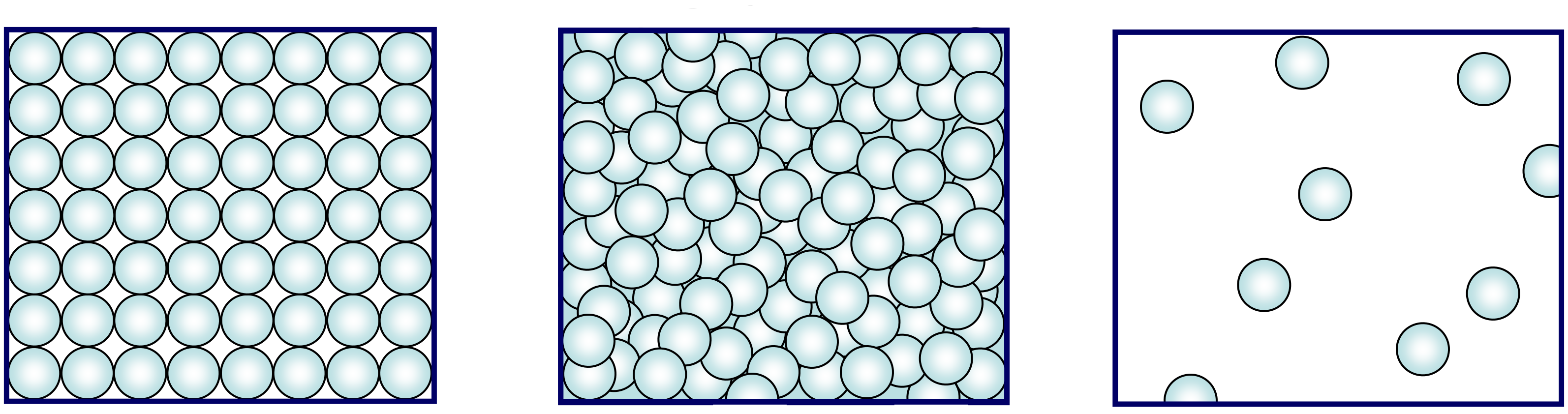
P1 Revision.

Physics.

P1.1

- *The transfer of energy by heating processes and factors that affect the rate at which energy is transferred.*

How are the particles arranged in a solid, a liquid and a gas?



solid **liquid** **gas**

Particles that are very close together can transfer heat energy as they vibrate. This type of heat transfer is called **conduction**.

Conduction is the method of heat transfer in **solids** but not liquids and gases. Why?

What type of solids are the best conductors?

Heat transfer

Heat is a type of energy called **thermal energy**.

Heat can be **transferred** (moved) by three main processes:

1. conduction

2. convection

3. radiation

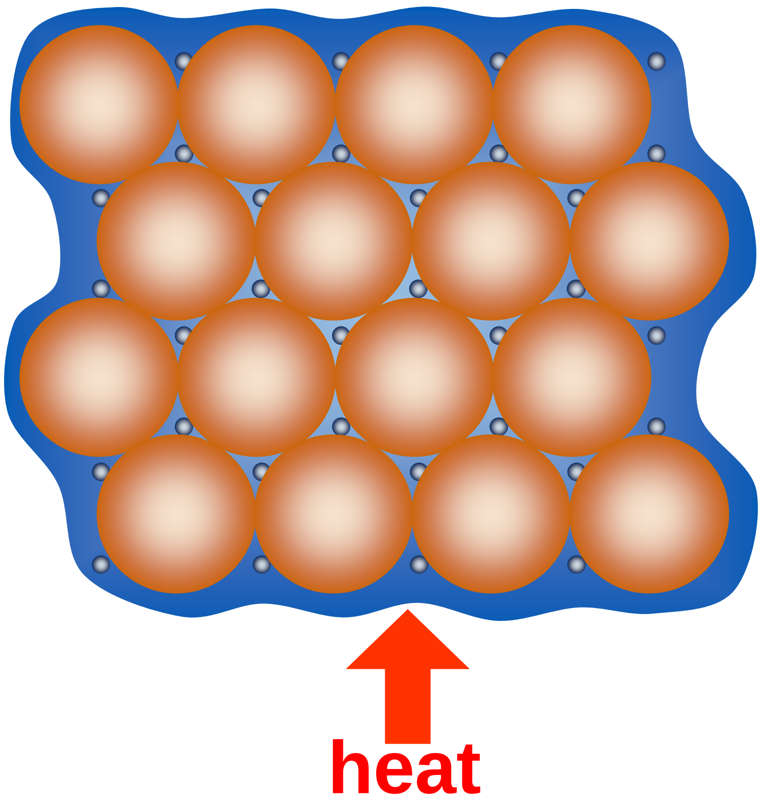
During heat transfer, thermal energy always moves in the same direction:

HOT → **COLD**

Heat energy only flows when there is a temperature difference from a **warmer** area to a **cooler** area.

Conduction in metals

The outer electrons of metal atoms are not attached to any particular atom. They are free to move between the atoms.

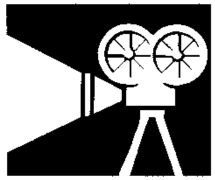


When a metal is heated, the free electrons gain kinetic energy.

This means that the free electrons move faster and transfer the energy throughout the metal.

This makes heat transfer in metals very efficient.

Insulators do not have these free electrons, which is why they do not conduct heat as well as metals.



Insulators

Some materials are very poor conductors of heat. These are called **insulators**.

Examples of materials that are insulators include **plastics**, **wood**, **ceramics** and **air**.

Air becomes a very effective insulator when it is **trapped** and stopped from moving.

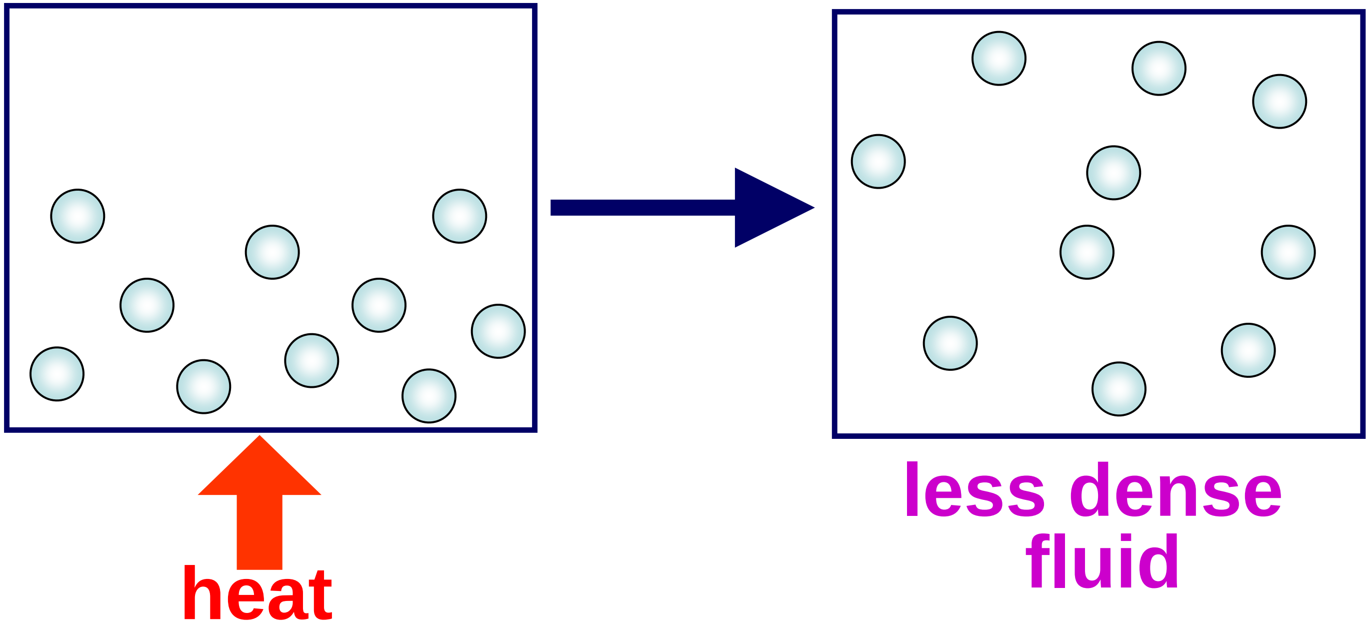
This is how your clothes keep you warm – air is trapped between the fibres and so acts as an insulator.

Other insulating materials, including polystyrene and loft insulation, use trapped air because it is so effective.

Heating fluids

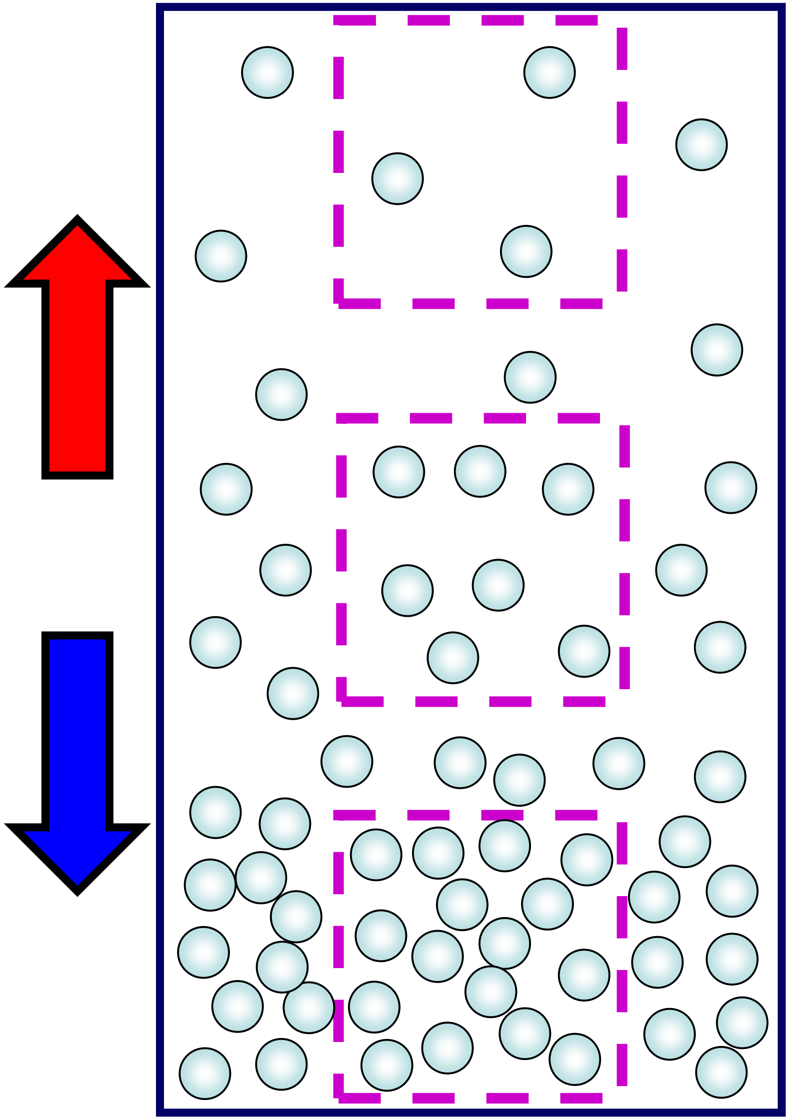
Liquids and gases can behave in similar ways and so are called **fluids**.

What happens to the particles in a fluid when it is heated?



The heated fluid particles gain energy, so they move about more and spread out. The same number of particles now take up more space so the fluid has become **less dense**.

What is convection?

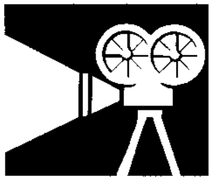


Cooler regions of a fluid are **more dense** than warmer regions of the same fluid.

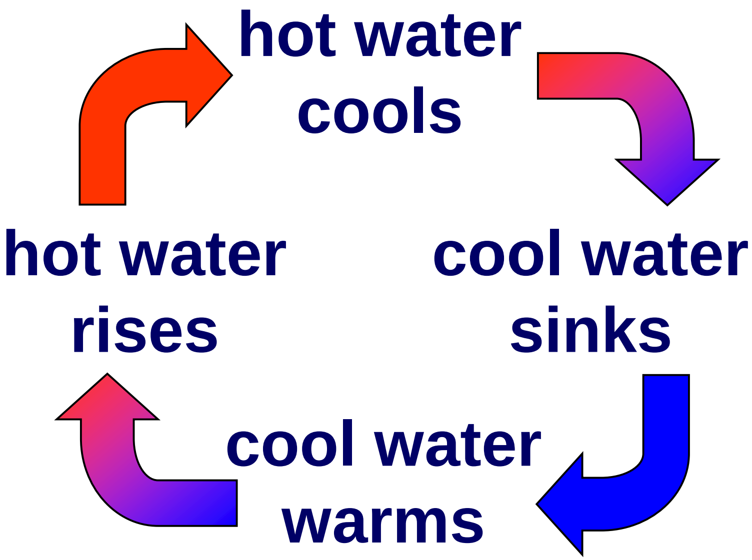
The **cooler** regions will **sink** as they have the greatest mass per unit volume.

The **warmer** regions will **rise** as they have a lower density. In effect, they float on top of the denser, cooler regions.

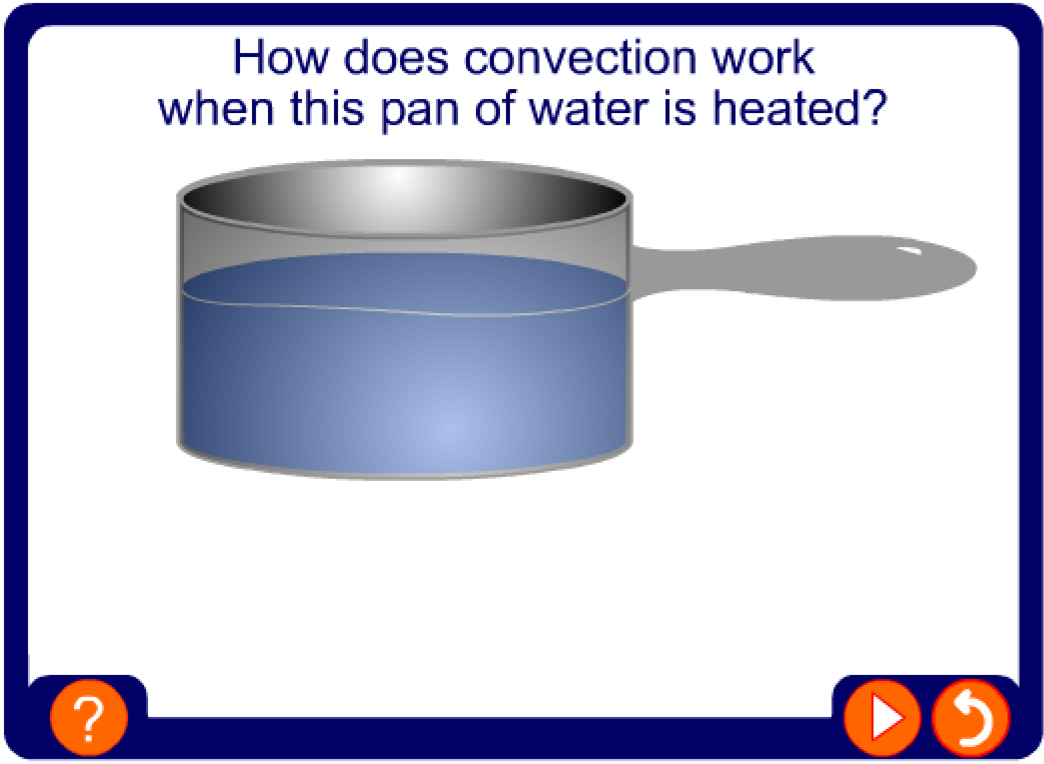
This is how heat transfer takes place in fluids and is called **convection**.



Convection current



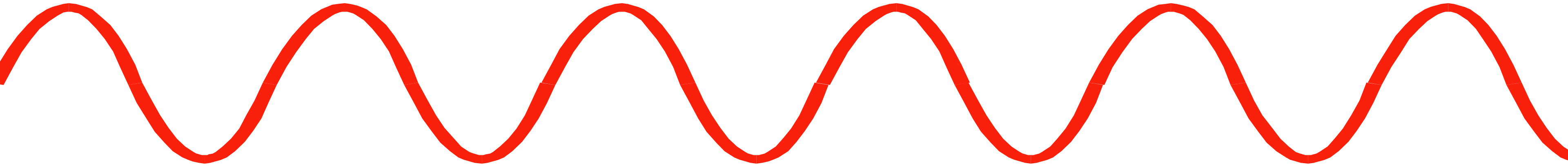
This is called a **convection current**.



Radiation

Heat can move by travelling as **infrared waves**.

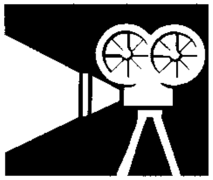
These are electromagnetic waves, like light waves, but with a longer wavelength.



This means that infrared waves act like light waves:

- They can travel through a vacuum.
- They travel at the same speed as light – 300,000,000 m/s.
- They can be reflected and absorbed.

Infrared waves heat objects that **absorb** them and so can be called **thermal radiation**.



Emitting thermal radiation

All objects **emit** (give out) some thermal radiation.

Some surfaces are better at **emitting** thermal radiation than others.

Matt black surfaces are the best emitters of radiation.

Shiny surfaces are the worst emitters of radiation.

Absorbing thermal radiation

Infrared waves heat objects that **absorb** (take in) them.

Some surfaces are better at **absorbing** thermal radiation than others – good emitters are also good absorbers.

Matt black surfaces are the best absorbers of radiation.

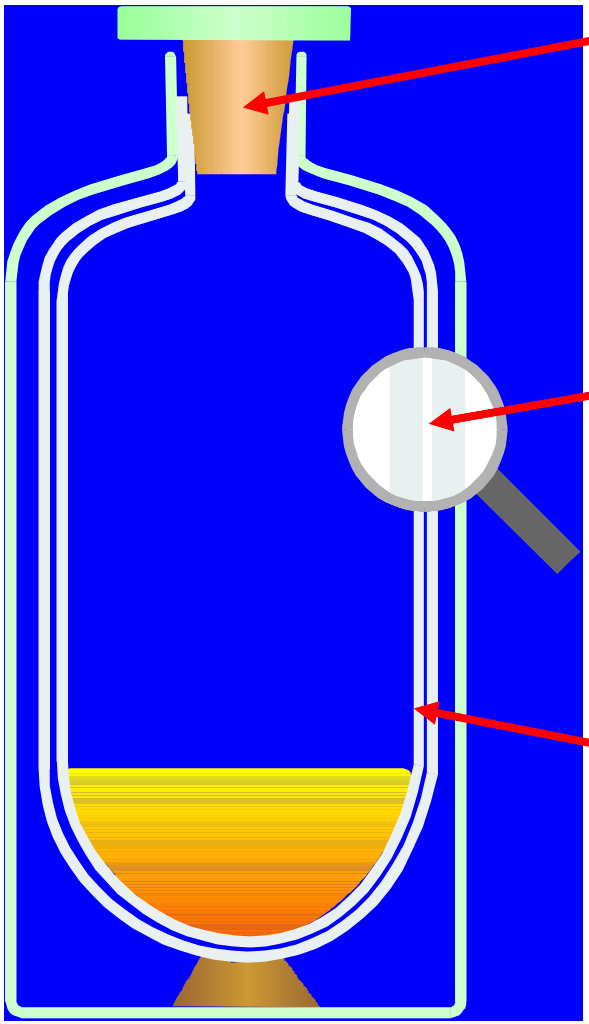
Shiny surfaces are the worst emitters because they reflect most of the radiation away.

Rate of heating up & cooling down depends on:

- Colour.
- Temperature.
- Material.
- Surface area.
- Volume
- Surface with which it is in contact with.

The vacuum flask

How does a vacuum flask keep hot drinks hot and cold drinks cold?



1. The plastic/cork lid is an insulator and prevents **convection** currents escaping.
2. The vacuum between the two layers of glass prevents heat leaving or entering by **conduction**.
3. The silvered walls prevent heat leaving or entering by **radiation**.

Specific heat capacity.

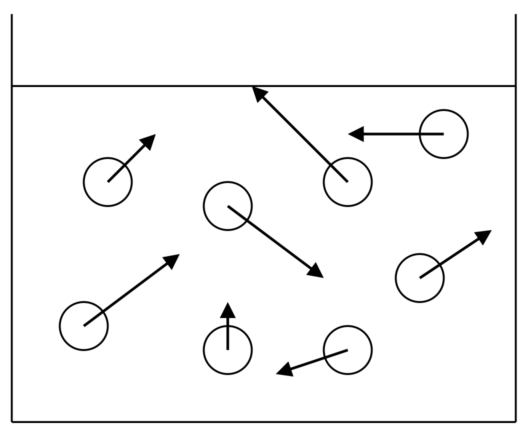
- The definition of specific heat capacity is as follows:
- *The specific heat capacity of a substance is the amount of heat energy required to change the temperature of one kilogram of the substance by one degree Celsius.*
- This can be written as a word equation:
- *Heat energy = mass* x *specific heat capacity* x *temperature change*
- This is written using the following symbols:
- $E = m \times c \times \theta$

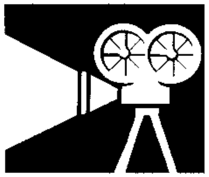
- The units for energy are joules (J), the units for mass are kilograms (kg), the units for specific heat capacity are joules per kilogram per degree Celsius (J/kg/^{o}C) and the units for temperature change are degrees Celsius (^{o}C).
- The heat energy can be energy absorbed or energy emitted by the substance and the temperature change can be an increase or a decrease.
- The specific heat capacity of water is very high this is why it is used to cool car engines and in the radiators of central heating systems.

<u>Evaporation: </u>(liquid to gas)

When the particles escape they use heat energy so the liquid cools.

- To escape the particles must have enough energy, be close to the surface and be moving in the right direction.





Condensation:

- When a gas turns into a liquid.
- Occurs when water vapour comes in contact with a cold surface.
- Occurs when the gas particles get close enough together and slow down.

U-values:

- U-values show how fast heat can travel through a material.
- A material with a low U-value is a good insulator.
- For example a single glazed window has a U-value of 5.6 $W/m^2/^oC$ and a double glazed window 2.9 $W/m^2/^oC$

P1.2

- *Energy and efficiency*

Useful energy transfer

Many everyday objects are designed to transfer energy from one form into another useful form.

Electric fan:

electrical energy → **kinetic energy**

Wind farm:

kinetic energy → **electrical energy**

Hydroelectric power station:

gravitational energy → **electrical energy**

An energy transfer diagram shows the input energy and the output energies for a device. This includes all the useful and wasted forms of energy.

For example, in a television:

electrical → **light**, **sound**, **heat**

What are the main energy transfers in a car engine?

chemical → kinetic, sound, heat

Calculating efficiency

The efficiency of a device can be calculated using this formula:

$$\textbf{efficiency} = \frac{\textbf{useful energy out}}{\textbf{total energy in}}$$

Useful energy is measured in joules (J).

Total energy is measured in joules (J).

This means that efficiency does not have any units.

It is a number **between 0 and 1** or a **percentage.**

This radio is supplied with 300J of electrical energy which it converts to 96J of sound energy.

a) How much energy is wasted? 204 J

b) In what form is the energy wasted? heat

c) What is the efficiency of the radio? 0.32 or 32%

Wasted energy = Total – Useful

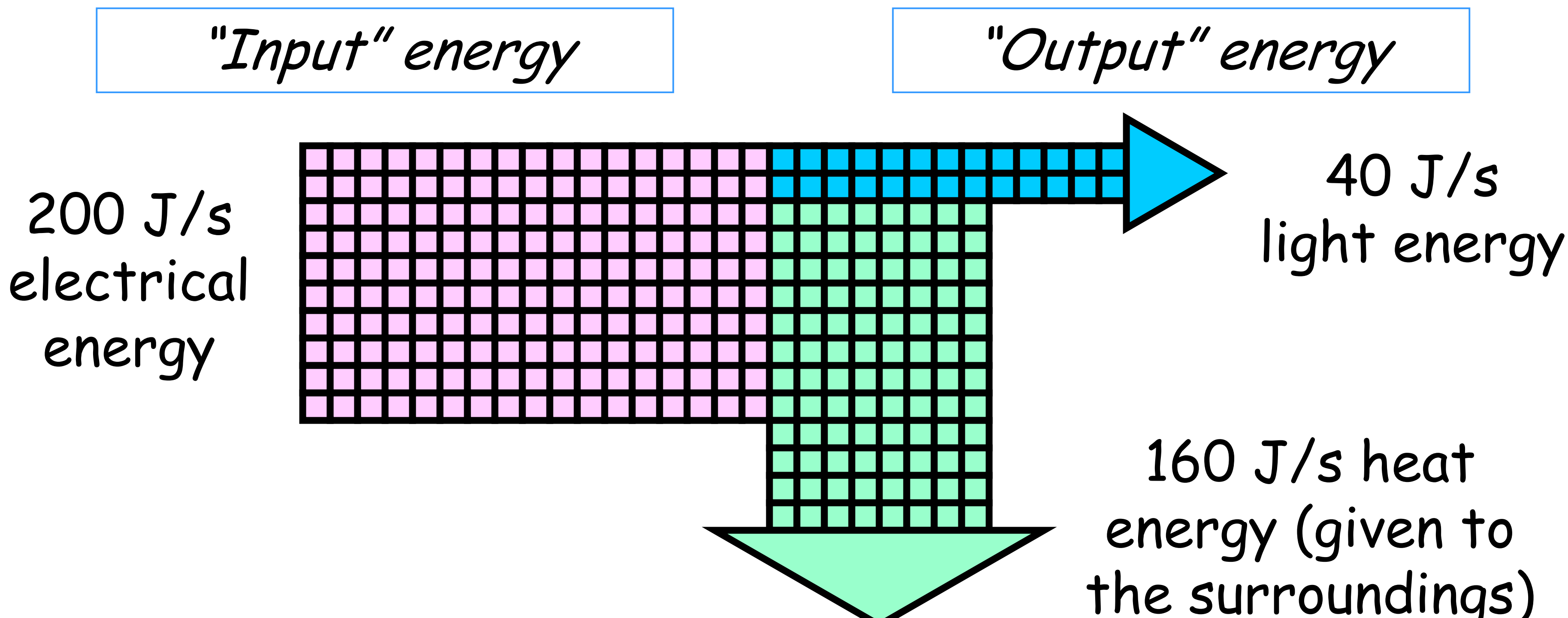
= 300 J – 96 J

= 204 J

$$\text{Efficiency} = \frac{\text{Useful}}{\text{Total}} = \frac{96\ \text{J}}{300\text{J}} = 0.32 \text{ or } 32\%$$

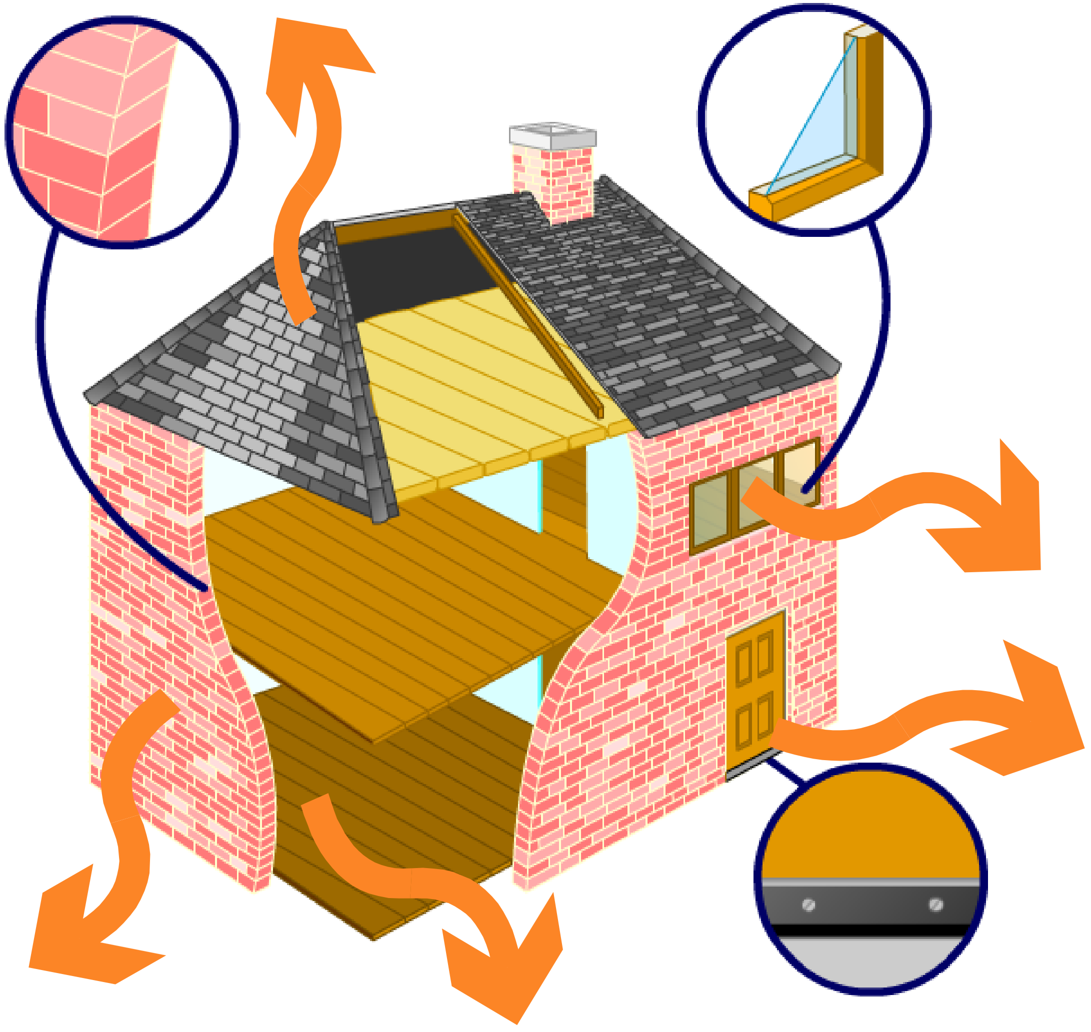
Sankey diagrams

Consider a light bulb. Let's say that the bulb runs on 200 watts (200 joules per second) and transfers 40 joules per second into light and the rest into heat. Draw this as a diagram:



Heat loss from houses

In houses, energy is lost from the roof, the door, the walls, the windows and the floors.

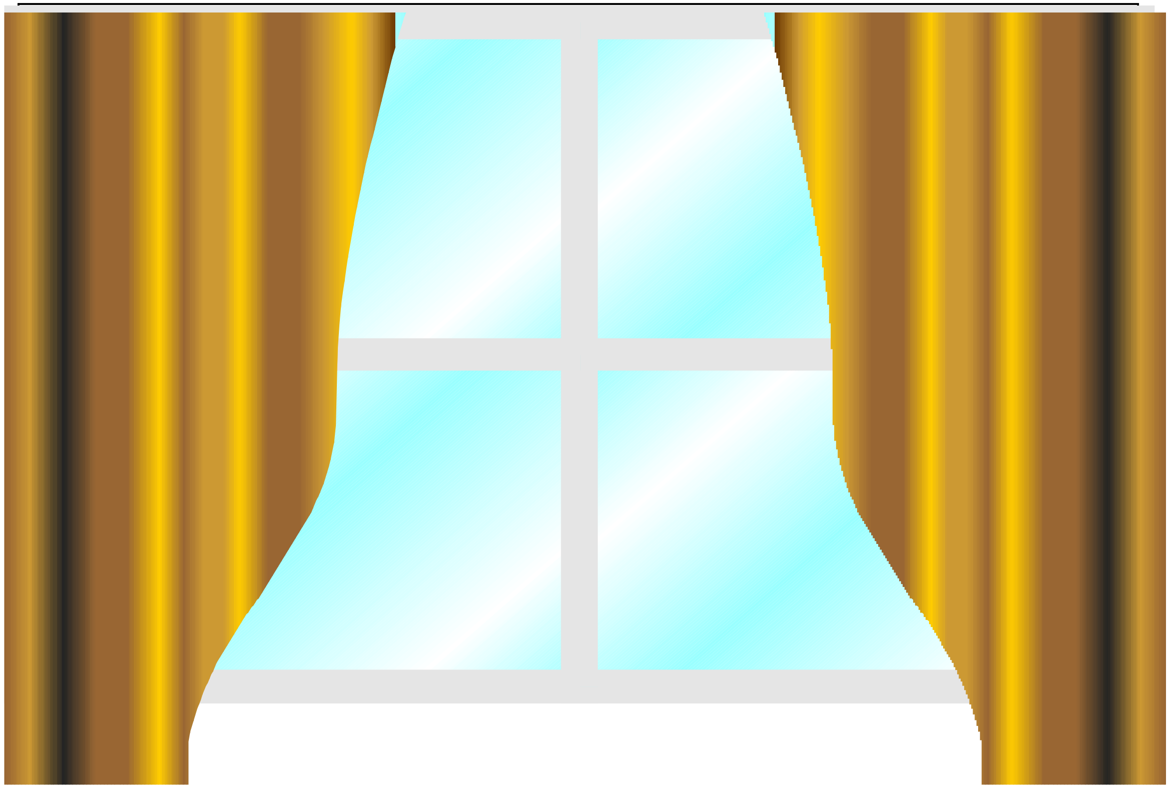


Most energy is lost through the roof and walls.

In order to reduce electricity bills and pollution, energy losses must be kept to a minimum.

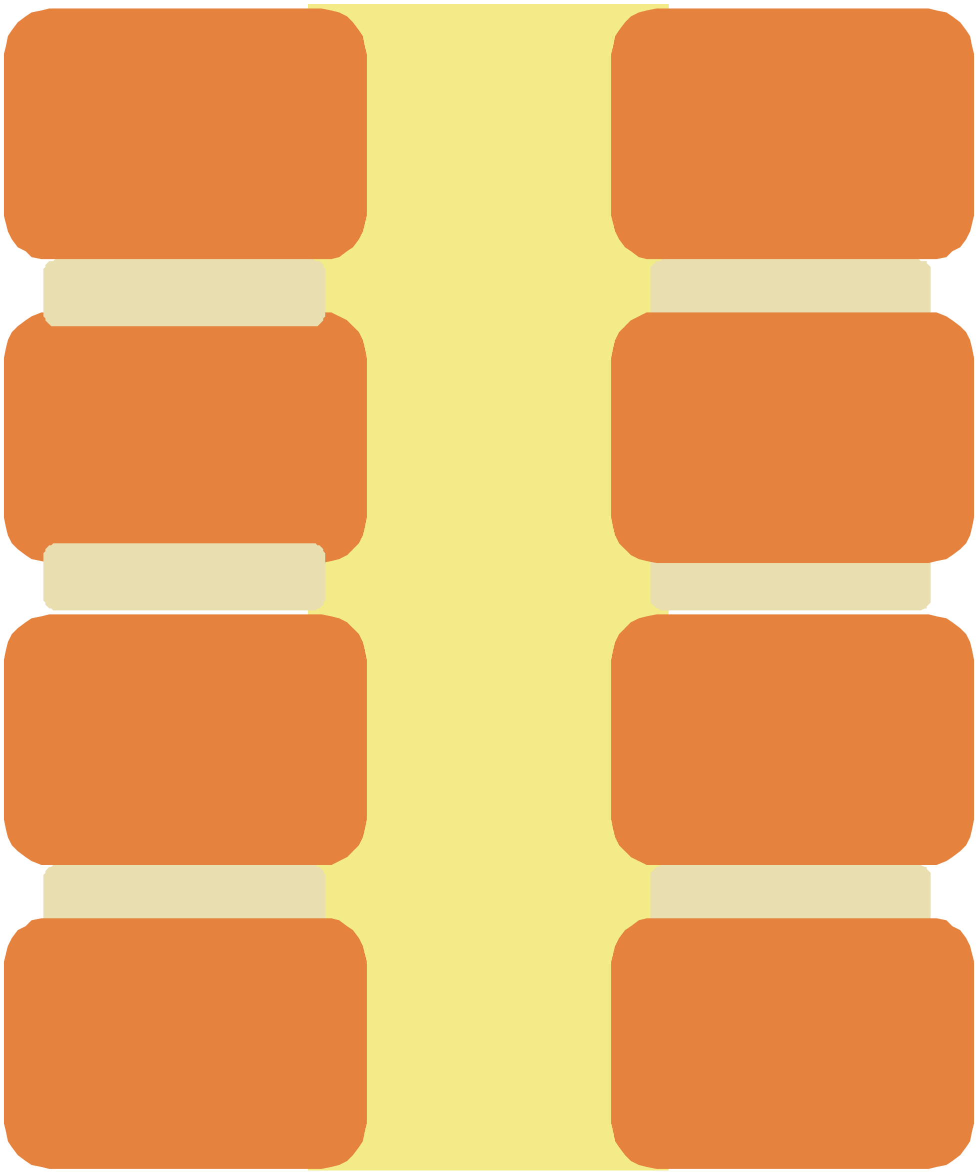

WHERE YOUR MONEY GOES
UNINSULATED
INSULATED
ROOF £125
WALLS £175
DRAUGHTS £75
FLOOR £75
WINDOWS £50
ROOF £40
WALLS £50
DRAUGHTS £45
WINDOWS £20
FLOOR £45
ANNUAL COST £500
ANNUAL COST £200

Heat Loss Prevention - Curtains



Curtains reduce draughts [convection currents] leaving the house. They are opaque and so don't allow much radiated heat to pass through them.

Heat Loss Prevention - Walls



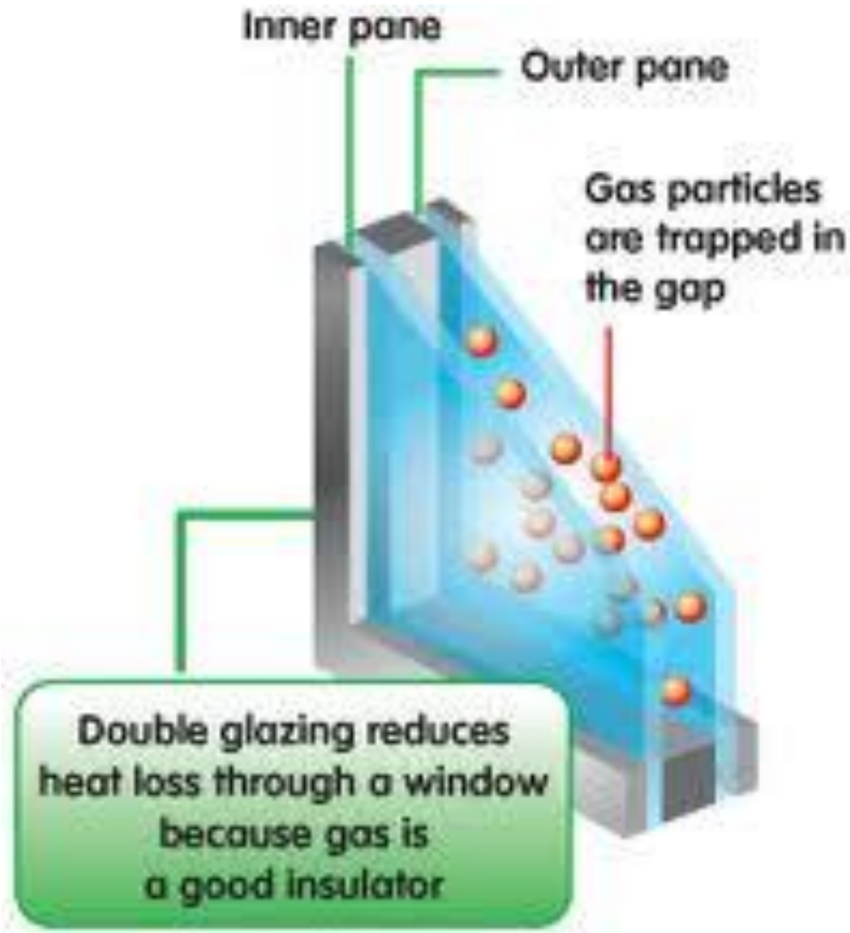
✓Most outside walls have an empty space between the 2 layers of bricks called a *cavity*.

✓This reduces heat loss by *conduction* through the bricks.

✓Cavity wall foam insulation is pumped in between the bricks to reduce *conduction* even more and prevent *convection* in the cavity.

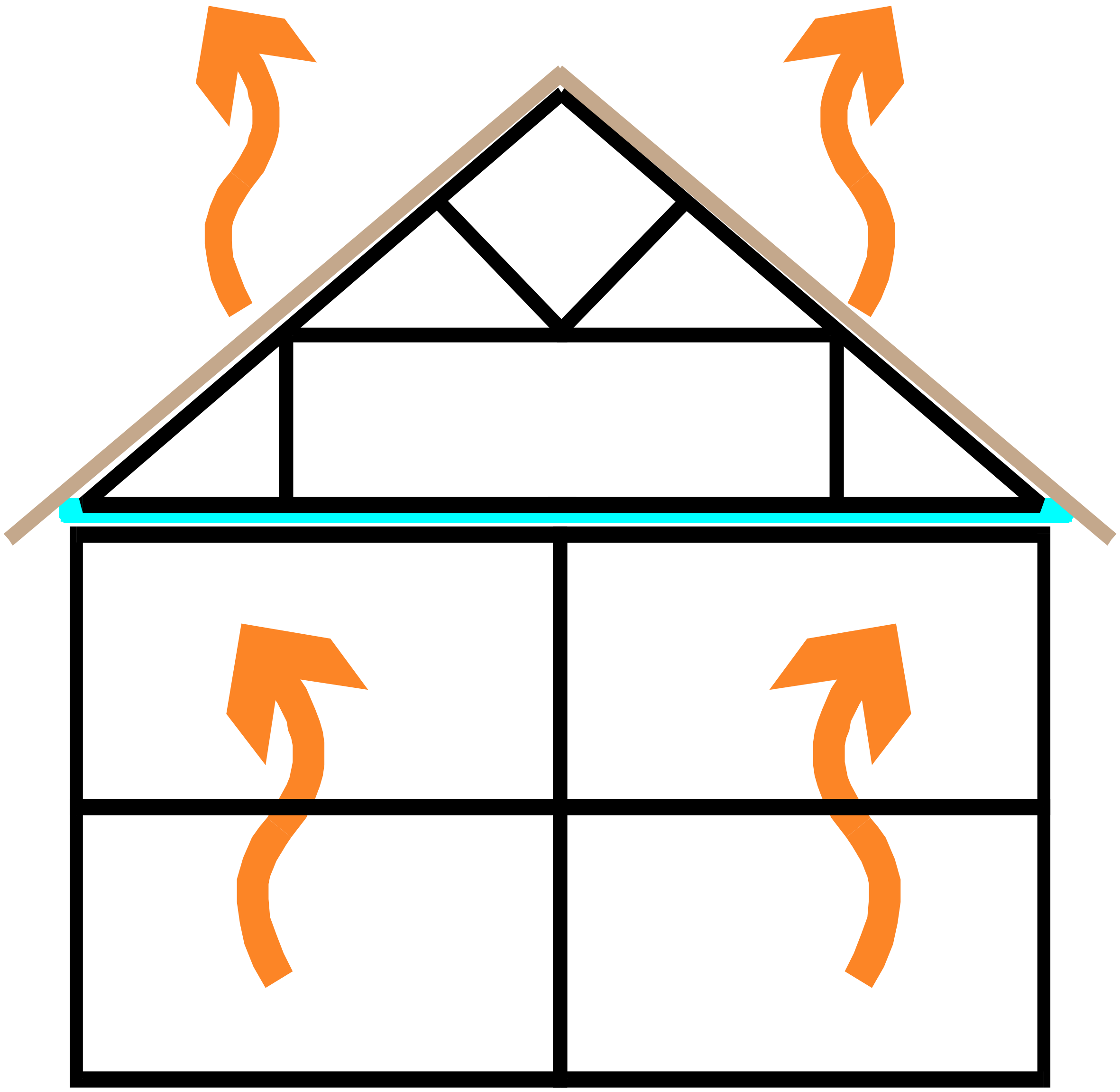
Heat Loss Prevention - Windows

- ✓ A great deal of energy is lost through windows.
- ✓ By adding an extra pane, the trapped air in between acts as an insulator to reduce heat loss by *conduction.*
- ✓ The insulating effect of the gap can be improved further by sucking all the air out to create a vacuum.
- ✓ Double glazing is expensive and almost impossible to smash without a special hammer.


Inner pane
Outer pane
Gas particles are trapped in the gap
Double glazing reduces heat loss through a window because gas is a good insulator


glass
air/gas-argon
spacer
desiccant
coating
polysulfide
butyl

Heat Loss Prevention - Roof



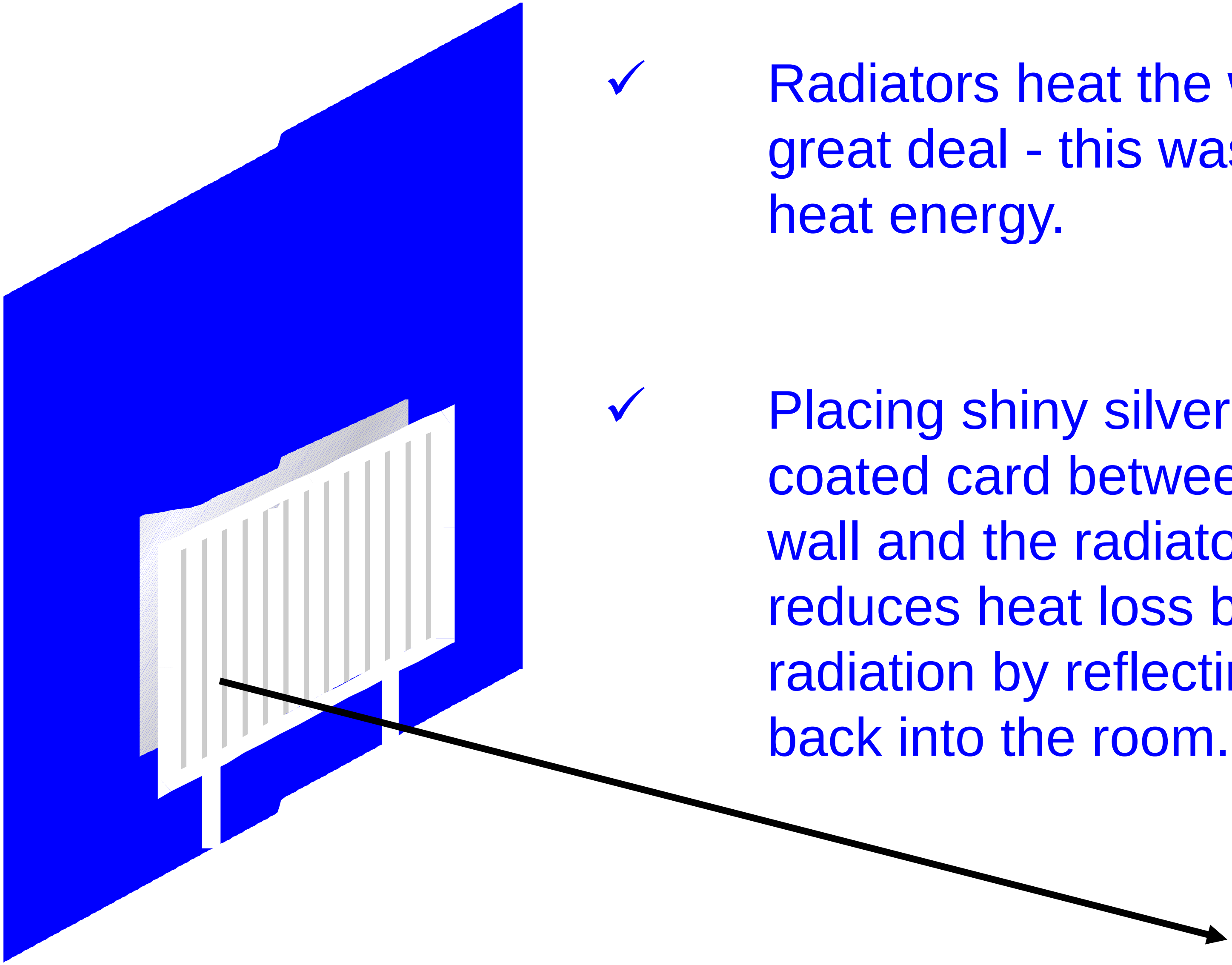
✓The air heated by central heating is less dense than the cooler air around it and rises.

✓The ceilings get heated and eventually the heat escapes through the roof.

✓Loft insulation contains trapped air which forms an insulating layer between the rooms and the attic.

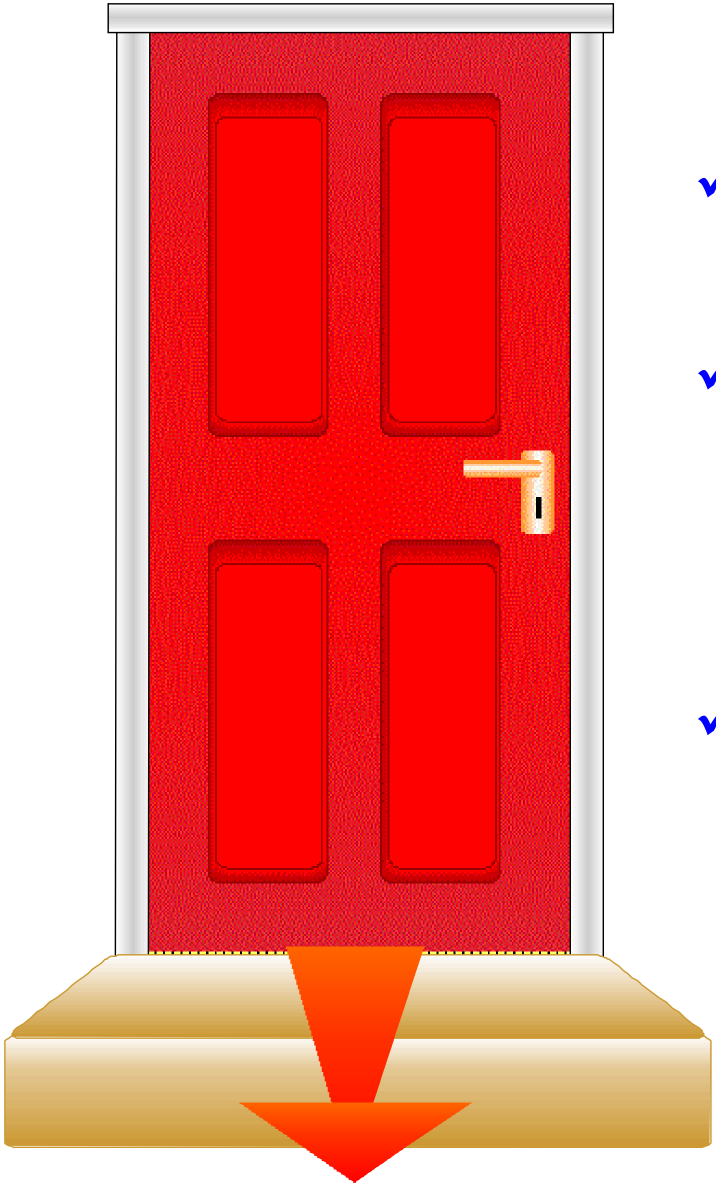

Insulated Loft
Heat
Heat

Heat Loss Prevention - Radiators



- ✓ Radiators heat the wall a great deal - this wastes heat energy.
- ✓ Placing shiny silver coated card between the wall and the radiator reduces heat loss by radiation by reflecting it back into the room.

Heat Loss Prevention - Draughts



- ✓ Draughts are convection currents.
- ✓ A great deal of heat energy is lost in this way but it is the easiest type to prevent.
- ✓ Draught excluders are hairy or spongy strips which close gaps and prevent the convection currents escaping.

Calculating payback time

What is the payback time for these types of insulation?

Heat escaping through…	Cost of heat escaping per year	Cost of insulation	Payback time
Roof	£80	£240	**3 years**
Windows	£40	£3,200	**80 years**
Draughts	£50	£50	**1 year**
Walls	£100	£500	**5 years**

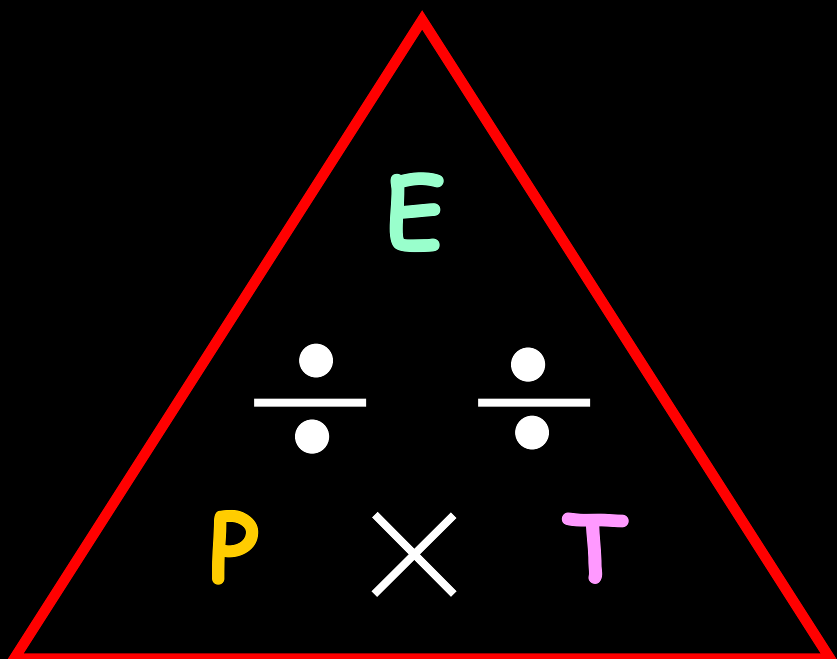
P1.3

- *The usefulness of electrical appliances.*

Energy and Power

The POWER RATING of an appliance is simply how much energy it uses every second.

In other words, 1 Watt = 1 Joule per second



E = Energy (in joules)

P = Power (in watts)

T = Time (in seconds)

Some example questions

1) What is the power rating of a light bulb that transfers 120 joules of energy in 2 seconds?
2) What is the power of an electric fire that transfers 10,000J of energy in 5 seconds?
3) Farhun runs up the stairs in 5 seconds. If he transfers 1,000,000J of energy in this time what is his power rating?
4) How much energy does a 150W light bulb transfer in a) one second, b) one minute?
5) Shaun's brain needs energy supplied to it at a rate of 40W. How much energy does it need during a physics lesson?
6) Damien's brain, being more intelligent, only needs energy at a rate of about 20W. How much energy would his brain use in a normal day?

Paying for Electricity.

- An electricity bill shows how much electrical energy you use and how much it costs.
- The amount of energy used depends on:

  The power of the appliance.

  How long it is used for.
- Electrical energy (kWh) = power (kW) x time (h)
- 1kWh = 1 "unit"
- Total cost = number of units used x cost per unit

The Cost of Electricity

Electricity is measured in units called "kilowatt hours" (kWh). For example...

A 3kW fire left on for 1 hour uses 3kWh of energy

A 1kW toaster left on for 2 hours uses 2kWh

A 0.5kW hoover left on for 4 hours uses __kWh

A 200W TV left on for 5 hours uses __kWh

A 2kW kettle left on for 15 minutes uses __kWh

The Cost of Electricity

To work out how much a device costs we do the following:

Cost of electricity = Power (kW) x time (h) x cost per kWh (p)

For example, if electricity costs 8p per unit calculate the cost of the following…

1) A 2kW fire left on for 3 hours	48p
2) A 0.2kW TV left on for 5 hours	8p
3) A 0.1kW light bulb left on for 10 hours	8p
4) A 0.5kW hoover left on for 1 hour	4p

P1.4

- *Methods we use to generate electricity.*

Energy resources

What type of energy are these resources?

renewable	non-renewable
?	?
?	?
?	?
?	?
?	
?	

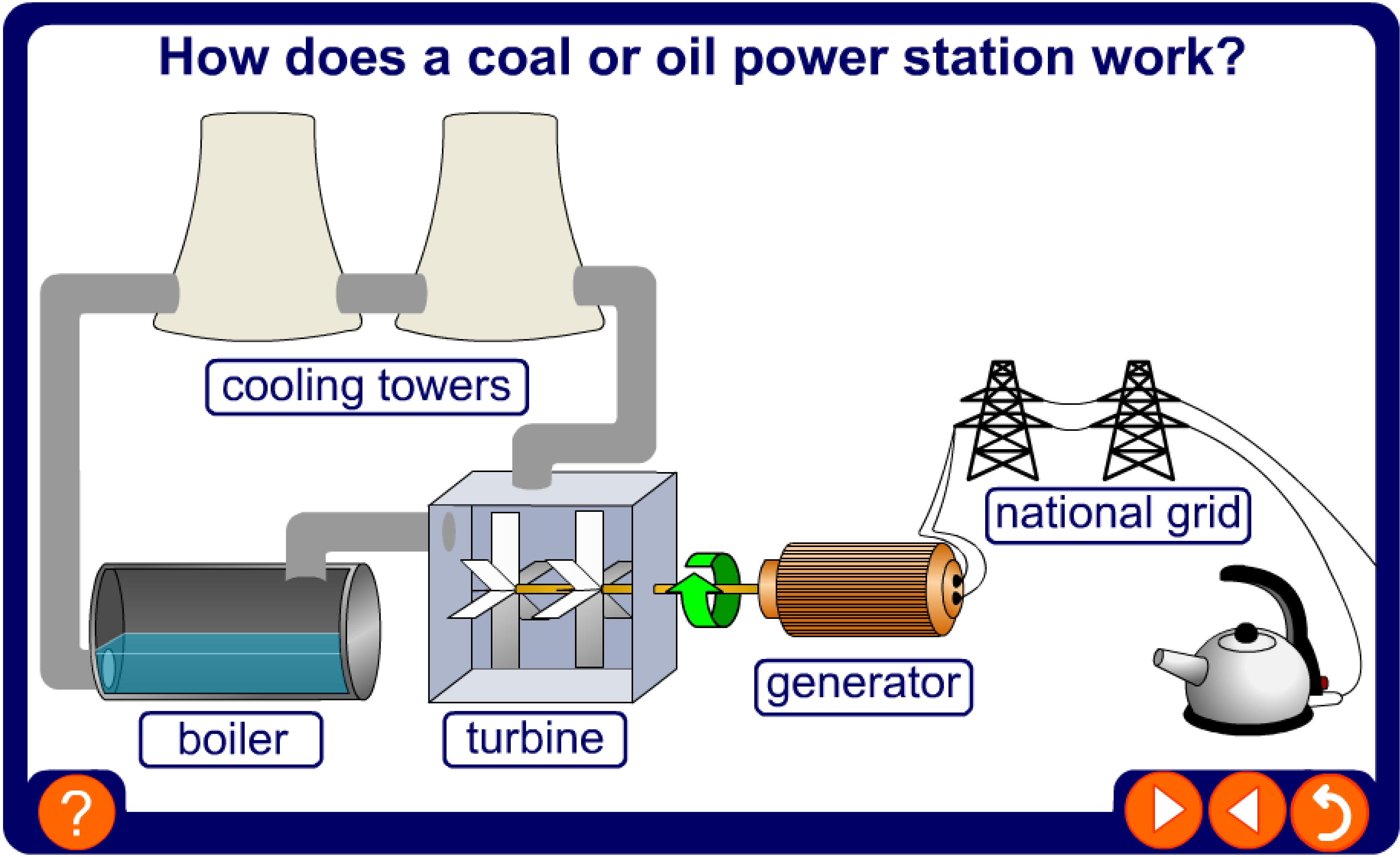
solar

?

C

solve

What happens in a power



Fossil fuels

Although there are problems burning fossil fuels in power stations there are also advantages:

Advantages	Disadvantages
readily available	non-renewable
easily transported	acid rain
low fuel cost	greenhouse effect
low building costs	inefficient
short start-up times	

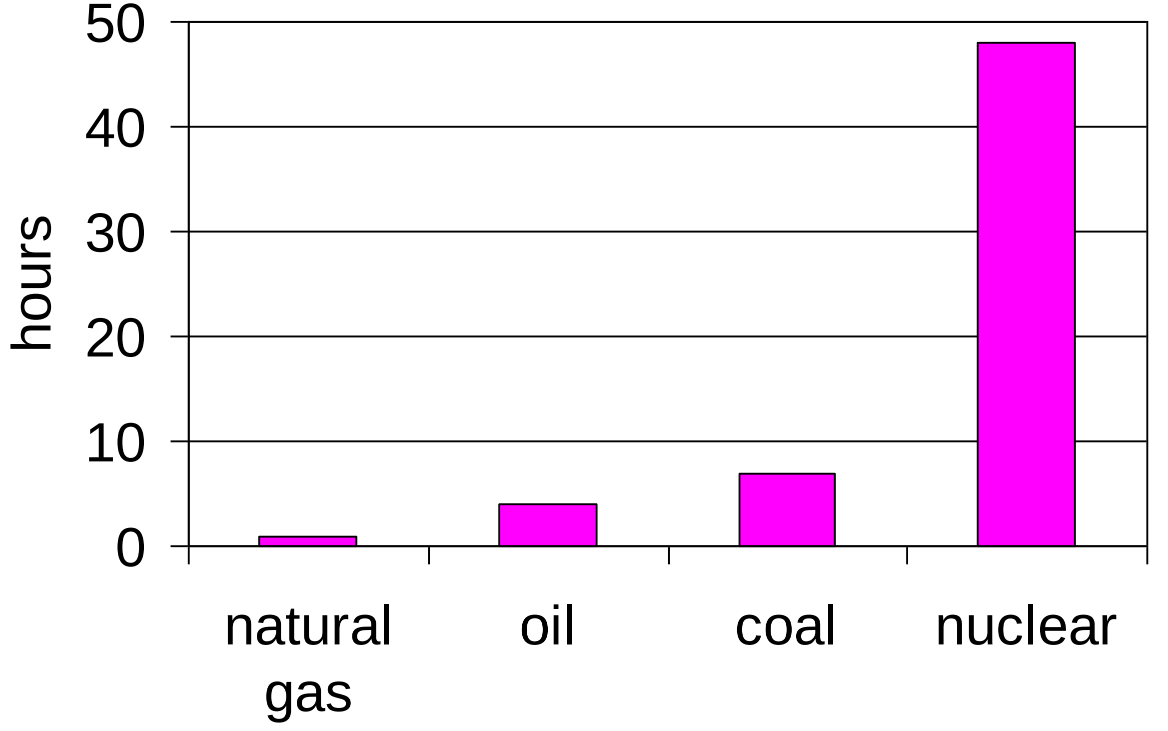
Although there are problems in the use of nuclear power, there are also advantages:

Advantages	Disadvantages
Cheap to run	Expensive to build
Conserves fossil fuels	Expensive to decommission
No sulphur dioxide emissions	Radioactive waste
No carbon dioxide emissions	Links with cancer
Safe under normal conditions	Non-renewable
Little fuel used means less transport needed	Risk of disaster

Start-up times

Power stations cannot just be turned on at the flick of a switch. They need to be started up – this process can take days!

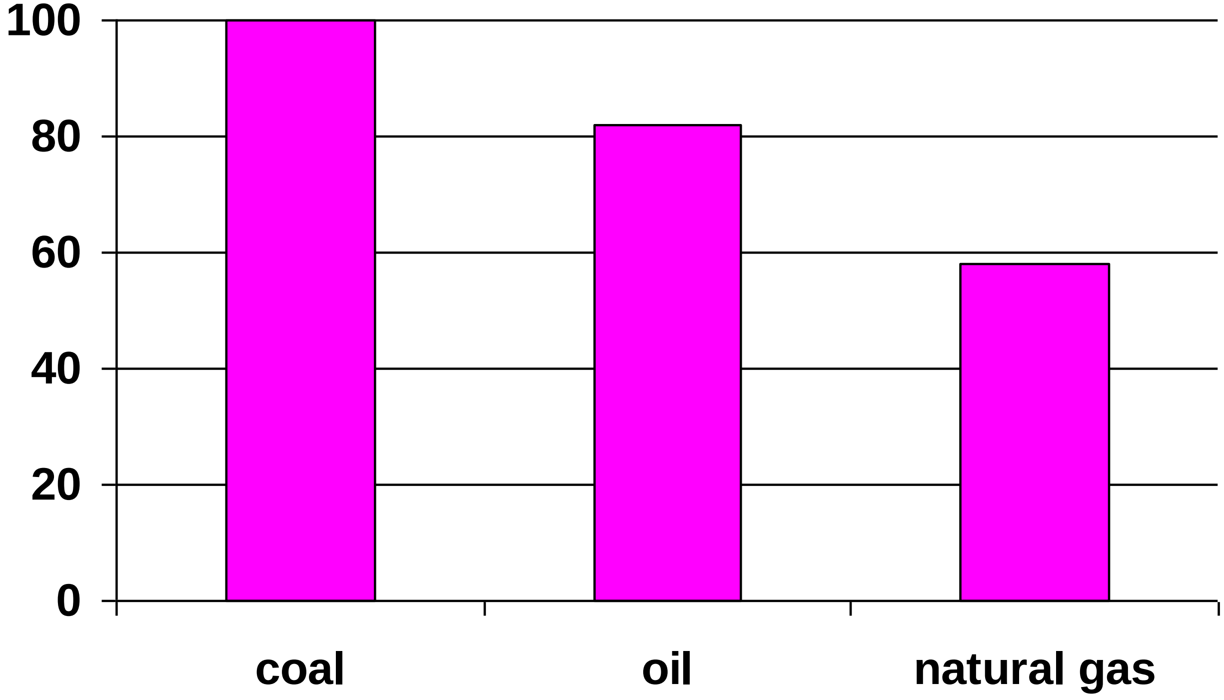
The graph below shows the typical start-up times for different types of power station



Carbon dioxide from fuels

Some fossil fuels release less carbon dioxide when burnt than others.

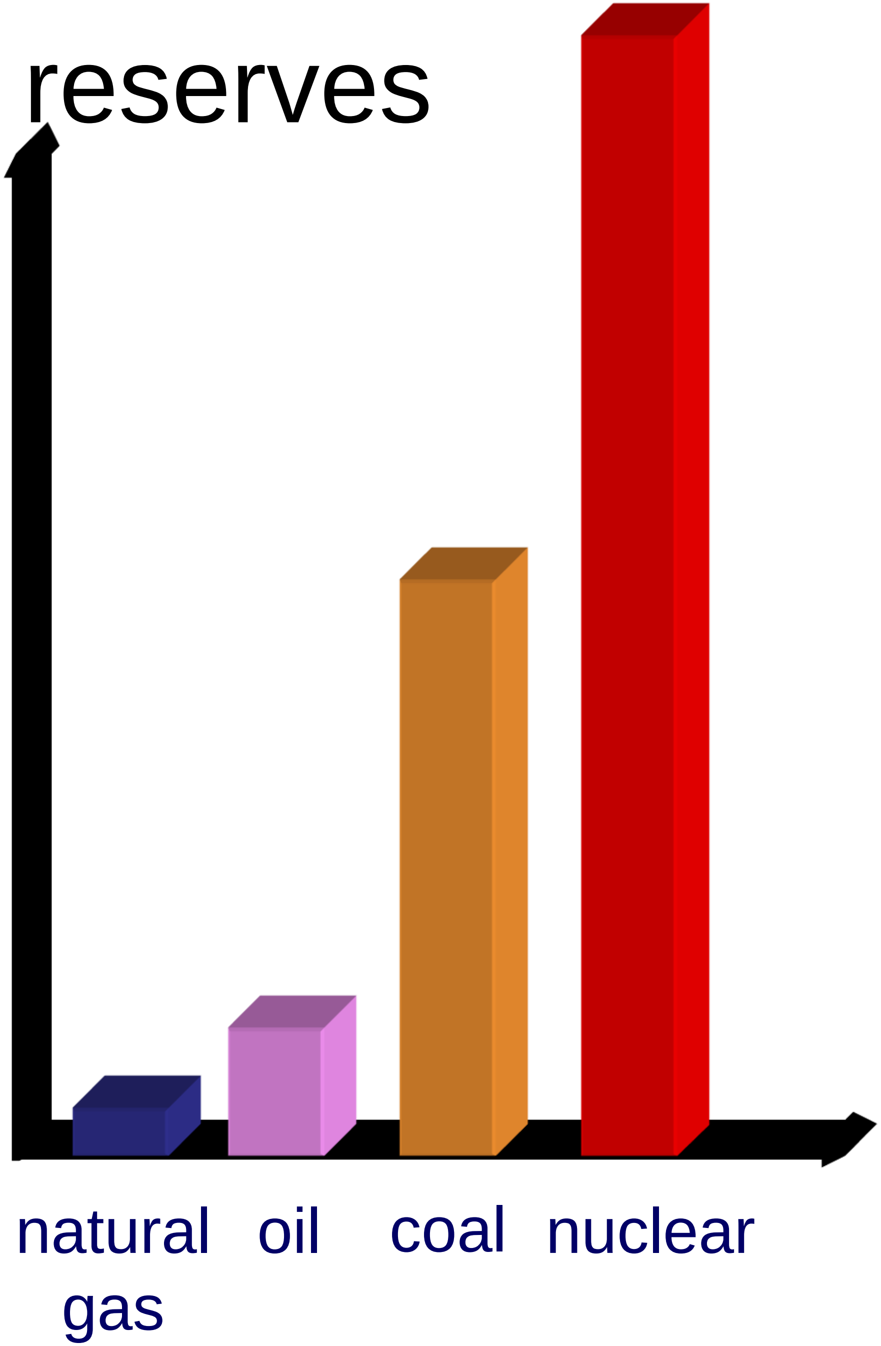
The graph below shows the relative amounts of carbon dioxide released per unit of electricity produced:



Fuel reserves

Fuel	Time until reserves run out (years)
natural gas	25-30
oil	about 75
coal	about 300
nuclear	thousands

Even though nuclear fuel will last thousands of years it will still run out eventually.



Glossary

- **acid rain –** Rainwater that is more acidic than normal because acidic gases have dissolved in it.
- **fossil fuel –** A fuel made from the remains of decayed plants or animals.
- **generator –** A device that transforms kinetic energy into electrical energy.
- **global warming –** The increase in the temperature of the Earth, which some scientists think is causing climate change.
- **greenhouse effect –** The trapping of heat from the Sun by certain gases in the Earth's atmosphere.
- **non-renewable –** An energy source that cannot be used again.
- **renewable –** An energy source that can be regenerated.
- **turbine –** A device that turns heat energy into kinetic energy.

Glossary

- **biomass energy –** Energy from living matter, which can used as fuels.
- **geothermal energy –** Heat from radioactive decay in rocks deep below the Earth's surface.
- **hydroelectric energy –** The gravitational potential energy of falling water, which is used to generate electricity.
- **solar energy –** Energy from the Sun, which is converted into thermal or electrical energy.
- **tidal energy –** Energy from the rise and fall of the tides, which can be used to generate electricity.
- **wave energy –** Energy from the up and down motion of waves, which can be used to generate electricity.
- **wind energy –** Energy from the movement of air, which is transferred to wind turbine and used to generate electricity.

Source	Disadvantages
Wind	Depends on weather, visual pollution, difficult to “store”
Wave	Harms wildlife, depends on size of waves, depends on weather
Tidal	Depends on size of tides, harms wildlife, visual pollution
Hydroelectric	Habitats can be destroyed, only good as a “short term” supply

Also these sources all have high setting up costs

THE NATIONAL GRID

The National Grid is a network of power stations and cabling that carries electricity around the country

Electricity is generated
at power stations and
distributed around the UK
through a vast circuit
of electrical cabling

TRANSPORTING ELECTRICITY

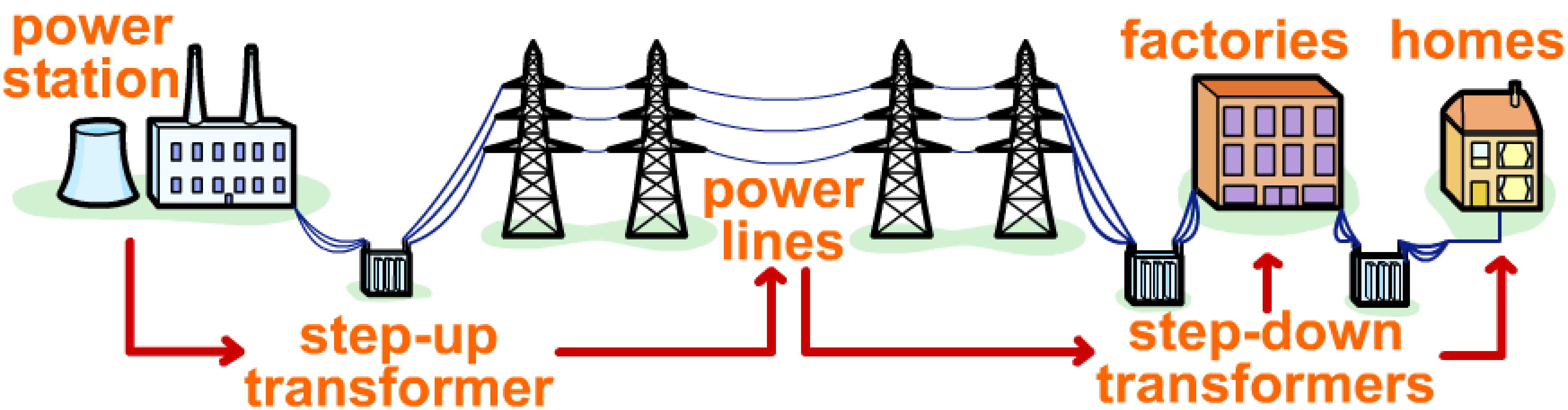



Step-Up Transformer

This is how our National Grid Works!!

Step-Down Transformer


How does the electricity supply chain work?



The diagram shows the electricity supply chain from a power station to where electricity is used.

Click on each part of the chain to find out how the voltage changes as the electricity travels to where it is needed .

Why do we need transformers?

Keeping the current low means electricity can be transported long distances without losing too much energy.

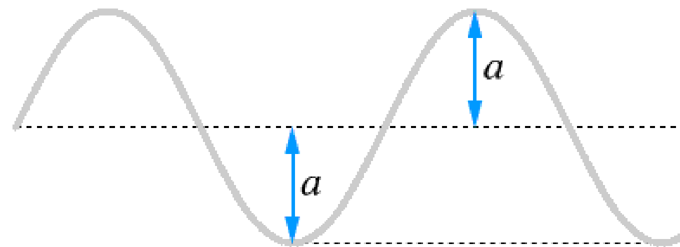
COMPARISON	Installation - cost	Installation - ease of	Environmental impact - visual impact	Environmental impact - the land itself	Maintenance and reliability
Overhead power lines	lower, simple erection of pylons and linking cables carrying the high voltage current	relatively easy, simple erection job	considerable, miles of pylons and cables stretching across the countryside - controversial in designated areas of outstanding natural beauty	slight - foundations of pylons	much more needed and much less reliable - weather damage eg from frost, snow, corrosion of structure
Underground cables	much higher, costly trenches and insulated cables	much more work, all that digging and filling!	minimal, not really seen at all	considerable, but temporary - digging trenches is disturbing the land, but no lasting damage	much less and more reliable, not affected by weather BUT not as easy to trace and access if fault develops

P1.5

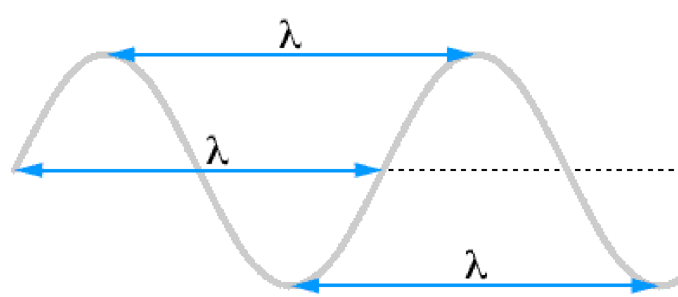
- *The use of waves for communication and to provide evidence that the universe is expanding.*

Wave properties.

1) **Amplitude** – this is "how high" the wave is:



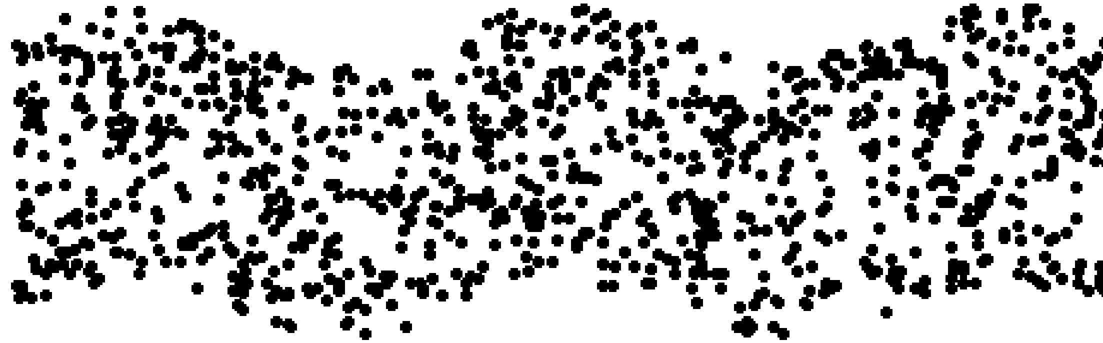
2) **Wavelength (λ)** – this is the distance between two corresponding points on the wave and is measured in metres:

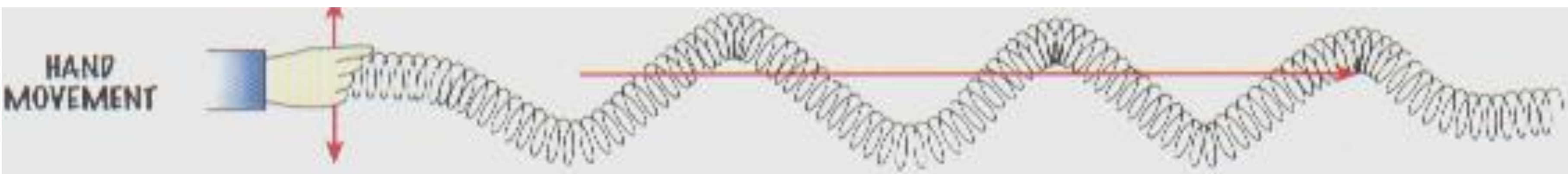


3) **Frequency** – this is how many waves pass by every second and is measured in Hertz (Hz)

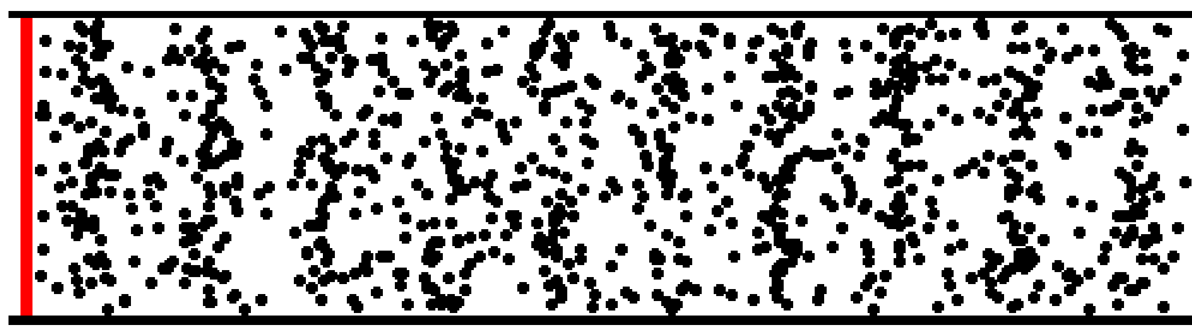
Some definitions…

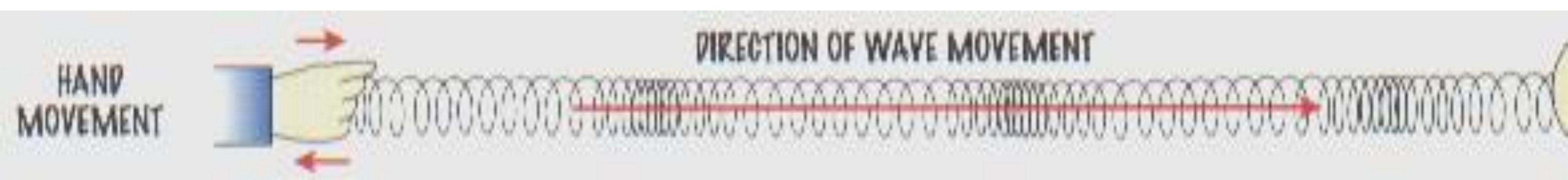
Transverse waves are when the displacement is at right angles to the direction of the wave…





Longitudinal waves are when the displacement is parallel to the direction of the wave…

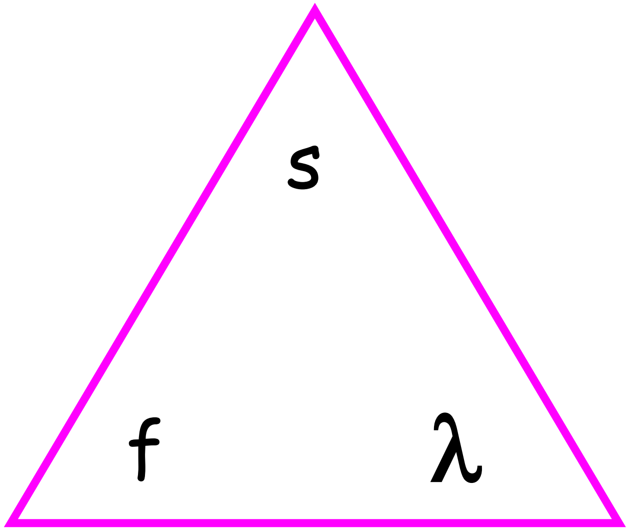




The Wave Equation

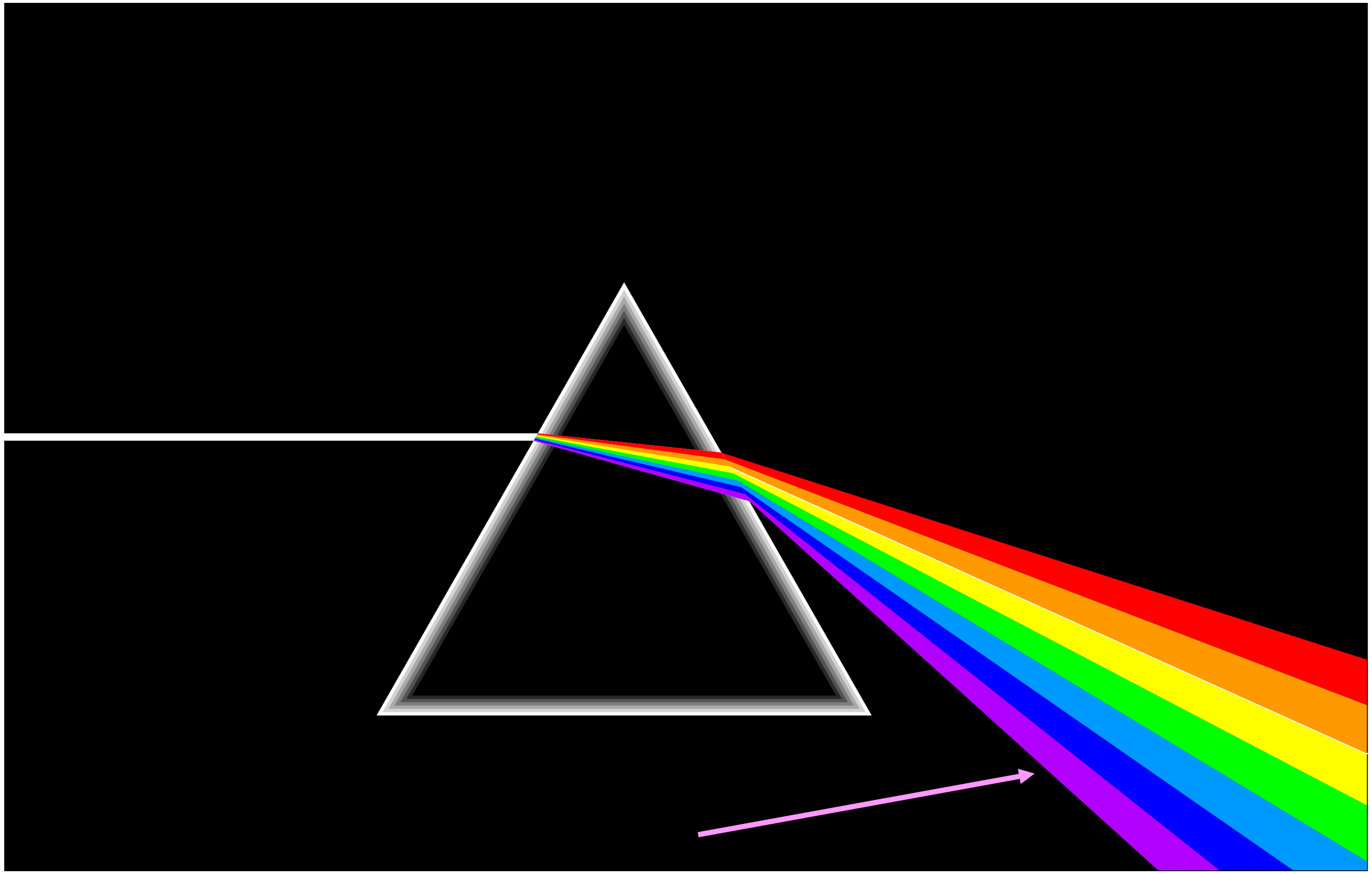
The wave equation relates the speed of the wave to its frequency and wavelength:

Wave speed (s) =	frequency (f) ×	wavelength (λ)
in m/s	in Hz	in m



Deviation of Light

RED LIGHT is refracted THE LEAST



VIOLET LIGHT is refracted THE MOST

The electromagnetic spectrum

Each type of radiation shown in the electromagnetic spectrum has a different wavelength and a different frequency:

High frequency, short wavelength → **Low frequency, long wavelength**

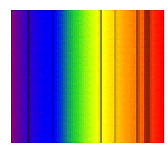
Gamma rays

γ

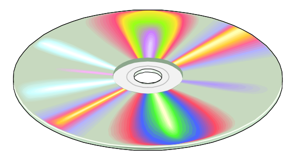
X-rays

Ultra violet

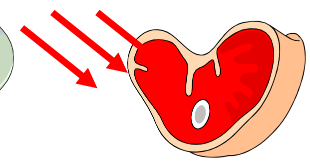
Visible light



Infra red



Microwaves

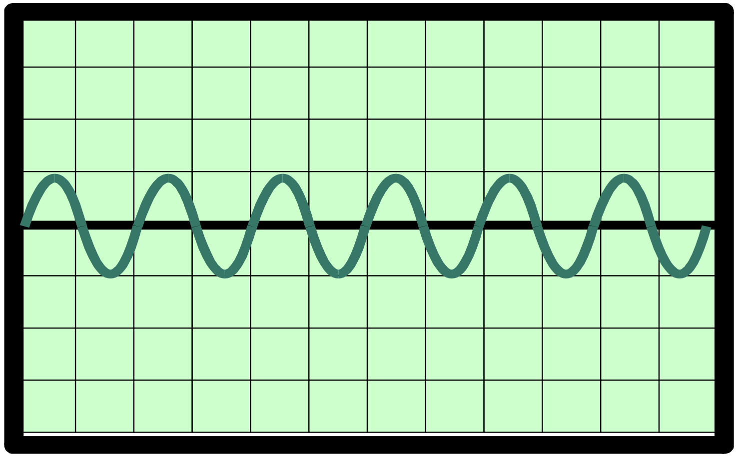


Radio/TV

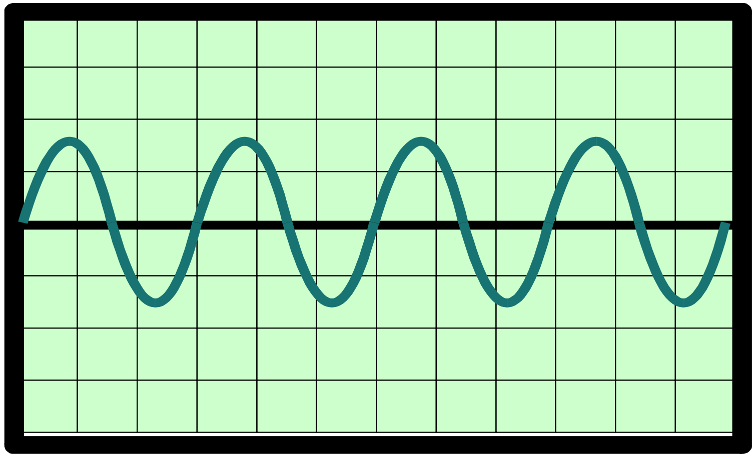
Each of these types travels at the same speed through a vacuum (300,000,000m/s), and different wavelengths are absorbed by different surfaces (e.g. infra red is absorbed very well by black surfaces). This absorption may heat the material up (like infra red and microwaves) or cause an alternating current (like in a TV aerial).

Sound waves on an oscilloscope:

What is the difference between the sound wave of a **quiet** sound and a **loud** sound?



quiet sound

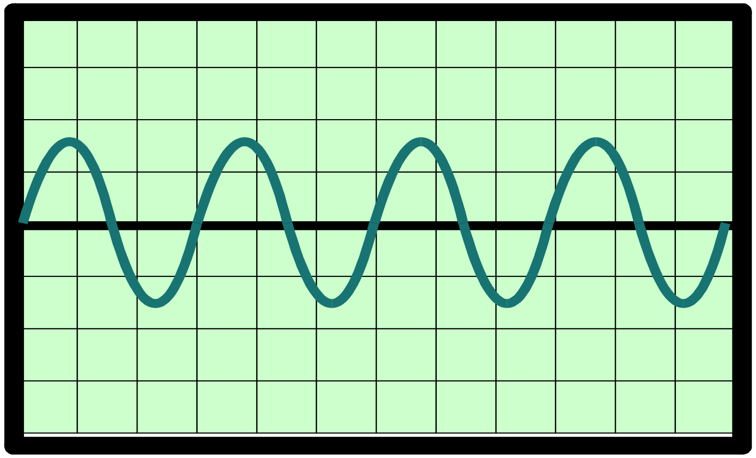


loud sound

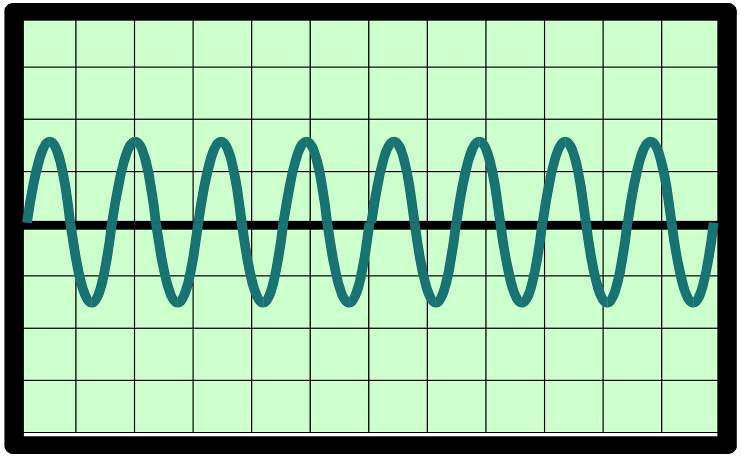
The **loud** sound has **taller** waves.

The **louder** the sound, the **greater** the **amplitude**.

What is the difference between the sound wave of a **low pitch** sound and a **high pitch** sound?



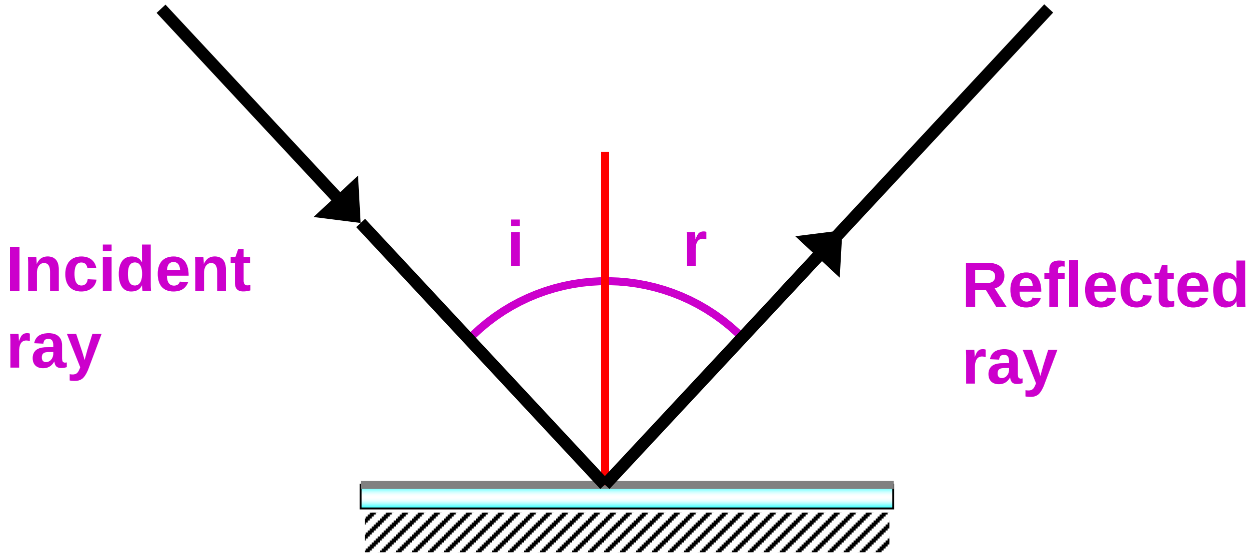
low pitch sound



high pitch sound

The **high pitch** sound has a **shorter wavelength**, so more waves are visible. It has **higher frequency** waves.

Law of reflection



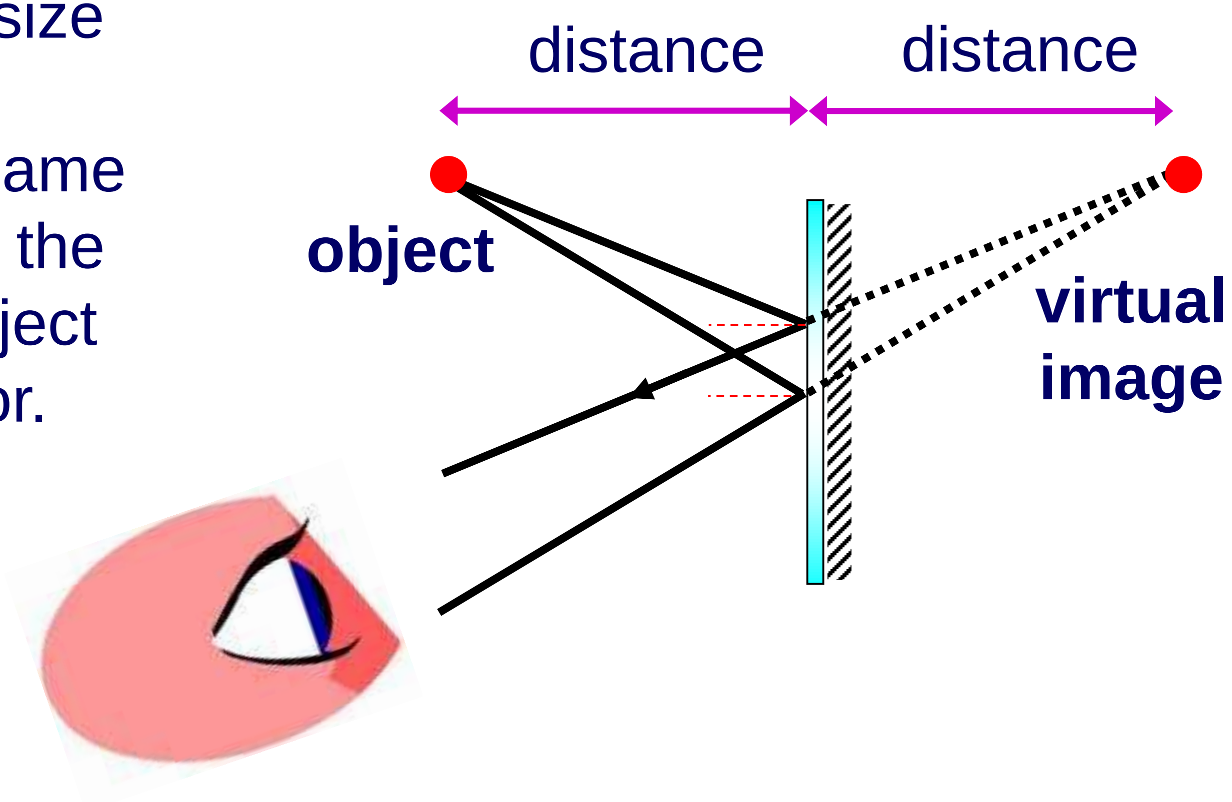
angle of incidence (i) = angle of reflection (r)

This is called the **law of reflection** and is true for any type of wave being reflected from a surface.

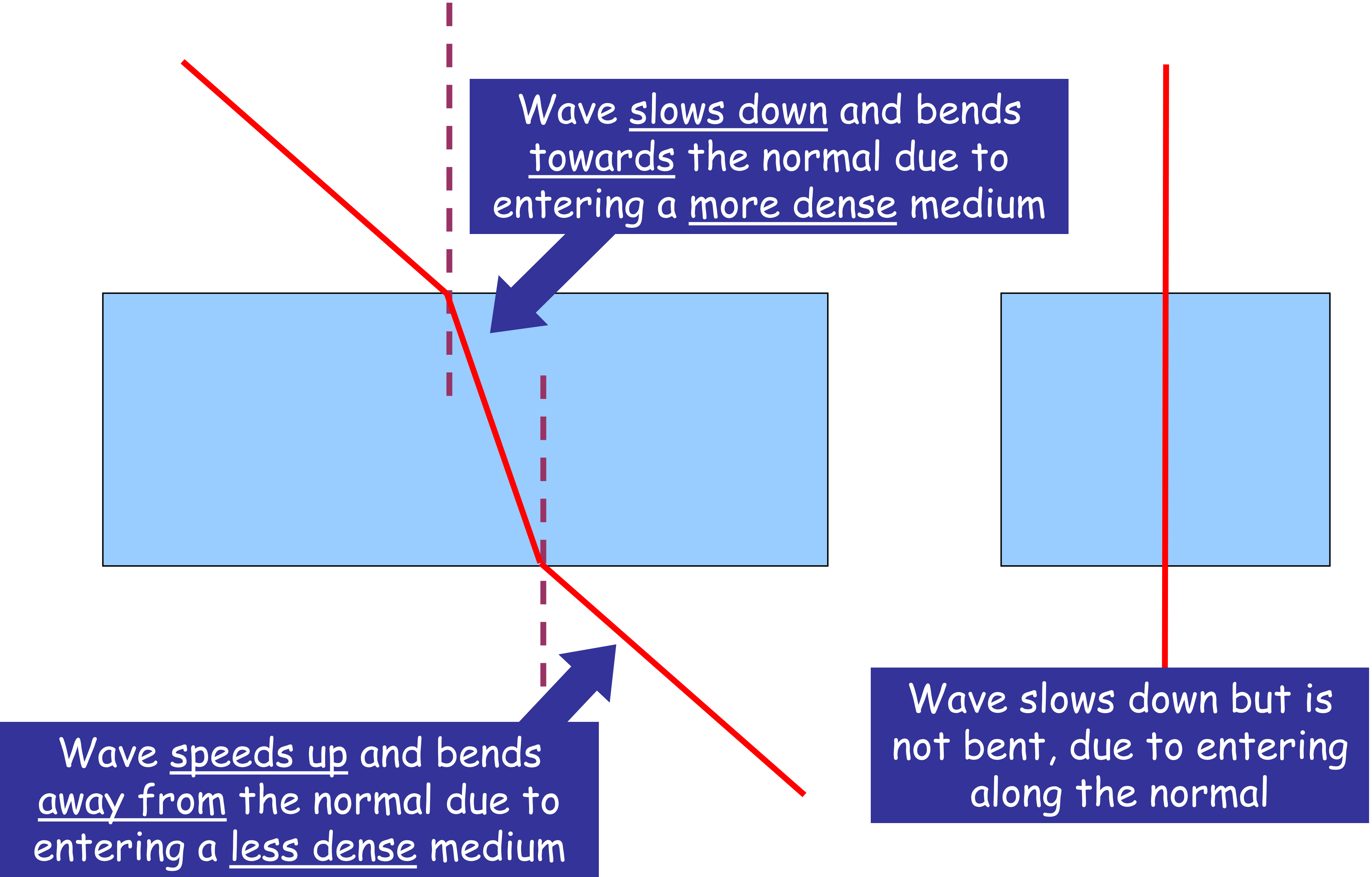
Virtual images

When you look at a mirror you see a virtual image that appears to be behind the mirror.

The image appears to be the same size as the original object and the same distance behind the mirror as the object is from the mirror.

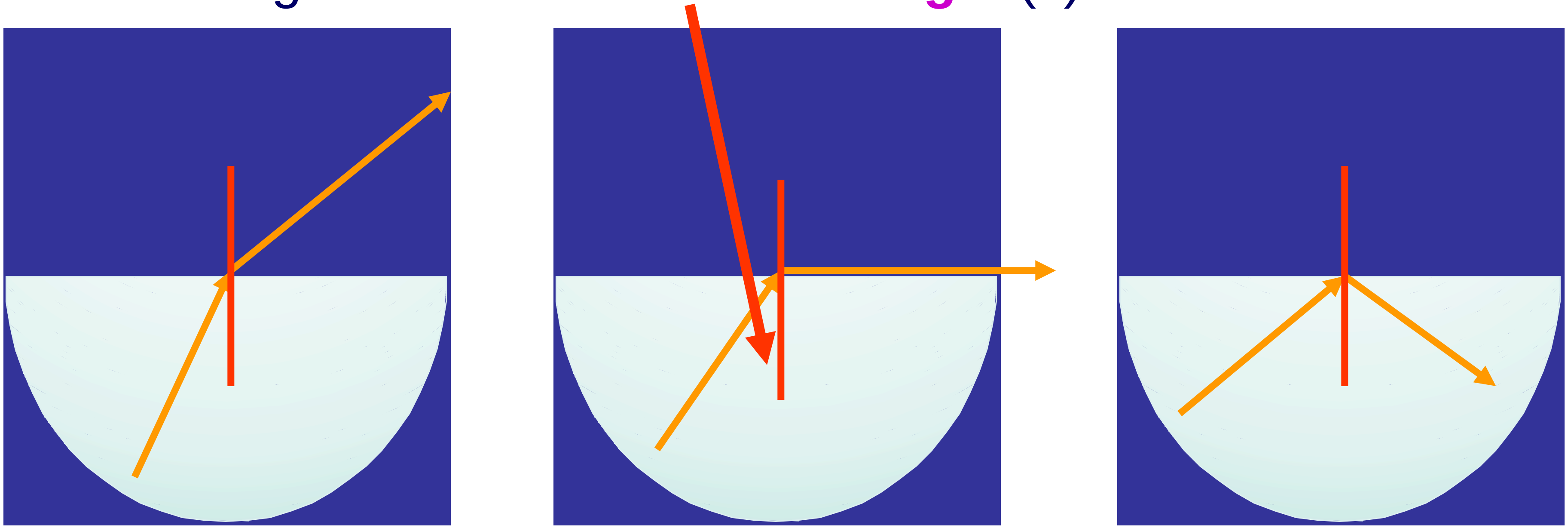


Refraction through a glass block:



Total internal reflection

This angle is called the **critical angle** (c).



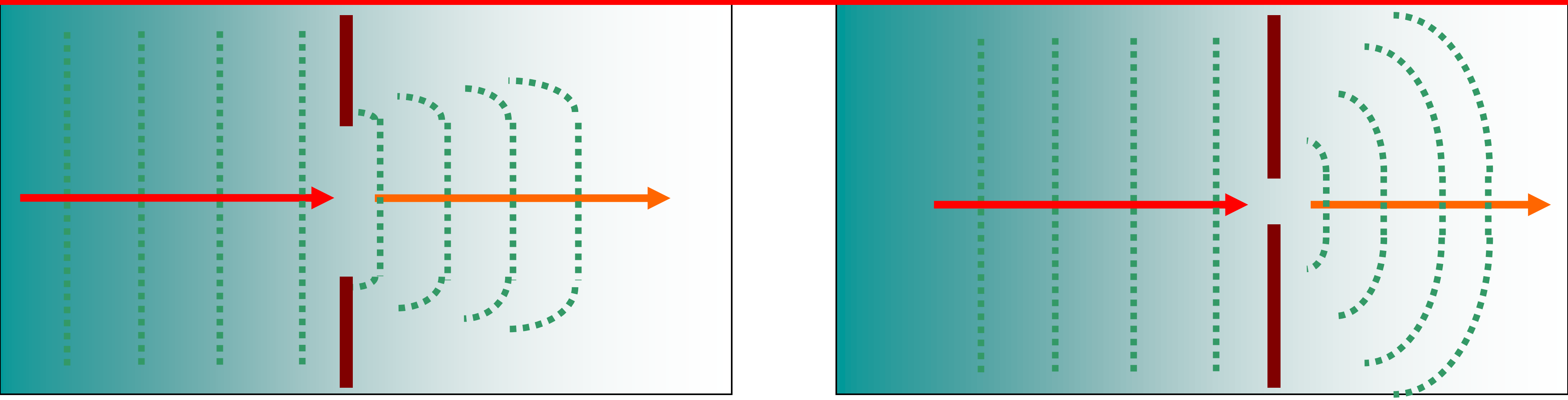
i < c | i = c | i > c

Refraction | Critical case | Total internal reflection (TIR)

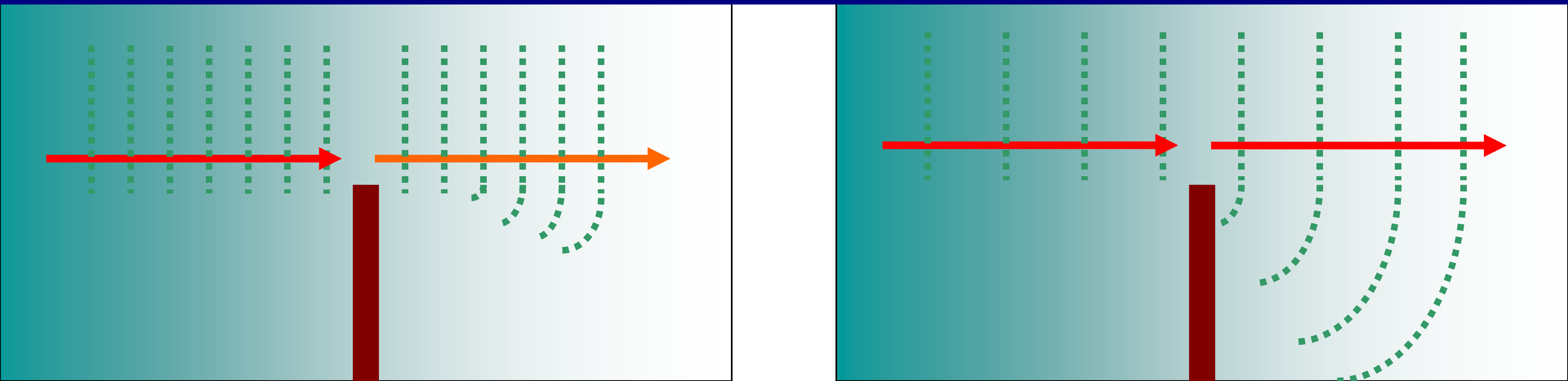
Different materials have different critical angles. Diamond has the lowest at 24°, which is why it reflects so much light.

Diffraction

More diffraction if the size of the gap is similar to the wavelength

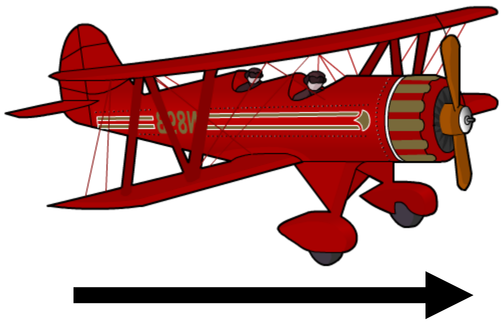


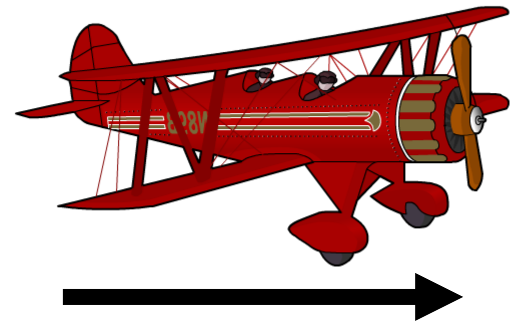
More diffraction if wavelength is increased (or frequency decreased)



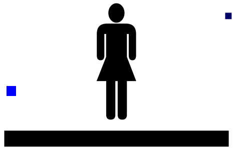
The Doppler effect

Think about the noise a plane makes as it passes you.





As the plane approaches, it sounds **higher pitched...**

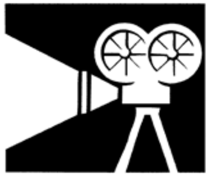


…as it moves away from you, it sounds **lower pitched**.

This apparent shift in frequency is called the **Doppler effect**.

The same thing happens with light:

- The wavelength of light emitted by approaching objects appears to be **shortened** (**blue-shifted**);
- The wavelength of light emitted by receding objects appears to be **increased** (**red-shifted**).



Edwin Hubble (1889-1953) was a famous scientist who examined the light from nearby galaxies. He made two important **observations**:

1. That most of the galaxies' light was shifted towards the red end of the spectrum;
2. The further away a galaxy was, the more its light was red-shifted.

From his observations, Hubble made these **conclusions**:

1. That most galaxies were moving away from our own;
2. The further away a galaxy was, the faster it was moving away from us;
3. That the Universe must be **expanding**.

The big-bang theory

The big-bang theory states that the Universe is expanding due to a large 'explosion' (big bang) billions of years ago.

Evidence to support this theory includes:

1. The Cosmic Microwave Background Radiation (CMB), which is thought to be an 'echo' of the initial explosion.
2. Hubble's observations about red-shifted light.

This theory gives rise to different fates for the Universe:

1. If the mass of the Universe is large enough, it will eventually start to contract due to gravity – **closed Universe**.
2. If the mass of the Universe is smaller, it will expand forever as there is not enough gravity to halt its expansion – **open Universe**.