include;
- Fossil fuels (Coal, oil and gas) which are burned to heat water or air
- Uranium and plutonium which release energy from nuclear fission and are used to heat water
- Biofuels that can be burned to heat water



Energy Transfers



Environmental concerns

Burning fossil fuels realises carbon dioxide into the environment which reflects back heat that otherwise would escape into space – this causes the earth to heat up and is leading to global climate change

Improving Efficiency

In "normal" power stations energy is wasted at every stage and they are around 35% efficient
The most efficient type of power station are combined heat and power stations –here waste heat energy is used to heat local homes and business. These can be upto 80% efficient

Generating electricity

Start up time

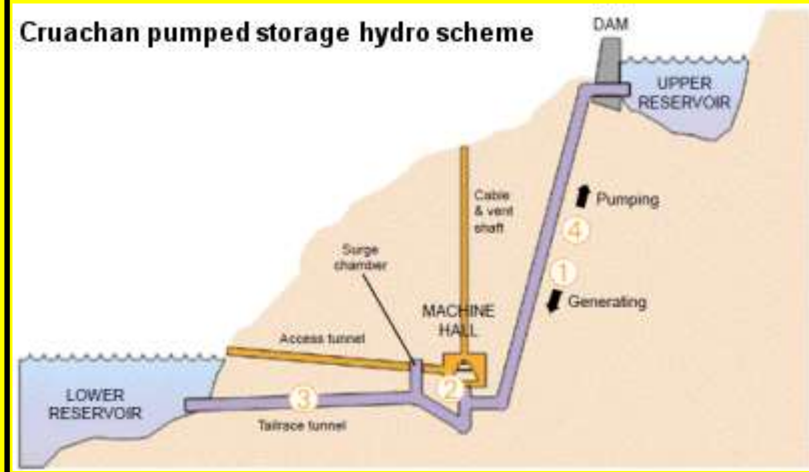
This is the time it takes for a power station to begin producing electricity after it has been "turned on"

Gas has the shortest start up time and is often used to meet "peak demands" times when electricity is most in demand

Decommissioning costs

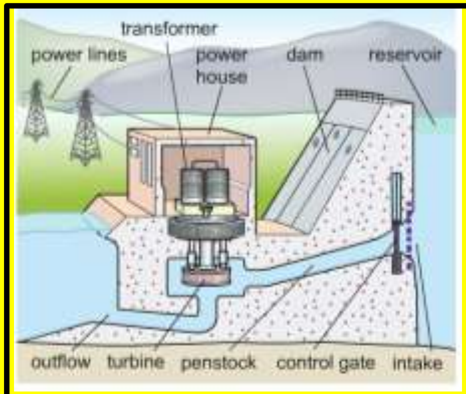
Nuclear power stations have a limited operating lifetime of 20-30 years – after this time the very fabric of the buildings become so radioactive it isn't safe to work in then. At this point the building has to be dismantled and safely disposed of. This is called decommissioning and is a costly affair

Pumped storage



When the amount of electricity produced exceeds demand the surplus can be used to pump water to a higher reservoir. This water can then be realised and generate extra electricity at peak times.

Generating electricity

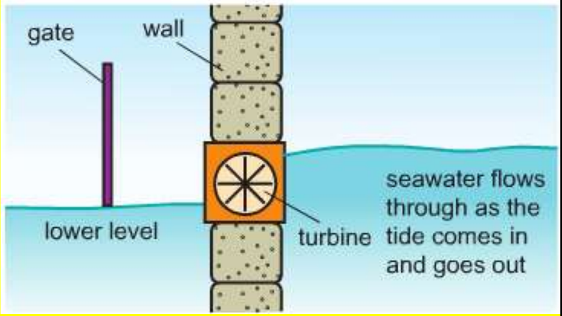


Hydro Electric power stations use falling water to turn turbines. A dam will hold back a river to form a reservoir. The water from the reservoir is allowed to flow through the turbines. The turbines then generate electricity. We can control when to realise the water meaning electricity is generated only when it is needed.

Wind causes the blades to spin, which if connected to a generator generates electricity.

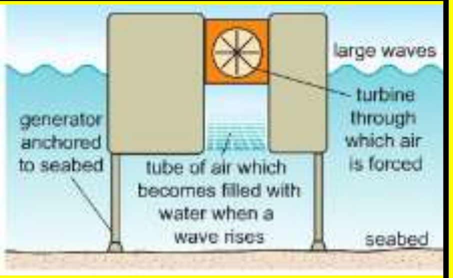
The faster the blades spin, the more electricity is produced.

Tidal Power stations are often built across river estuaries.



As the tide comes in, water flows through the turbines, which spin and generate electricity. As the tide falls the water again flows through the turbines. Tidal power stations need a tidal difference of at least 15m

Wave power Generators. When a wave hits the generator it forces the air in the tube to rise which in turn forces the air through a turbine, this makes the turbine spin and if connected to a generator generates electricity.



Generating electricity

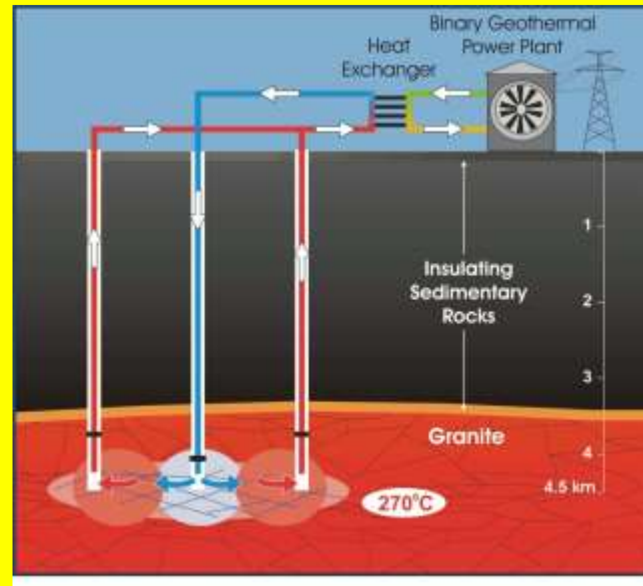
Solar cells use the suns light to directly produce electricity.
Although not producing electricity **solar panels** use the suns heat to heat water meaning less electricity needs to be produced.

Solar cells

solar panels

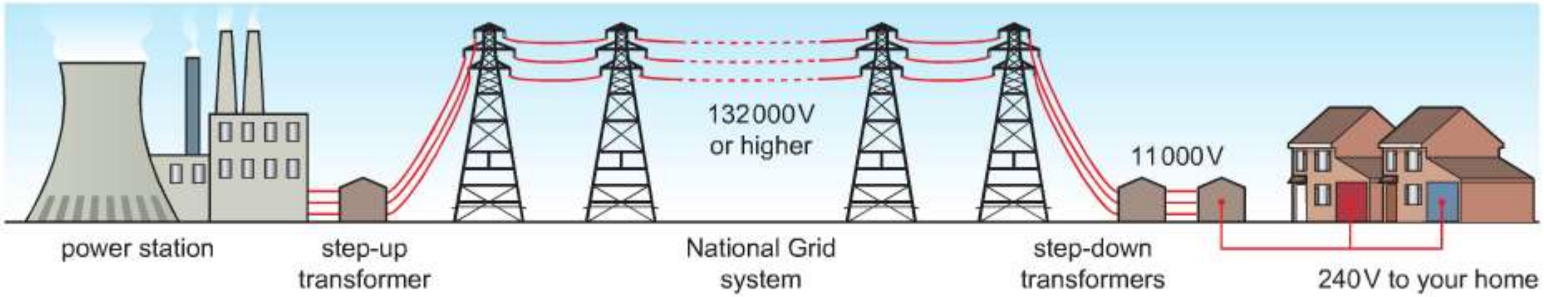
Using different energy resources has different effects on the environment. These effects can include;
The release of substances into the environment
Production of waste material
Noise and visual pollution
The destruction of wildlife habitats

In some volcanic areas hot water and steam rise to the surface. This steam can be tapped and used to drive turbines. This is known as **geothermal energy**.



Small scale production of electricity may be useful in some areas and for some uses, I.E hydroelectricity in remote areas and solar cells for roadside signs.

The national Grid



The National Grid

Electricity is distributed from power stations to consumers along the National Grid.

The national grid is made up of;

- Wires and pylons

- Step Up transformers

- Step down transformers

What do transformers do?

Electric current generates heat as it moves through electrical wires. If electricity is transmitted at a very high voltage and low current this means less energy is wasted as heat making the whole system more efficient.

Step up transformers – Increase the voltage and decrease the current.

Step down transformers - Decrease the voltage and Increase the current.

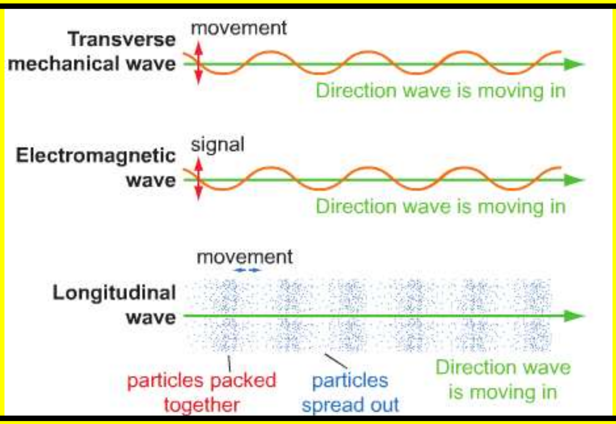
Model Question

Electricity is distributed from power stations to consumers along the National Grid. The voltage across the overhead cables of the National Grid needs to be much higher than the output voltage from the power station generators. **Explain why.**

Model Answer

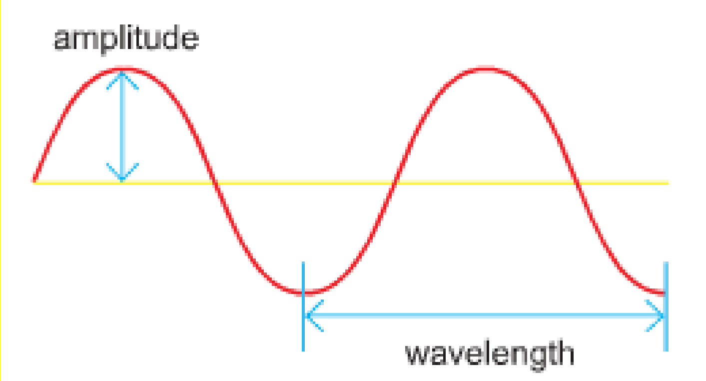
By increasing the voltage the current is reduced
this reduces the energy / power loss from the cable
and this increases the efficiency (of transmission)

General Properties of waves



<u>Longitudinal</u>
The vibrations are in the same direction as the energy is travelling. Examples - Sound

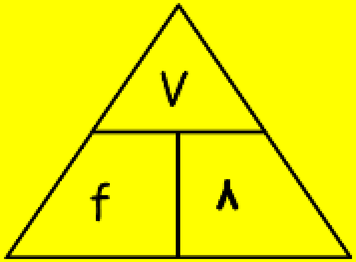
<u>Transverse</u>
The wave vibrates at 90 degree to the direction the energy is travelling in. Example – Electro-Magnetic waves



Wavelength is the distance between 2 of the same points on a wave. Normally it measured from peak to peak or trough to trough.

Amplitude is half the height of a wave

Frequency is the number of waves per second

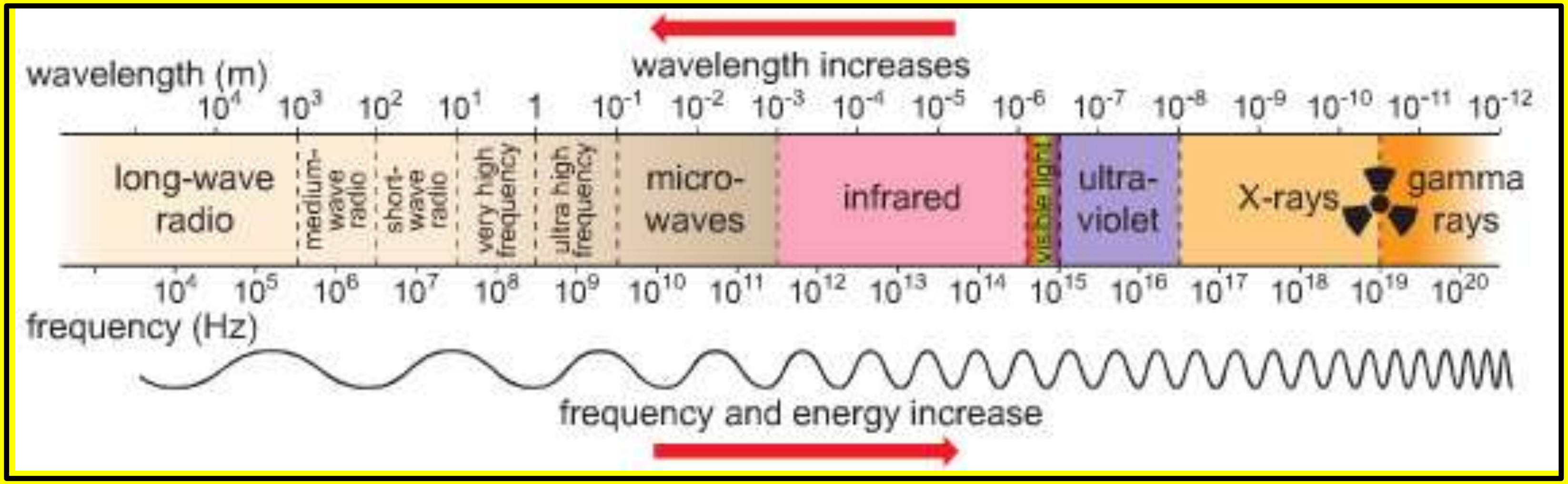


Wave Speed = Frequency X Wavelength

(m/s)	(Hz)	(M)
V	F	λ

General Properties of waves

Electromagnetic Spectrum



Electromagnetic waves are transverse waves which all travel at the same speed through a vacuum (the speed of light)

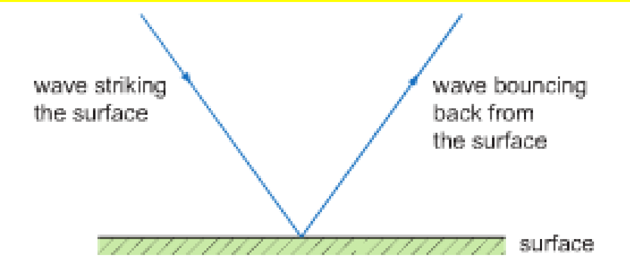
The low energy end of the electromagnetic spectrum are used for communications.
Radio – Television and radio signals
Microwave – Mobile phone and satellite television signals
Infra Red – Remote controls

The high energy end of the electromagnetic spectrum Ultra-violet, X-Rays and Gamma rays are harmful to health and can cause some cancers.

The 7 members of the electromagnetic spectrum form a continuous spectrum

Reflection, Refraction and Diffraction

Reflection

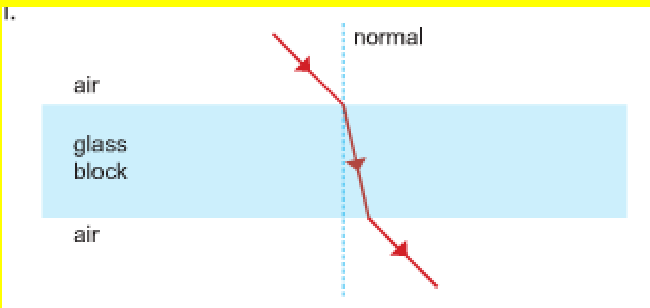


The "normal" is a construction line perpendicular to reflecting surface at the point of incidence.

The angle of incidence is equal to the angle of reflection.

The image produced in a plane mirror is virtual

Refraction



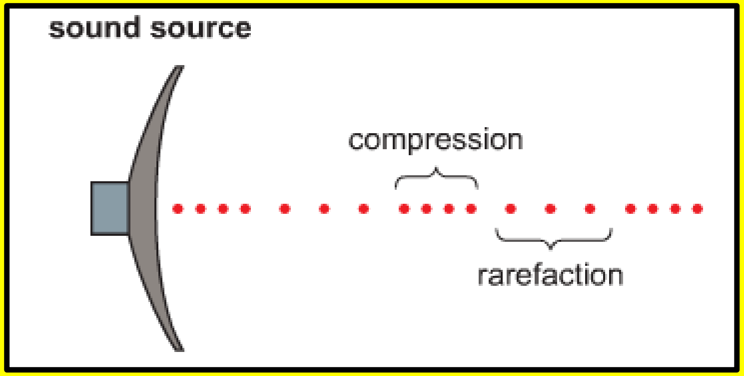
Refraction occurs when a waves passes between objects of difference densities.
Waves undergo a change of direction when they are refracted at an interface.
If the wave is travelling along the normal then the wave is not refracted.

Diffraction

Diffraction is when a wave spreads out after passing through a gap.

Significant diffraction only occurs when the size of gap the wave is passing through is of a similar magnitude to the wavelength.

Sound



Sound waves are longitudinal waves and cause vibrations in a medium, which are detected as sounds.

There are areas of compression where the particles in the medium bunch together and areas of rarefaction where the particles in the medium spread out.

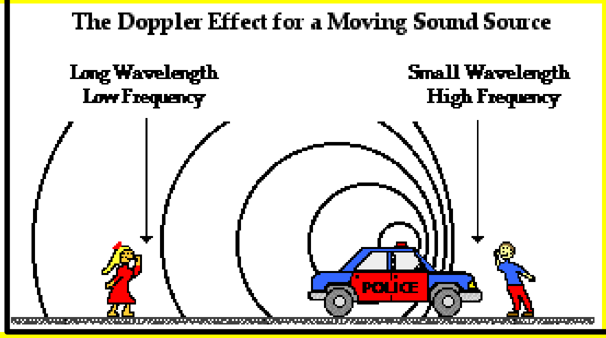
The pitch of a sound is determined by its frequency and its amplitude

Echoes are reflections of sounds

Red Shift

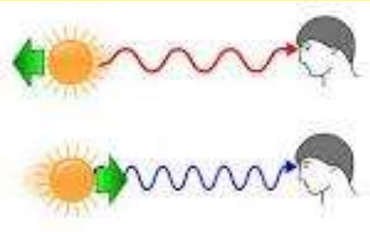
Doppler Shift

If a wave source is moving relative to an observer there will be a change in the observed wavelength and frequency. If the wave source is moving towards you the wave gets "bunched" up the wavelength gets shorter and the frequency higher. If it is moving away from you the wave gets spread out the wavelength is longer and the frequency gets lower.



Red Shift

As well as sound the Doppler effect happens to all waves, including light. This means the wavelength of galaxies moving away from us is stretched towards the red end of the spectrum and galaxies moving towards us is squashed towards to blue end of the spectrum



Evidence for the big bang?

The big bang theory is that the universe began from a very small point 13.6 billion years ago.

The evidence is;

1.) From observed red shift of other galaxies we can see that the universe is expanding. This means at some point in the past everything must have started expanding from the same point.

2.) Cosmic microwave background radiation (CMBR) This is a form of radiation that is present everywhere in the universe and is uniform in all directions. The big bang theory is the only theory that can explain the presence of this.