Physics

Topic 1 - energy transfers

Conduction

Conduction is the transfer of heat through solids

The metal is heated up, particles gain energy and start to vibrate, bumping into their neighboring particles. The metal's free electrons speed up this process as there are more things to bump into.

- metals are the best conductors of heat
- wool and fiberglass are the best insulators
- conduction in a metal is due to free electrons transferring energy inside of the metal
- non-metals are poor conductors because they don't have any free electrons
- trapped air is a good insulator because when trapped, the particles are forced to move against each other, making heat

Convection

Convection is heat transfer in liquids and gases

The hotter, therefore less dense part of the fluid rises and cooler, denser matter takes its place. The fluid that rose will cool when it reaches a colder area. This results in the particles moving closer together and getting denser, causing it to fall, replacing the particles at the bottom which are rising. This circular motion is called a convection current.

Coastal winds

Convection currents cause these winds. The land by the sea heats up faster than the water. The heat from the land rises (because particles move apart and become less dense). As a convection current does, the particles cool once in the air and this cool air falls towards the sea. It travels back to land as wind, starting the current again.

Convection heaters and Hot water tanks

Hot water goes in through the bottom and heats up from the heating element. The fluid becomes less dense and rises through the vent, new cold fluid replacing it.

Radiation

Infrared radiation is the transfer of energy through electromagnetic waves. It can travel through a vacuum because it doesn't involve the movement of particles. Everything absorbs and emits infrared radiation (the hotter the object, the more radiation).

- Dark, matt surfaces are good absorbers and emitters (heat up quickly, cool quickly)
- light, shiny surfaces (the opposite) are good reflectors of radiation.

The rate of energy transfer depends on:

- surface area and volume
- colour
- the material and nature of the object with which it is in contact

Condensation

Gas to liquid

To have large amounts of condensation there should be:

- humid air
- large surface area
- cool temperature of the surface

Evaporation

Liquid to gas

A liquid starts to heat up and the particles get more energetic, the most energetic particles escape off the surface of the liquid - this lowers the average kinetic energy of the liquid, meaning it cools down.

Dependent on:

- volume and surface area
- whether there's a wind
- whether it's a hot day

Specific heat capacity

This is the number of Joules it takes to increase 1kg of a substance by 1 degree Celsius. If it has a high heat capacity, it will take longer to heat up but can store the heat for a lot longer e.g. water.

$E = M \times C \times \theta$ ('theta')

J = kg x J/kg degrees Celsius x temperature change in degrees Celsius

U Value

How good an insulator something is. Low U value = good insulator

Vacuum Flask

- A vacuum flask reduces the rate of energy transfer because of the gap between the two walls of the container - this vacuum acts as an insulator and stops both conduction and convection from occurring.

- These walls are made from glass which is a good insulator which means there isn't very much energy transfer through conduction through the walls.
- The main wall around the two glass walls is made from plastic, which is again a good insulator for conduction.
- The plastic cap on the top of the drink stops the drink from cooling through evaporation and stops hot fluid from rising out of the container through convection.
- Inside surfaces are silvered to stop heat loss through radiation.
- The final layer of the flask is silver and shiny which means infrared radiation is reflected from it, making it a good insulator.

Storage Heaters

A storage heater uses electricity at night to heat special bricks/concrete blocks in the heater. The bricks have a high specific heat capacity so they store lots of energy. They warm up slowly when the heating element is on and cool down slowly when it's off. They're cost effective and energy transfer from the bricks keeps the room warm.

Motorcycle engine

It has fins on its outside surface which increases the surface area of engine in contact with air so the engine transfers energy faster to its surroundings.

Heating and insulating buildings

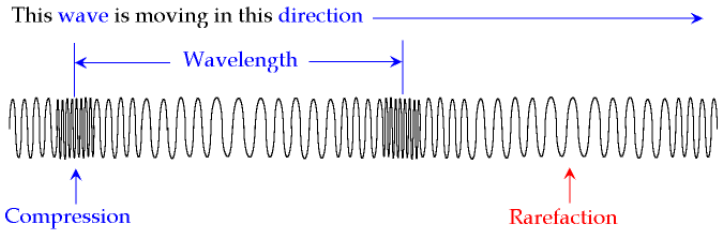
- **loft insulation** such as fiberglass reduces energy transfer through the roof since it's a good insulator. The air between fibers helps to reduce rate of energy transfer by conduction.
- **cavity wall insulation** reduces heat loss through outer walls of house. It's a space between two layers of bricks. The insulation is put in this cavity which traps air in small pockets and reduces energy transfer through convection.
- **aluminium foil** between the radiator panel and wall reflects radiation away from wall
- **double-glazed windows:** windows can be double glazed, there is a gap between the first and second glazes and the trapped air in between acts as an insulator. There is a gap in the heat transfer.

Topic 2 - Waves

Waves transfer energy and information without transferring matter

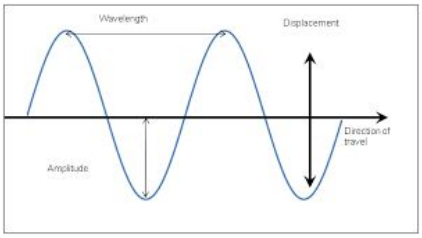
Longitudinal Waves

In a longitudinal wave the oscillations are parallel to the direction of energy transfer. For example sound waves. They have areas of compression and rarefaction.



Transverse Waves

In a transverse wave, the oscillations are perpendicular to the direction of energy transfer. For example electromagnetic waves.



Mechanical Waves

Waves which need a medium or substance to travel through. They can be longitudinal (sound) or transverse (water/slinky spring). Electromagnetic waves are NOT mechanical because they can travel through a vacuum.

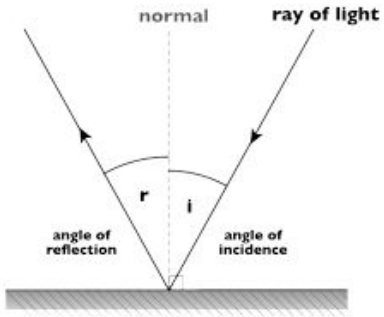
The wave equation: speed = frequency x wavelength

Mirror images

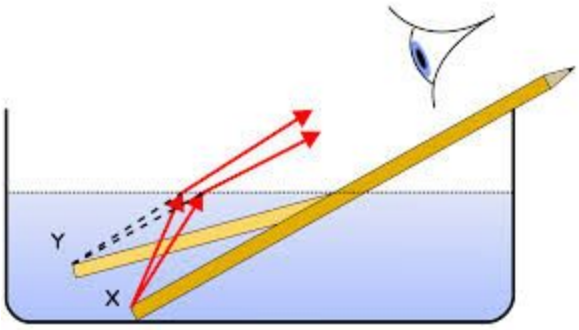
A mirror image is:

- virtual
- upright
- laterally inverted

Reflection

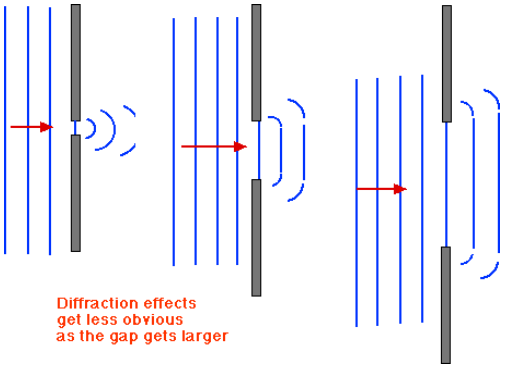


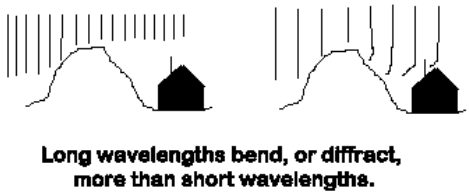
Refraction



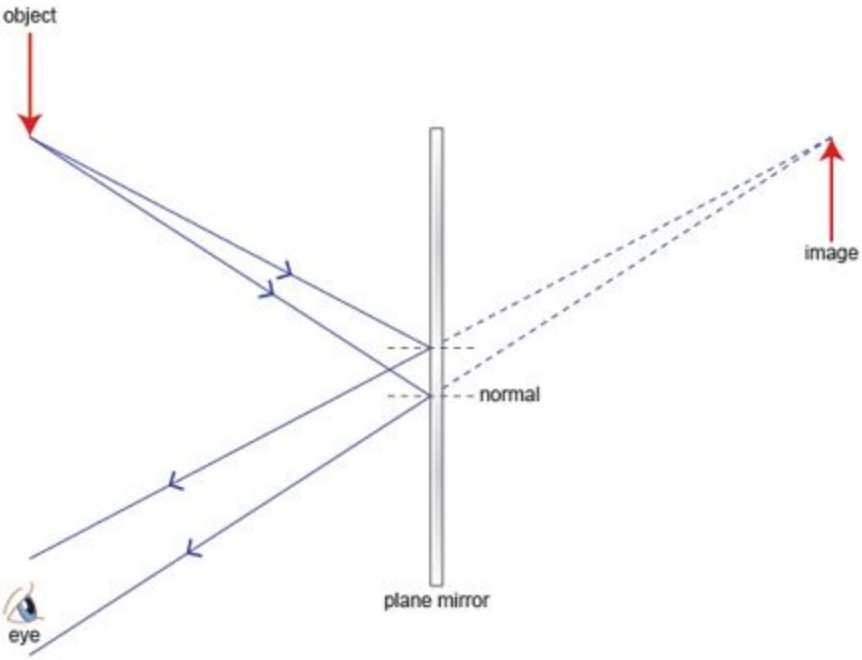
Light moves at different speeds through different substances. For example, it moves faster through air that water. When light is travelling slower it will bend towards the normal. Therefore, when we look at objects in the water, they look slightly above what they actually are which is why, when fishing with spears, you should aim higher than where you see the fish.

Diffraction





Finding a mirror image



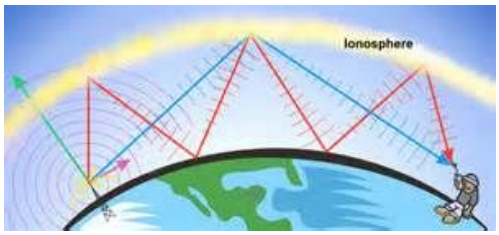
Topic 3 - Electromagnetic Waves
All electromagnetic waves travel at the same speed through a vacuum

Radio Waves
Microwaves
Infrared Radiation
Visible Light
Ultraviolet Light
X-rays
Gamma Rays

Uses
Radio Waves - Tv transmitter mast, Radio
Microwaves - heating food, mobile phones, Tv satellite
Infrared Radiation - cooking, Tv remote handsets
Visible Light - seeing! photography, Tv receiver
Ultraviolet Light - detecting forged banknotes, tanning
X-rays - medical imaging, aircraft security
Gamma Rays - to kill cancer cells (radiotherapy), sterilise medical equipment, nuclear weapons

Dangers
Radio Waves - none
Microwaves - causes water molecules to vibrate, meaning water molecules inside of us vibrate
Infrared Radiation - it's hot and can cause skin burns
Visible Light - looking at the sun, lasers are very intense and can cause harm
Ultraviolet Light - sunburn, it's ionising, it can cause skin cancer
X-rays - ionising, can damage or kill cells
Gamma Rays - damages growing tissue and can mutate, causes cell damage and can result in cancer

The ionosphere
Radio waves reflect across the ionosphere. The wave will hit the ionosphere then return to the earth's surface since it cannot pass through.



Microwaves and waves higher than this on the electromagnetic spectrum can pass through the ionosphere. Waves near the end of the radio wave spectrum can sometimes pass through the ionosphere; however, its ability to reflect can change. Energy can be lost.

Mobile Phone Risks
- there is a 50% increase in chance of getting cancer in your salivary gland
- mobile phone companies think there might be a correlation

Topic 4 - Generating Electricity

	Advantages	Disadvantages
Fossil Fuels	it's quick and produces a lot of energy	it releases carbon dioxide and it's non-renewable. It releases sulfur dioxide and ash which is disposed of in landfill sites.
Nuclear Power	Produces a lot more energy than other sources	it can have disastrous effects on human health
Solar Power	converts light straight into electrical, doesn't require much space	expensive, some chemicals in solar cells are not very efficient
Wind Power	great for windy areas, non-polluting	need a lot of space, expensive
Tidal Power	once built, the energy is free	expensive, difficult to maintain, only provides power for around 10 hours a day
Hydroelectric Power	designed to last for decades. build up of water means that it can be stored until needed	very expensive, can damage the surrounding ecosystem
Wave Power	all energy produced is clean and non-polluting. Once built, energy is free	expensive, difficult to maintain, only provides power for around 10 hours a day. During construction affects marine ecosystem
Geothermal Power	generates quite a lot of energy	radioactive
Biomass and Biofuels	carbon-neutral	releases carbon dioxide

In some energy stations, energy resources are used to heat up water. The steam produced drives a turbine which is connected to a generator.

Carbon Capture
Fossil fuels produce CO_2 when burnt. This is a greenhouse gas which can contribute towards global warming. To prevent it building up in the atmosphere, we can trap and store it. This is usually done in old oil and gas fields underground, e.g. under the North Sea. The capture and storage of CO_2 produced by burnt fossil fuels

Hydroelectric Power
It is economically efficient because at night when people aren't using electricity as much, electricity companies can use their excess energy to pump the water back up to the top, so that it will produce energy the next day.

Geothermal Energy
In Volcanic Areas, hot water and steam rise to the surface. The steam can be used to turn turbines.

Nuclear Energy
- The energy is released through **nuclear fission,** where the atoms are split to produce a lot of heat energy.
- The energy is used to heat the water.
- The process does not release any greenhouse gases.
    - Nuclear power stations produce radioactive waste

Fossil Fuels

- Gas emits the least CO2
- Gas has the fastest start up time

The National Grid

- The national grid is a network of cables and transformers that distributes energy from the power station to homes and other buildings
- Step-up transformers raise the voltage and lower the current
- Step-down transformers lower the voltage and raise the current
- Why step up?

The low current mean less energy is lost to heating, so more energy can be used in homes.

- Why step down?

The low voltage means less energy is supplied to houses and so it's safer for appliances

Power = Energy / Time

Total Cost = number of KwH used x cost per KwH

Pay Back Time = cost of installing / amount saved

Cost effectiveness

To compare this we have to consider:

- the capital cost (buying/installing)
- running cost (fuel/maintenance)
- environmental cost (disposal of old equipment)
- other costs (interest/loan)

Clockwork Radio

- The kinetic energy from turning the handle turns an electrical generator
- this gives stored elastic potential energy

Kinetic ---> elastic potential + sound + thermal

Light Bulbs

Type of bulb	Advantages	Disadvantages
Filament lightbulb	Cheap	inefficient, gets hot
Halogen lightbulb	fairly cheap, bright	inefficient, gets hot
Low-energy compact fluorescent bulb	efficient, not too expensive	takes a few minutes for full brightness. Disposal must be in a sealed bag due to mercury.
Low-energy light-emitting bulb	very efficient, long life time	expensive to buy, not very bright

Topic 5 - Energy Resources and Efficiency

Types of Energy

- light
- sound
- thermal
- electrical
- kinetic
- chemical
- gravitational potential
- nuclear
- elastic potential

Bungee Jumping

- the slack rope means some gravitational potential energy is turned into kinetic as the jumper falls
- once the slack is used up, the rope slows the bungee jumper's fall.
- Most gravitational potential and kinetic energy turns into elastic potential energy
- when the jumper reaches the bottom, the rope pulls the jumper back up. As they go up, most elastic potential energy is transferred back into gravitational potential and kinetic energy

Energy cannot be created or destroyed. It just changes from one form to another. This idea is known as the **conservation of energy.**

Wasted energy **dissipates** into the surroundings, which causes the area to become warmer.. It continues to spread out, making it less and less useful.

Topic 6 - The Big Bang Theory

What is it?

The big bang theory is a theory as to how the universe first began. The big bang is the creation of space, time and matter in one explosion from a single, small point in less than a second. It is the expansion of the universe.

What is red shift and how does it provide evidence for the big bang?

If something is moving away from us its wavelength of light gets longer, this means that it shifts towards the red in the spectra. We can see red shift in our universe, meaning things are moving away from us and the universe is expanding.

What is Cosmic Microwave Background Radiation

The universe appears to be filled with electromagnetic radiation. At the time of the big bang, it is expected that the wavelengths were short gamma rays. As the universe expanded, the wavelengths became longer so it's now microwave radiation. This tells us that the universe is expanding.

A galaxy is a collection of stars.