# P1 – Energy Stores

## Energy Stores and Systems

| Energy Stores | |
|---|---|
| kinetic | Moving objects have kinetic energy. |
| thermal | All objects have thermal energy. |
| chemical | Anything that can release energy during a chemical reaction. |
| elastic potential | Things that are stretched. |
| gravitational potential | Anything that is raised. |
| electrostatic | Charges that attract or repel. |
| magnetic | Magnets that attract or repel. |
| nuclear | The nucleus of an atom releases energy. |

Energy can be transferred in the following ways:

mechanically – when work is done;

electrically – when moving charge does work;

heating – when energy is transferred from a hotter object to a colder object.

## Conservation of Energy

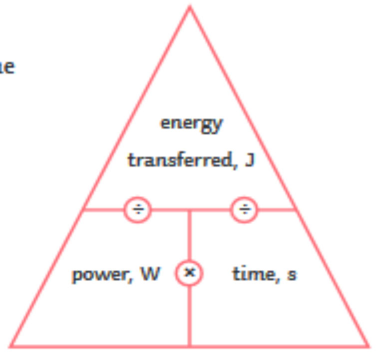
Energy can never be created or destroyed, just transferred from one form to another. Some energy is transferred usefully and some energy gets transferred into the environment. This is mostly wasted energy.

## Power

Power is the rate of transfer of energy – the amount of work done in a given time.

**power = energy transferred ÷ time**

**P (W) = E (J) ÷ t (s)**

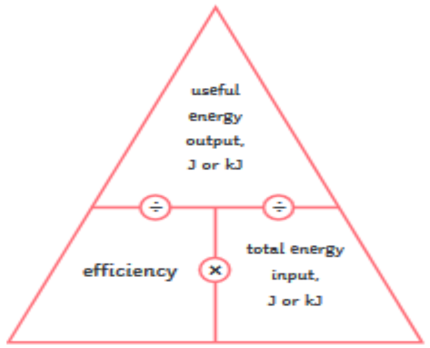



## Efficiency

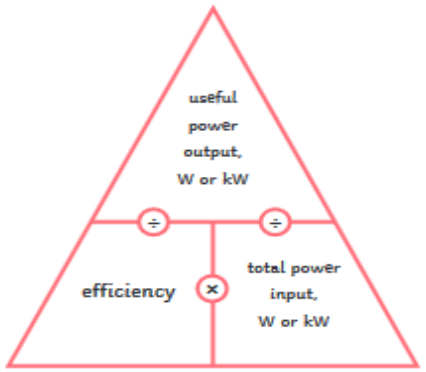
When energy is transferred, some energy is wasted. The less energy that is wasted during the transfer, the more efficient the transfer.

There are two equations to calculate efficiency:

$$\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$$




$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$




Some energy is always wasted. Nothing is 100% efficient.

## Example of Energy Transfers- Kettle

Chemical energy store from fuel at power station decreases →

→ Thermal energy store of water and surroundings increases

Electrical pathway

## Example of Energy Transfers- Car

Chemical energy store from fuel decreases →

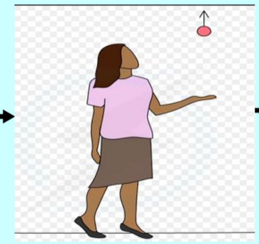
→ Kinetic energy store of car increases
Thermal energy store of car and surroundings increases

Mechanical pathway
Radiation pathway

| Material | Thermal Conductivity (W/m K) |
|---|---|
| Silver | 406 |
| Copper | 385 |
| Aluminium | 205 |
| Iron | 79 |
| Concrete | 0.8 |
| Steel | 50 |
| Concrete | 0.8 |
| Red Brick | 0.6 |
| Asbestos | 0.08 |
| Fibreglass | 0.04 |
| Rock wool | 0.04 |
| Wood | 0.04-0.12 |

## Example of Energy Transfers – Projecting Ball Upwards

Chemical energy store from person decreases →



→ Kinetic energy store of ball increases
GPE store of ball increases
Thermal energy store of ball and surroundings increases

Mechanical pathway

## Thermal Conductivity

- Conduction is when thermal energy transfers through a solid material
- Thermal conductivity is a measure how fast thermal energy transfers through a material
- The higher the thermal conductivity, the faster thermal energy transfers through the material
- The table above shows some thermal conductivity values. Materials used in houses have low thermal conductivity values to make sure heat is not lost and reduction of energy bills (and save energy resources)

## Example of Energy Transfers – Ball Hitting a Wall

Kinetic energy store from ball decreases →

→ EPE store of ball increases
Thermal energy store of ball and surroundings increases

Mechanical pathway

## Reducing Energy Loss

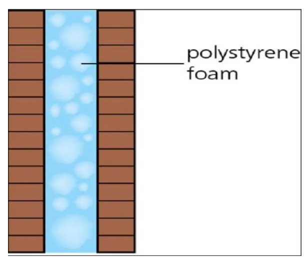
### Reducing Loss by Friction

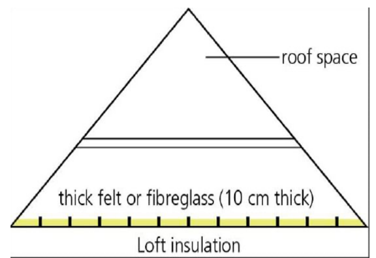
Friction between surfaces can lead to energy dissipating into the thermal energy store of the surroundings. To reduce this, lubricants, such as oil can be placed between the surfaces, reducing the friction.

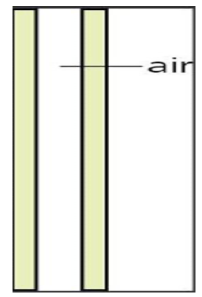
### Reducing Energy Loss from a House

Energy can be lost within the home, mainly from the house, walls and windows/doors. This can be reduced by the following:-

- Double Glazed Windows – the poor thermal conductor of air within the 2 panes of glass
- Thick Walls – greater distance so slower rate of thermal energy transfer through wall
- Wall Cavity Insulation – walls also have layers of insulation that have low thermal conductivity
- Roof Insulation – made of materials that have a low thermal conductivity, as well as having a thick layer of insulation



# P1 and P2 – Electricity Generation

| Name of Wite | Colour of Wire | Where does it go? | Potential Difference |
|---|---|---|---|
| Live | Brown | Right | 230V |
| Neutral | Blue | Left | 0V |
| Earth | Yellow/Green Stripes | Top | 0V |

## Renewable and Non-Renewable Energy Resources

Renewable energy resources can be replenished at the same rate as it is used. So, they will not run out. Examples are wind, solar, hydroelectric, biofuel and geothermal.

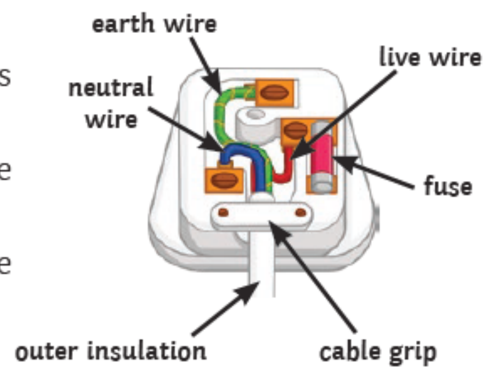
Non-renewable energy resources cannot be replenished at the same rate as it is being used. So, they will run out. Examples are fossil fuels (oil, coal, natural gas) and nuclear

## Electricity in the Home

**AC –** alternating current. Constantly changing direction - UK mains supply is 230V and has a frequency of 50 hertz (Hz).

**DC –** direct current. Supplied by batteries and only flows in one direction.

**Cables –** most have three wires: live, neutral and earth. They are covered in plastic insulation for safety.




**Live wire** – provides the potential difference from the mains.

**Neutral wire** – completes the circuit.

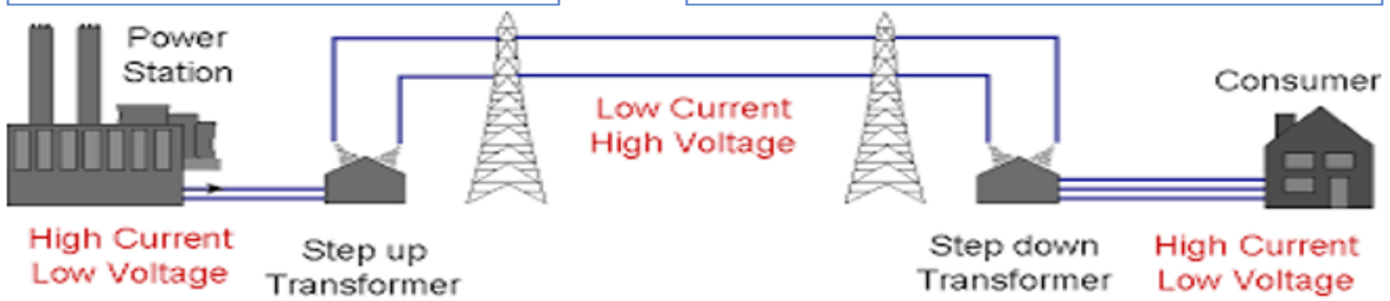
**Earth wire** – protection. Stops the appliance from becoming live. Carries a current if there is a fault.

Touching the live wire can cause the current to flow through your body. This causes an electric shock.

## National Grid

Power stations produce electricity with a certain power output You would want as much of this to reach the consumers

Pylons – support and hold the cables
Cables – made up of low resistance wires, to reduce loss via heating. Cables have low density to prevent sagging




Step up transformer increases the voltage, and this decreases the current. Reducing the current, prevents heating of the cables and energy loss as heat

Step down transformer decreases the voltage, which increases the current. This is for safety reasons before the voltage reaches the consumers

| Energy Resource | Advantages | Disadvantages | Used for….. |
|---|---|---|---|
| Coal | • Reliable<br>• Easily available | • Non-renewable<br>• Produces $CO_2$ (global warming) | Transport<br>Heating<br>Electricity |
| Oil | • Reliable<br>• Easily available<br>• Easy to transport | • Non-renewable<br>• Produces $CO_2$ (global warming) | Transport<br>Heating<br>Electricity |
| Natural Gas | • Cleaner than other fossil fuels<br>• Abundant and reliable | • Non-renewable<br>• Produces $CO_2$ (global warming) | Heating<br>Electricity |

| Energy Resource | Advantages | Disadvantages | Used for….. |
|---|---|---|---|
| Solar | • Renewable<br>• Does not release (so does not contribute to global warming)<br>• Free once installed | • Expensive to install<br>• Unreliable – depends on weather | Heating<br>Electricity |
| Wind | • Renewable<br>• Does not release (so does not contribute to global warming)<br>• Free once installed | • Noise/visual pollution<br>• Unreliable – depends on weather<br>• Could kill wildlife (birds) | Electricity |
| Nuclear | • Lots of energy from small amounts of fuel<br>• Does not release (so does not contribute to global warming) | • Non-renewable<br>• Produces radioactive waste - cancer | Electricity |

| Energy Resource | Advantages | Disadvantages | Used for….. |
|---|---|---|---|
| Biofuel | • Renewable<br>• Carbon neutral (plants take in $CO_2$ for photosynthesis when they grow) | • Needs lots of land to grow crops – could be used to grow crops for food<br>• Deforestation occurs for this land – loss of habitat for animals/plants | Transport<br>Electricity<br>Heating |
| Hydroelectric | • Reliable all year long<br>• Renewable<br>• Does not produce $CO_2$ | • Location dependent (need a large water source)<br>• Floods nearby land damaging wildlife | Electricity |
| Geothermal | • Reliable all year long<br>• Renewable<br>• Does not produce $CO_2$ | Location dependent | Electricity |
| Tidal (water waves) | • Renewable<br>• Does not produce $CO_2$ | • Location dependent<br>• Water waves are unreliable but tidal is as it relies on the moon | Electricity |

# P2 – Electricity Basics

## Current and Circuit Symbols

**Current**: the flow of electrical charge.
**Potential difference (voltage)**: the push of electrical charge.
**Resistance**: slows down the flow of electricity.

| | | | | | |
|---|---|---|---|---|---|
| cell | | closed switch | | fuse | |
| resistor | | ammeter | | LDR | |
| battery | | voltmeter | | LED | |
| variable resistor | | bulb | | thermistor | |
| open switch | | diode | | | |

## Equations and Maths

Charge Flow = Current x time

Potential difference = current x resistance

Power = potential difference x current

Power = current$^2$ x resistance

Energy = power x time

Energy = charge x potential difference

**Conversions**

k- x 1000

m - ÷ 1000

mins – x 60 hours – x 3600

### Units

Charge flow → Coulombs (C)

Current → Amps (A)

Time → seconds (s)

Potential difference → Volts (V)

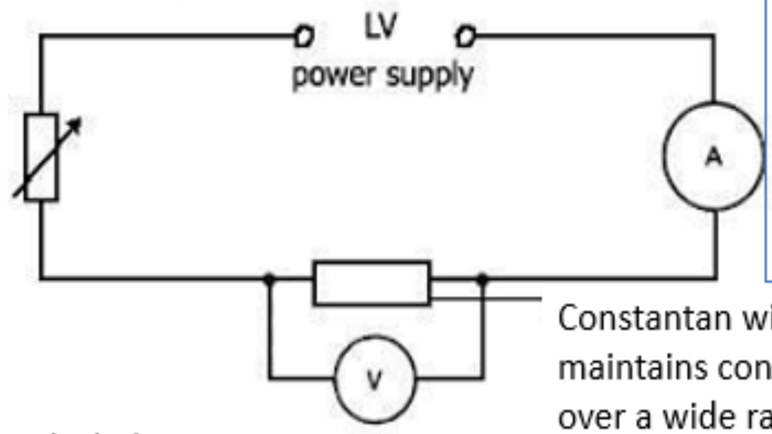
Resistance → Ohms (Ω)

Power → Watts (W)

Energy – Joules (J)

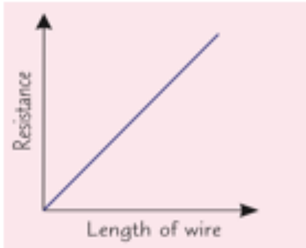
# Resistance of a Wire Practical (Required Practical)

Low voltage supply – low current to prevent overheating, melting of wire




If investigating how length of wire affects resistance, change the length of wire, measure the current using the ammeter, measure the voltage using the voltmeter. Then, resistance = voltage/current
Longer wire, more metal ions to impede electrons, more resistance

Constantan wire – used as it maintains constant resistivity over a wide range of temperatures



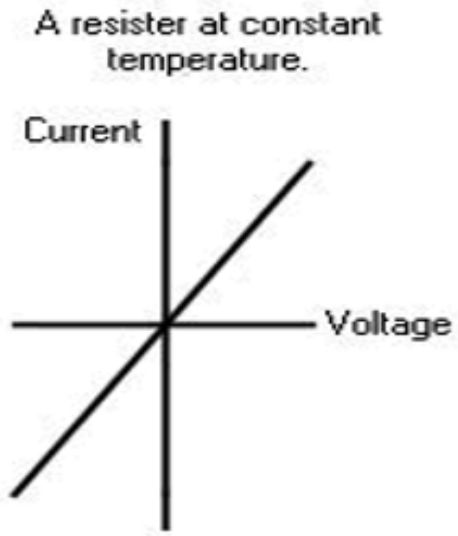

Lengths below 20cm may not be used as this would low resistance and high current

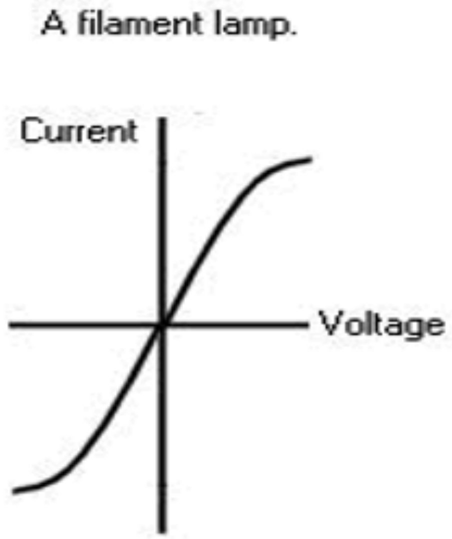
If your graph doesn't go through the origin, it could be because the first clip isn't attached exactly at 0 cm, so all of your length readings are a bit out. This is a systematic error

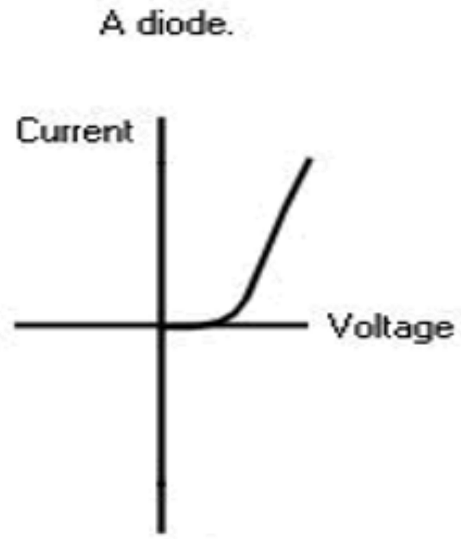
**Control Variables**
**Type of wire** – different metals have different resistivity values
**Temperature** – as there is current flowing the wire, the wire will heat up. This will cause metal ions to vibrate faster, and increase resistance. Wait for wire to cool down
**Thickness of wire** – thicker the wire, the more space for electrons to flow through, and so smaller resistance

## Fixed Resistor, Filament Lamp & Diode

Linear – straight line
Non-Linear - Curves




The current flowing through a wire is directly proportional to the potential difference (voltage) across it provided the temperature remains constant. Called an ohmic conductor

AS the current through the lamp increases, lamp increases in temperature, so resistance increases

Diode - only lets current flow in one direction. Reverse direction has very high resistance and so, no current

# P3 - Particle Model of Matter

## Required Practical

**Measuring the density of a regularly shaped object:**

- Measure the mass using a balance.
- Measure the length, width and height using a ruler.
- Calculate the volume.
- Use the density ($\rho = m/V$) equation to calculate density.

**Measuring the density of an irregularly-shaped object:**

- Measure the mass using a balance.
- Fill a eureka can with water.
- Place the object in the water - the water displaced by the object will transfer into a measuring cylinder.
- Measure the volume of the water. This equals the volume of the object.
- Use the density ($\rho = m/V$) equation to calculate density.

## Density

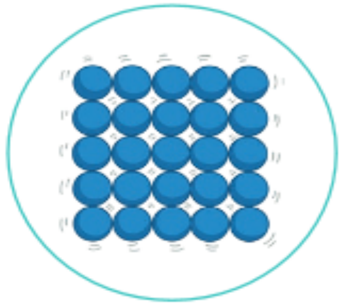
Density is a measure of how much mass there is in a given space.

Density ($kg/m^3$) = mass (kg) ÷ volume ($m^3$)

A more dense material will have more particles in the same volume when compared to a less dense material.

## Particles

**Solids** have strong forces of attraction. They are held together very closely in a fixed, regular arrangement. The particles do not have much energy and can only vibrate.



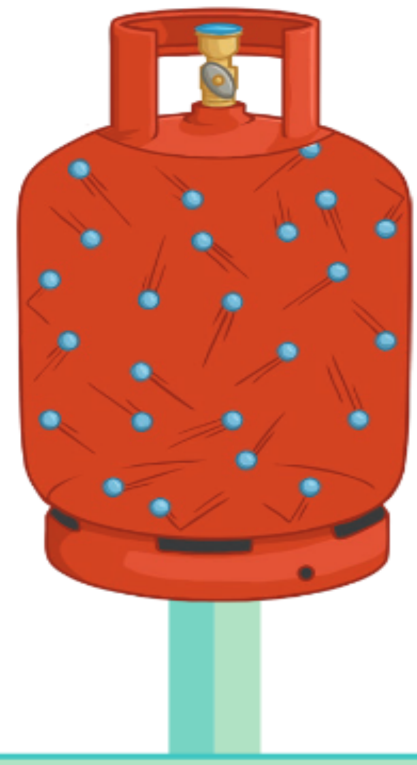
**Liquids** have weaker forces of attraction. They are close together, but can move past each other. They form irregular arrangements. They have more energy than particles in a solid.

**Gases** have almost no forces of attraction between the particles. They have the most energy and are free to move in random directions.

## Particles

Gas particles can move around freely and will collide with other particles and the walls of the container. This is the pressure of the gas.

If the temperature of the gas increases, then the pressure will also increase. The hotter the temperature, the more kinetic energy the gas particles have. They move faster, colliding with the sides of the container more often.



## Density

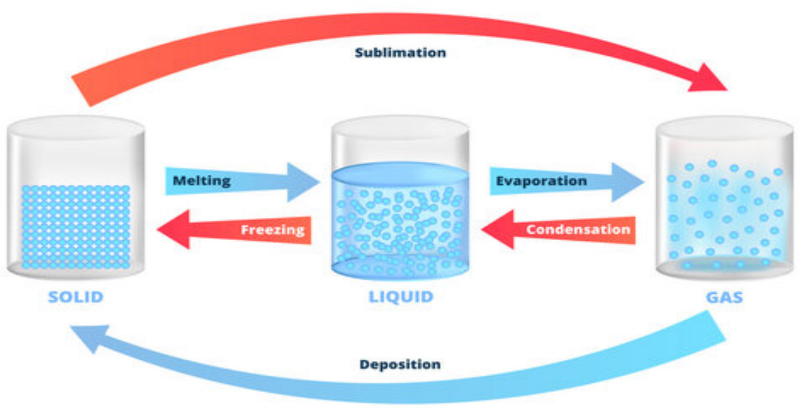
The density of an object is 8050kg/m³ and it has a volume of 3.4m³ - what is its mass in kg?

8050 = mass ÷ 3.4

8050 × 3.4 = mass

27 370kg

### CHANGING STATES OF MATTER




When a substances changes states, it is a physical change and not a chemical change. This is because the chemical; stays the same. For example, ice is $H_2O$, water is $H_2O$, and steam is also $H_2O$. So, the substance has changed state, but the chemical has remained the same

A change of states also obeys the law of conservation of mass. For example, if 7kg of water is boiled, the mass of steam would also be 7kg. No mass is lost or created.

# P3 – Internal Energy

## Specific Heat Capacity

Specific Heat Capacity is the energy needed to change the temperature of 1kg of a substance by $1^0$C.

Substances that a have a lower specific heat capacity need less energy to heat up, so increase in temperature quicker.

For example, if the same mass of oil and water are heated for the same amount of time (same energy), the oil will increase in temperature more.

**Specific Heat Capacity Equation**

Change in Energy = mass x specific heat capacity x temperature change

The equation above shows that the thermal energy store of a substance depends on three things.

- Mass
- Temperature
- Specific heat capacity of the material

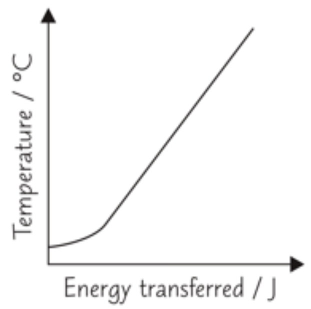
**Units**

- Energy – Joules
- Mass – kilograms
- Specific heat capacity – J/kg$^0$C
- Temperature - $^0$C

## Specific Heat Capacity (Required Practical)

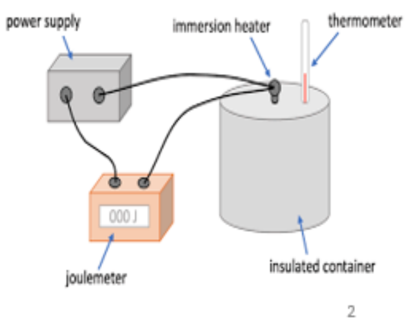
1. Measure mass of metal block using a mass balance
2. Set up the equipment as shown in the diagram below (draw it in the exam)
3. Measure the starting temperature of the block using a thermometer
4. Turn on the heater, and measure the temperature of the block every minute for 10mins
5. Measure the energy transferred using a joulemeter
6. Calculate the specific heat capacity using the equation

Energy = mass x specific heat capacity x temp change




**Errors in the experiment**

- Takes time for the heater to heat up – why graph is curved at start
- Heat energy lost to the surroundings rather than heating up the block. So, temperature change not as high as it should and specific heat capacity value greater than the actual value.
- Reduce second error by adding insulation




## Internal Energy

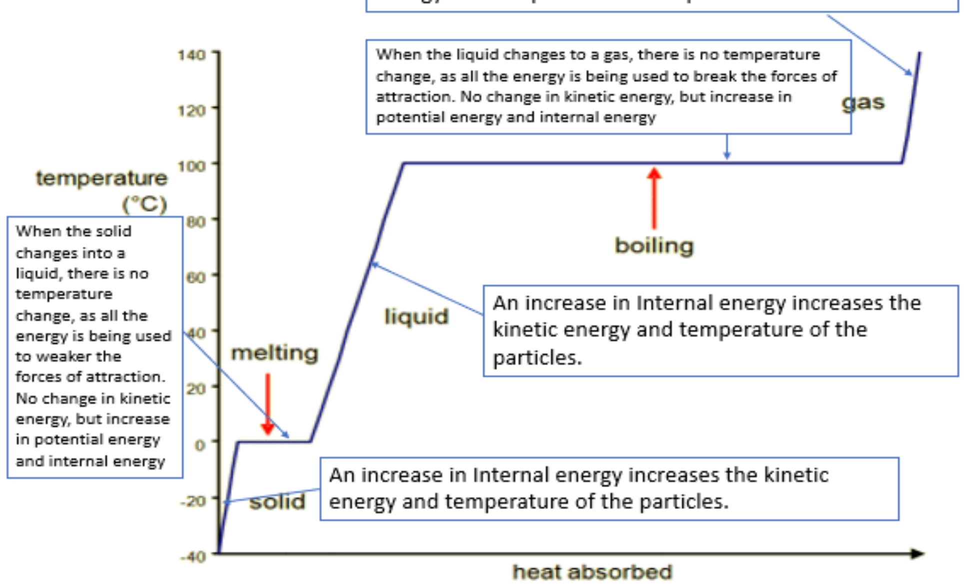
Internal energy is the total kinetic energy and potential energy of all the particles in a system.

Internal Energy = Kinetic Energy + Potential Energy

If the internal energy of a system is increased, this ….

- Increases the temperature of the particles (kinetic energy).
- Changes state by breaking forces between particles (potential energy).

## Heating Curves

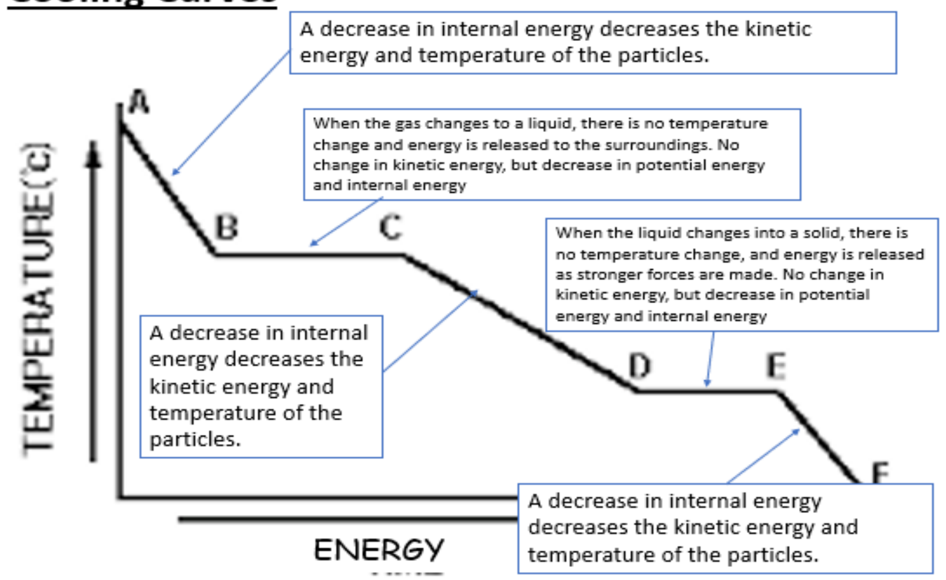



If the internal energy of a system is decreased, this ….

- Decreases the temperature of the particles (kinetic energy).
- Changes state by increases forces between particles (potential energy).

The internal energy lost, ends up in the surroundings.

## Cooling Curves




## Specific Latent Heat

Specific Latent Heat is the energy needed to change the state of 1kg of a substance with no change in temperature.

Specific latent heat of fusion is the energy needed to change 1kg of a solid into a liquid with no change in temperature (also liquid to solid).

Specific latent heat of vaporisation is the energy needed to change 1kg of a liquid into a gas with no change in temperature (also gas to liquid).

**Specific Latent Heat Equation**

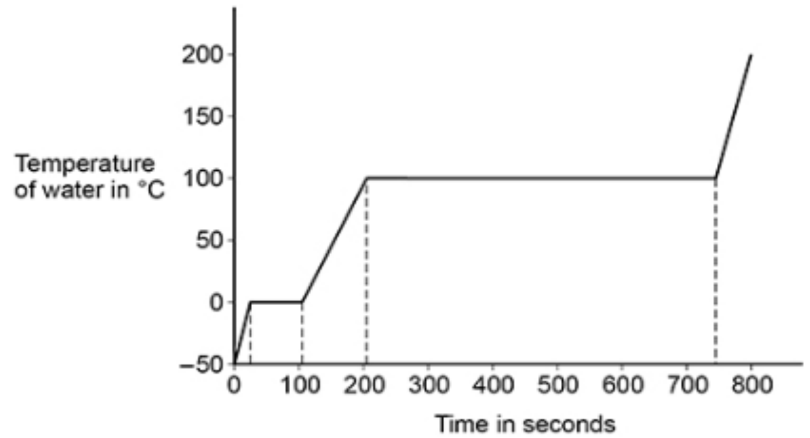
Energy = mass x specific latent heat

**Units**

- Energy – Joules
- Mass – kilograms
- Specific latent heat – J/kg

## HT only

The graph below shows the heating curve for ice




The specific latent heat of vaporisation of water is greater than the specific latent heat of fusion of ice. This is shown by the much bigger flat line (more time needed) for boiling than melting.

This is because lots more energy is needed to break the forces in a liquid to turn it into a gas compared to breaking forces in a solid.

The specific heat capacity of ice is greater than the specific heat capacity of water. This is shown the steeper gradient for the ice (0s) than water (100s-200s). This shows that ice increases in temperature quicker as it has a lower specific heat capacity and needs less energy to heat up.

# P5 and P7 – Forces and Magnetism

## Scalar and Vector Quantities

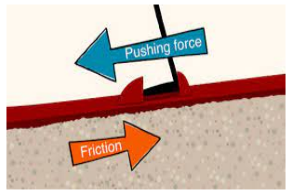
Scalar quantities have just magnitude and no direction e.g., speed of a car is 30mph

Vector quantities have magnitude and direction e.g., velocity of a car is 30mph North

| Scalar Quantities | Vector Quantities |
|---|---|
| Time | Force |
| Mass | Weight |
| Temperature | Momentum |
| Power | Velocity |
| Energy | Displacement |
| Speed | Acceleration |
| Distance | |

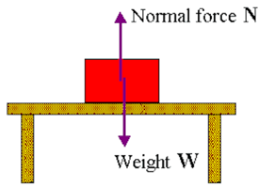
## Contact Forces and Non-Contact Forces

Contact Forces are when the force only occurs if the objects are touching



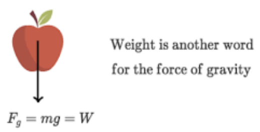

Friction


Air Resistance

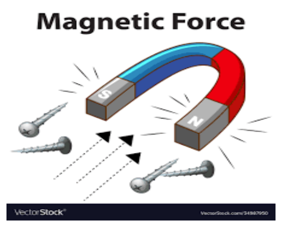



Normal Contact Force

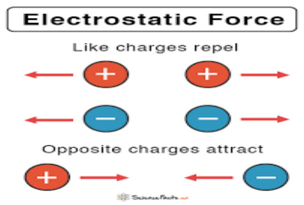
Non-Contact Forces are when forces can act over a distance and do not need to be touching




Weight (Gravity)




Magnetic




Electrostatic

| Mass | Weight |
|---|---|
| The amount of **matter** in an object | The **force** acting on an object, due to gravity |
| **Never changes** | Changes depending on the **strength of gravity** |
| Measured in **kg** | Measured in **N** |

**weight = mass x Gravitational field strength (g)'**

## Drawing Force Diagrams

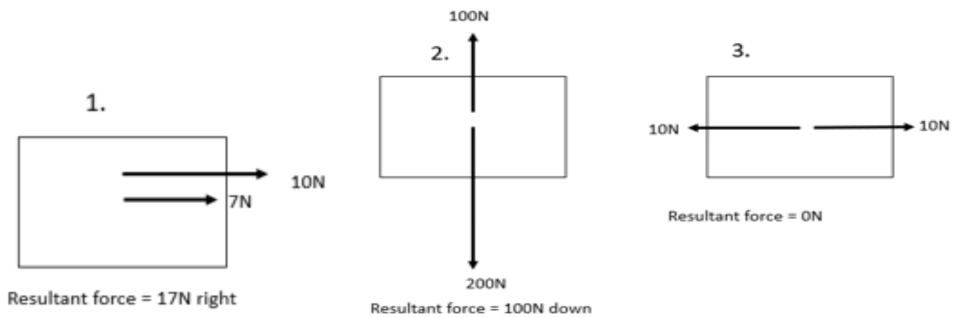
Forces are vector quantities and therefore have magnitude and direction.

The size of the arrow represents the magnitude (size) of the force and the direction of the arrowhead represents the direction. The arrow should also be labelled with the name of the force

## Resultant Forces

A resultant force is one overall force that can replace all the forces you have in a diagram.

**Examples**




**Describing Motion Based on Resultant Force**

If the resultant force = 0N, the object will either be stationary or moving at a constant speed

If the resultant force is not 0N, the object will accelerate, decelerate, or change direction

Reaction
10 N
Resultant Force = 10 -10 = 0
Gravity
10 N

The forces here are balanced, and the resultant force is 0N
This means that the mince pie will be either at rest or moving at constant speed. Looking at the picture, it will b stationary

Air Resistance (Drag)
500 Newtons

Motive Force (Thrust)
2000 Newtons

The forces here are unbalanced, and the resultant force is 1500N to the right
As the forward force is bigger, the fighte jet will accelerate

Resultant Force = 2000 – 500 = 1500N to the right.

## Permanent Magnets

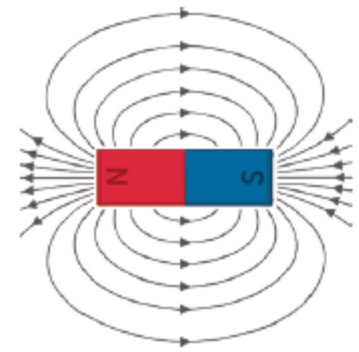
Permanent magnets have their own magnetic field, will always be magnetic and can either have a force of attraction or repulsion.

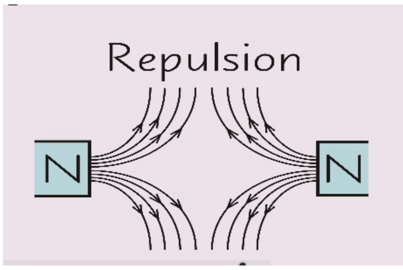
Magnetic materials are made of either iron (steel), cobalt and nickel

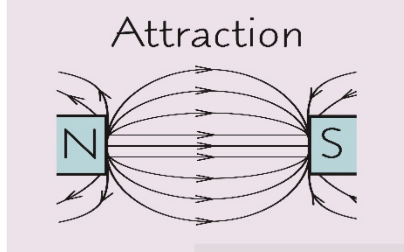
The diagram on the right shows the magnetic field around a simple bar magnet

The poles are at the end of the bar magnet, and this is the magnetic field is strongest (more denser field lines)

Further away from the poles, magnetic field strength decreases, and field lines get further apart




## Plotting Magnetic Field Lines

Magnetic fields can be detected by scattering iron filing nearing a magnetic material and the field lines should become visible.

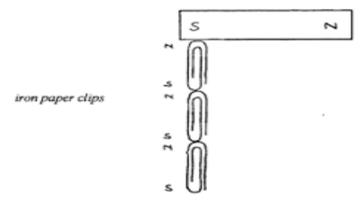
They can be plotted using a compass by using the following method

1. Place a bar magnet on a centre of a piece of A4 paper
2. Place the compass around the magnet and draw the arrow
3. Move the compass around the bar magnet and keep drawing arrows
4. Join the arrows up to show the magnetic field

Without a magnetic material nearby, the compass needle will also move, and this is due to the Earth's magnetic field

## Induced Magnetism

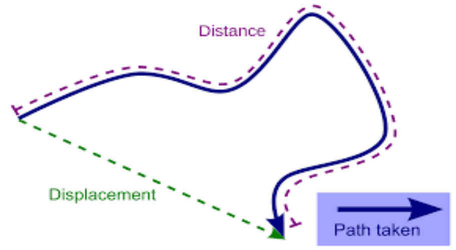
- An induced magnet is one that becomes magnetic when placed inside a magnetic field
- Magnetic materials are iron, steel, cobalt and nickel
- Induced magnetism always causes a force of attraction
- When removed from the magnetic field, an induced magnet will lose all/most of its magnetism very quickly



# P5 – Motion Graphs

## Scalar and Vector Quantities

- Scalar quantities have only magnitude.
- Vector quantities have magnitude and direction.
- Speed is how fast an object moves, but velocity is speed in a given direction. Speed is a scalar quantity, whilst velocity is vector.
- This means that an object can travel at the same speed but still accelerate if it is changing direction (example, planet orbiting the Sun)
- Distance is how far an object travels. Displacement is the distance from start to finish in a straight line, as well as the direction.
- Distance is a scalar quantity, whilst displacement is vector.




## Equations

distance travelled (m) = speed (m/s) × time (s)

$$a = \frac{\Delta v}{t}$$

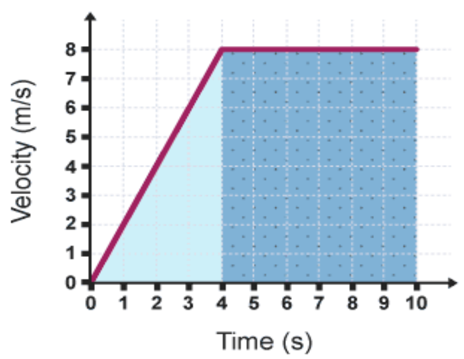
Acceleration (m/s²) — Change in velocity (m/s) — Time (s)

$$v^2 - u^2 = 2as$$

Final velocity (m/s) — Initial velocity (m/s) — Acceleration (m/s²) — Distance (m)

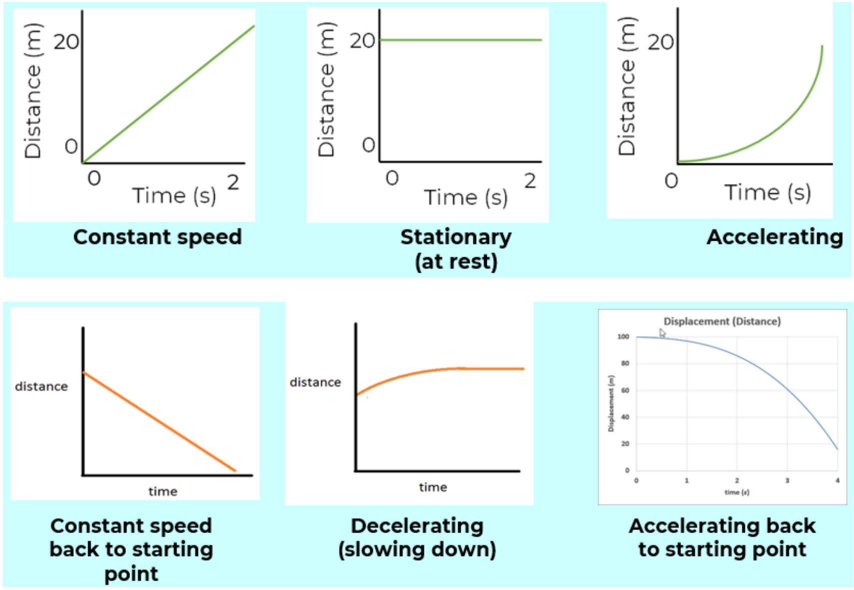
## Distance from V-T Graphs (HT only)

This is calculated from the area under the graph by turning the area under the graph into triangles, rectangles, or trapeziums.



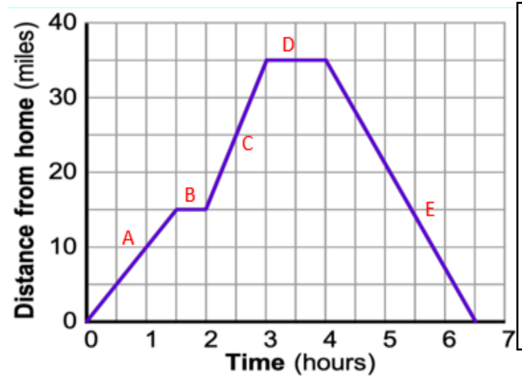

If the lines on the V-T graphs are curved, the distance can be estimating by counting squares under the line (more than half counts as 1 square. The number of squares is then multiplied by the area of one square.

## Distance-Time Graphs




The gradient of the line is the speed. Therefore, the steeper the line, the faster the speed.

### Example of Describing Distance-Time Graph

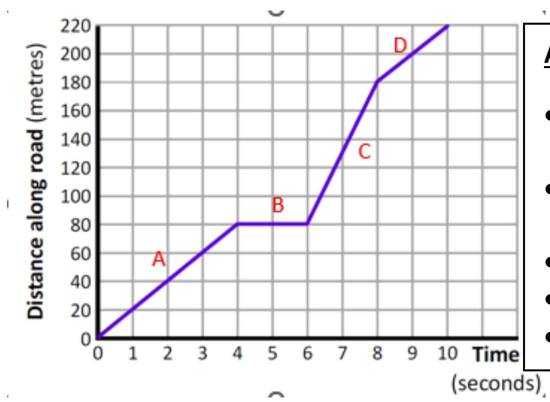



- Point A – constant speed (of 10mph)
- Point B – stationary for 30mins.
- Point C – constant speed (of 20mph)
- Point D – stationary for 1h
- Point E – constant speed (of

- Speed at point C is the fastest as the line is the steepest.
- Speed can be calculated by using speed = distance/time

### Calculating Speed from the Graph

Average speed can be calculated by using speed = distance/time

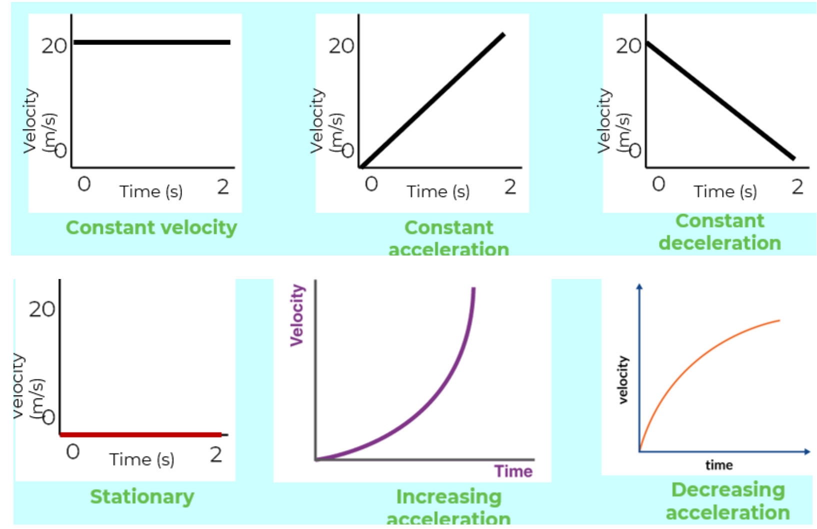



**Average Speed at Point C**

- Distance travelled at point C is 80m to 180m, which is 100m.
- Time difference is 6s to 8s, which is 2s.
- Speed = distance/time
- Speed = 100/2
- Speed = 50m/s

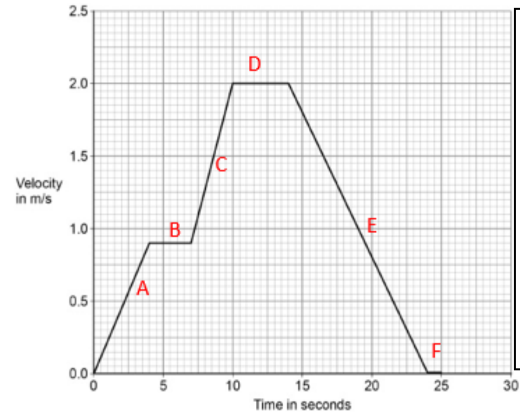
Calculating the speed at one particular moment in time is calculated by working out the gradient. If it is a curve, a tangent will have to be used, followed by the gradient.

## Velocity-Time Graphs




The gradient of the line is the acceleration. Therefore, the steeper the line, the higher the acceleration.

### Example of Describing Velocity-Time Graph



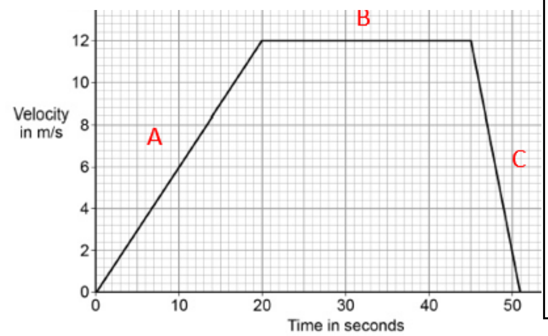

- Point A – constant acceleration.
- Point B – constant velocity.
- Point C – constant acceleration.
- Point D – constant velocity.
- Point E – constant deceleration.
- Point F – stationary.

Higher acceleration at point C as line is steepest.

### Calculating Acceleration from the Graph

Average acceleration can be calculated by using….

acceleration = change in velocity/time taken




**Acceleration at Point C**

- Velocity has changed by -12m/s
- Time difference is 6s.
- Acceleration = -12/6
- Acceleration = -2m/s²

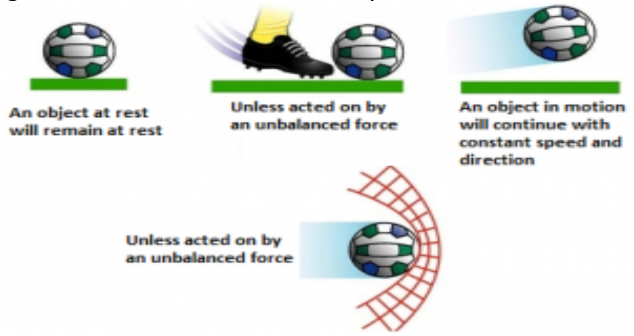
Calculating the acceleration at one particular moment in time is calculated by working out the gradient. If it is a curve, a tangent will have to be used, followed by the gradient.

# P5 - Newton's Laws of Motion

## Newton's First Law of Motion

Newton's first Law states that if an object has no resultant force due to forces being equal and opposite, it will remain in its state of motion. For example.

- If stationary, it will remain stationary.
- If moving, it will continue at constant speed in the same direction.




However, if the object has a resultant force due to forces being unequal, the object will either…

- Accelerate (speed up)
- Decelerate (slow down)
- Change direction (change velocity)

## Newton's Second Law of Motion

The acceleration of an object is directly proportional to the resultant force on the object.
The acceleration of an object is inversely proportional to the mass of the object.
This can be summarised by the equation below.

$$resultant\ force = mass \times acceleration$$

$$F = m\,a$$

force, $F$, in newtons, N

mass, $m$, in kilograms, kg

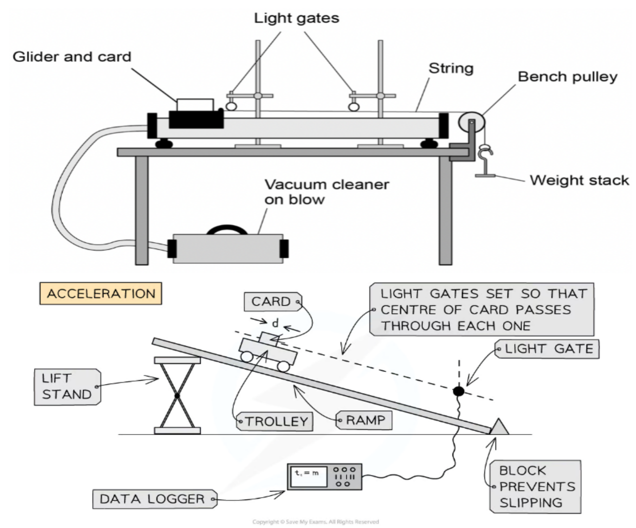
acceleration, $a$, in metres per second squared, m/s$^2$

**HT only**
Inertial mass is the measure of how difficult it is to change the motion of an object. It is the ratio of force and acceleration.
Example, a cricket ball would require a bigger force to decelerate compared to a tennis ball.

## Newton's Third Law of Motion

Whenever 2 objects interact, they exert an equal and opposite force on each other.
For example, when walking, a person pushes the ground backwards, so the ground pushes the person forwards.
For example, when writing with a pen, the pen exerts a force downwards on the paper and the paper exerts a force upwards on the pen.

## F = ma Required Practical




**Independent Variable**
Changing the force by either increasing the weight on the weight stack (top diagram) or increasing the height of the ramp (second diagram)

**Dependent Variable**
2 light gates measure the initial velocity and final velocity.
Light gates measure the time difference (or use stopwatch)
Acceleration = change in velocity / time taken
Light gates measure the velocity by timing how long it takes the card to go through them (speed = length of card / time)

**Control Variables**
Type of surface, mass of car

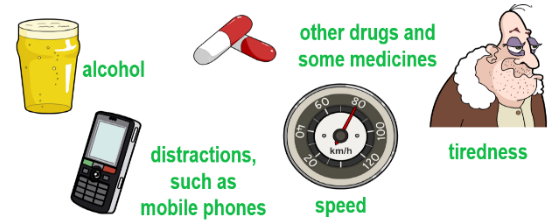
**Other Notes**
Same method could be used to investigate the effect of mass on acceleration. Here, the mass of the car would be the independent variable (by adding masses onto the car) and the weight stack would be the control variable.
Advantage of the top method would be that the air track would reduce the force of friction on the glider.

## Stopping Distance

Stopping Distance = thinking distance + braking distance

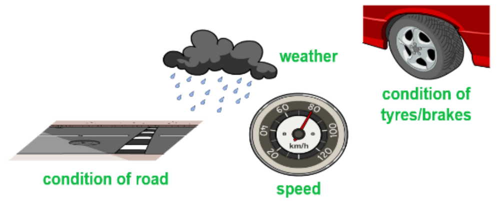
Thinking distance – distance the car travels from seeing the hazard to pressing the brakes. This depends on reaction time.
Reaction times vary from person to person but range from 0.2s to 0.9s.
Factors that affect thinking distance are….

- Drugs
- Tiredness
- Alcohol
- Age
- Distractions
- Speed




Braking Distance – distance the car travels once the brakes have been applied.
Factors that affect braking distance are….

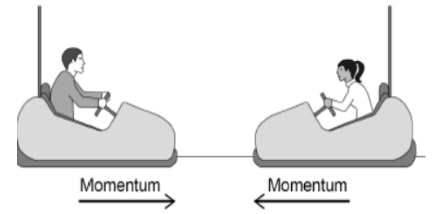
- Tyre/brake conditions
- Conditions of road
- Mass of car
- Speed
- Braking force




Faster speeds require a larger braking force to stop in the same distance. A large deceleration could lead to skidding, loss of control and brakes overheating.

## Momentum (HT only)

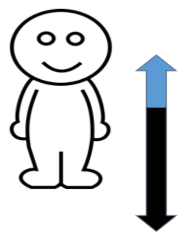
Momentum is a product of mass and velocity.
Momentum = mass x velocity
Momentum has the units kg m/s



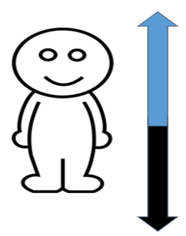

**Law of Conservation of Momentum Example**
The bumper cars on the right have an equal and opposite momentum.
So, total momentum before is zero.
So due to law of conservation of momentum, total momentum after also has to be zero. Therefore, bumper cars have to be stationary after the crash.

## Terminal Velocity

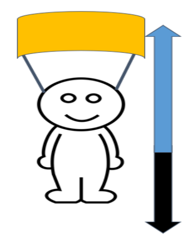
This is the maximum speed reached by an object moving through a fluid (example is air)



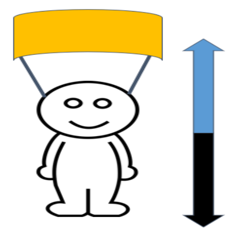
Weight is greater than air resistance. Skydiver accelerates.



Air resistance increases as speed increases, until air resistance equals weight. Skydiver reaches terminal velocity.

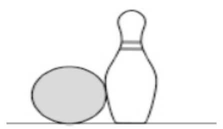


Opening the parachute increases air resistance. Air resistance greater than weight, so skydiver decelerates downwards.



Air resistance decreases as speed decreases, until air resistance equals weight. Skydiver reaches lower constant speed.

## Another Example of Law of Conservation of Momentum (HT only)



Before the bowling ball hits the pin, the bowling ball has momentum, but the pin has no momentum as it is stationary.
After the collision, the bowling ball loses velocity and therefore momentum.
The pin gains velocity and therefore momentum.
Total momentum before = total momentum after.