Year 11 Revision.

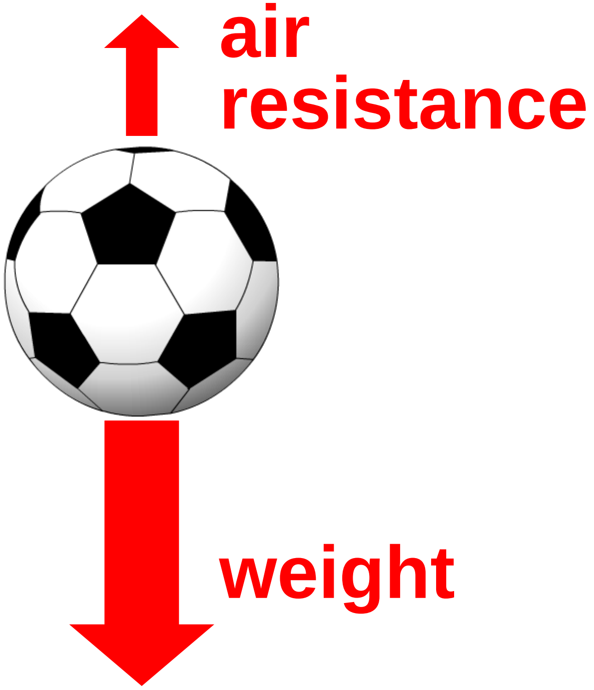
(P2: Physics)

Force diagrams.

A force diagram uses **arrows** to show the forces acting on an object.

- The **direction** of each arrow shows you the direction of each force.
- The **size** of each arrow can be used to compare the sizes of the forces.

What is the force diagram for this falling object when it first starts to fall?

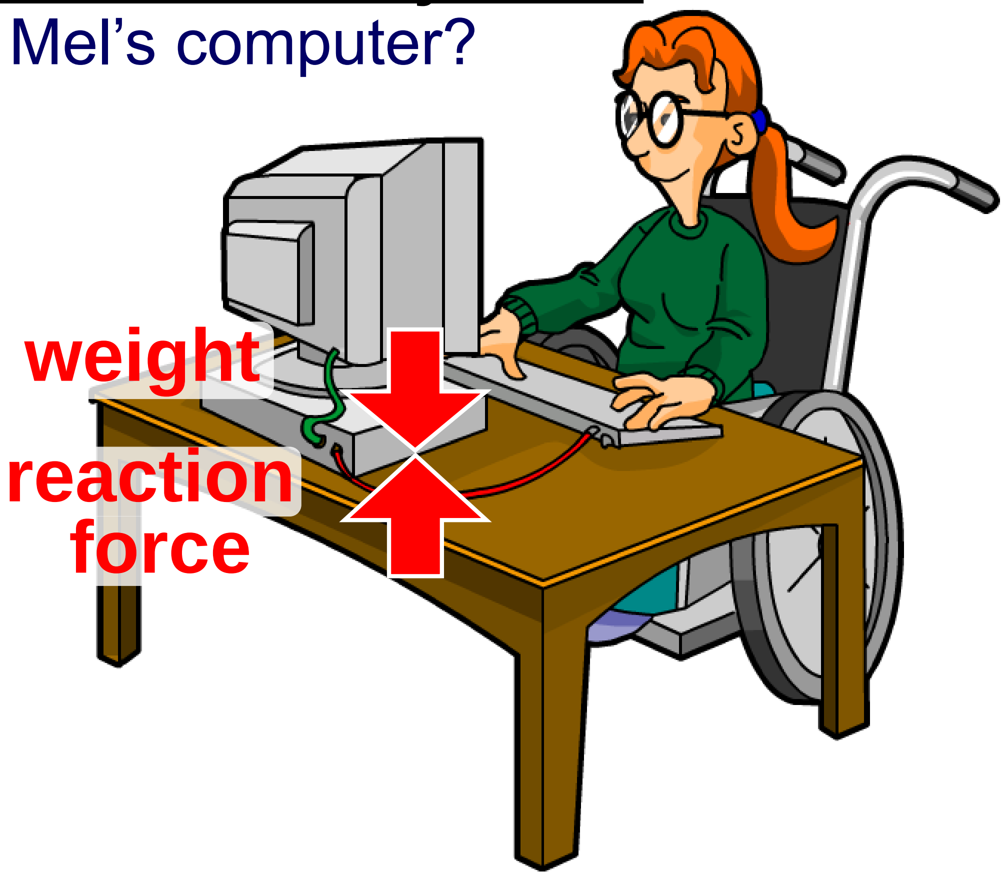


Forces on still objects.

What forces are acting on Mel's computer?

The computer is pulled downwards by the force of **gravity** and causes it to have **weight**.

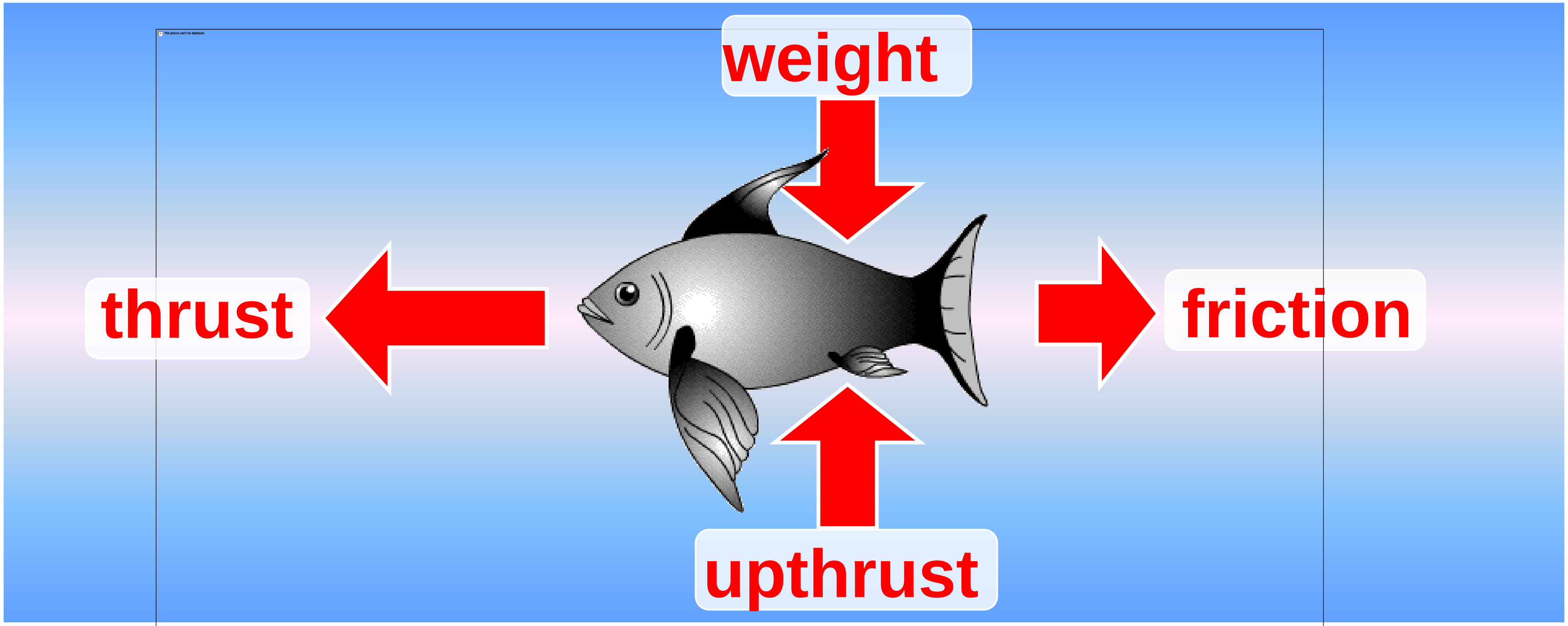
The table exerts an **equal and opposite** force pushing upwards on the computer. This is called the **reaction force** **(or normal contact force)**.



These forces are **balanced** so the computer does not move.

Forces on a swimming fish.

What forces are acting on this fish as it swims?



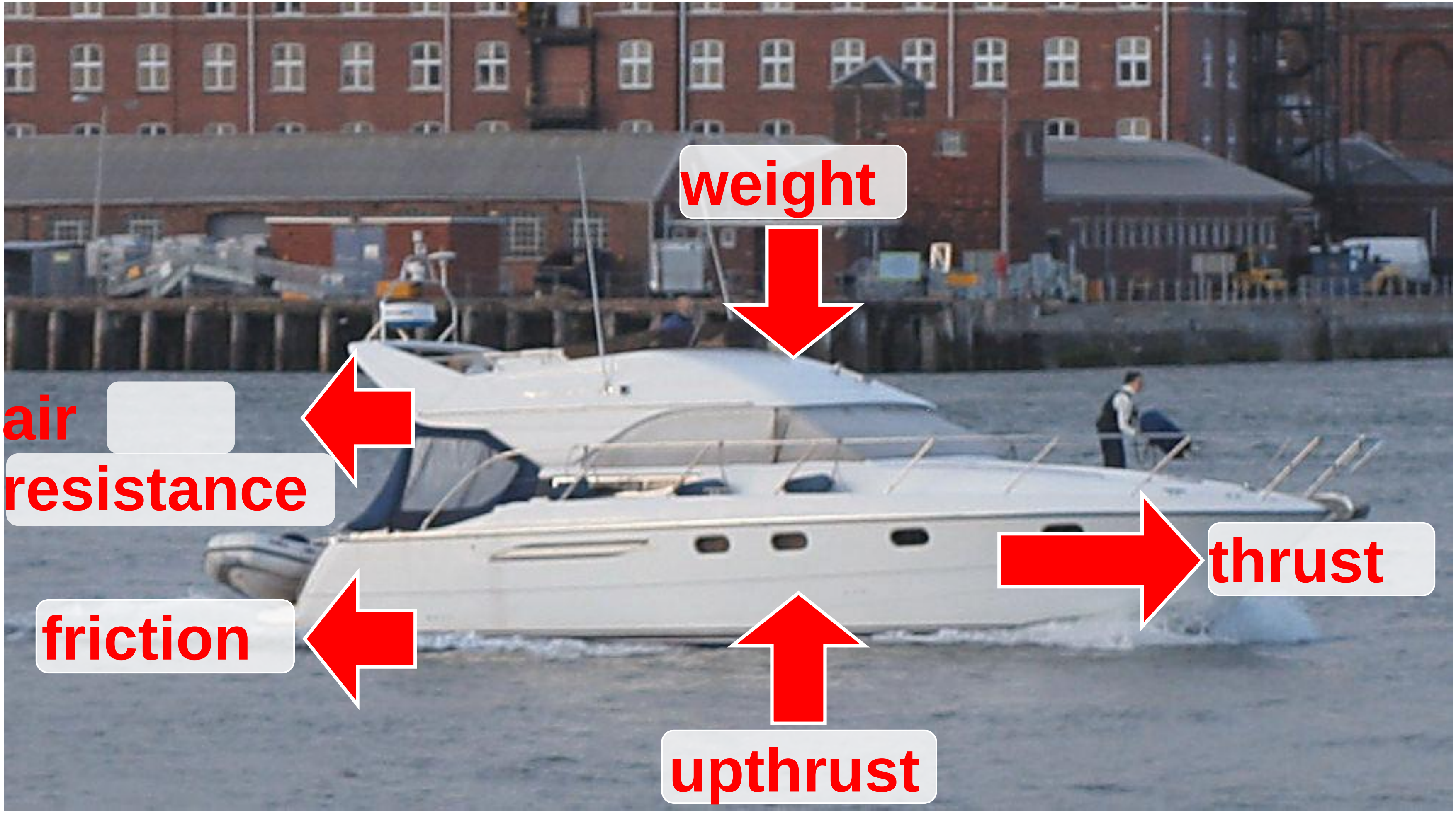
Upthrust is the **upwards** force on the fish caused by the water around the fish. Sometimes this is called **buoyancy**.

Thrust is the **forwards** force acting on the fish.

Friction acts **against** the movement of the fish.

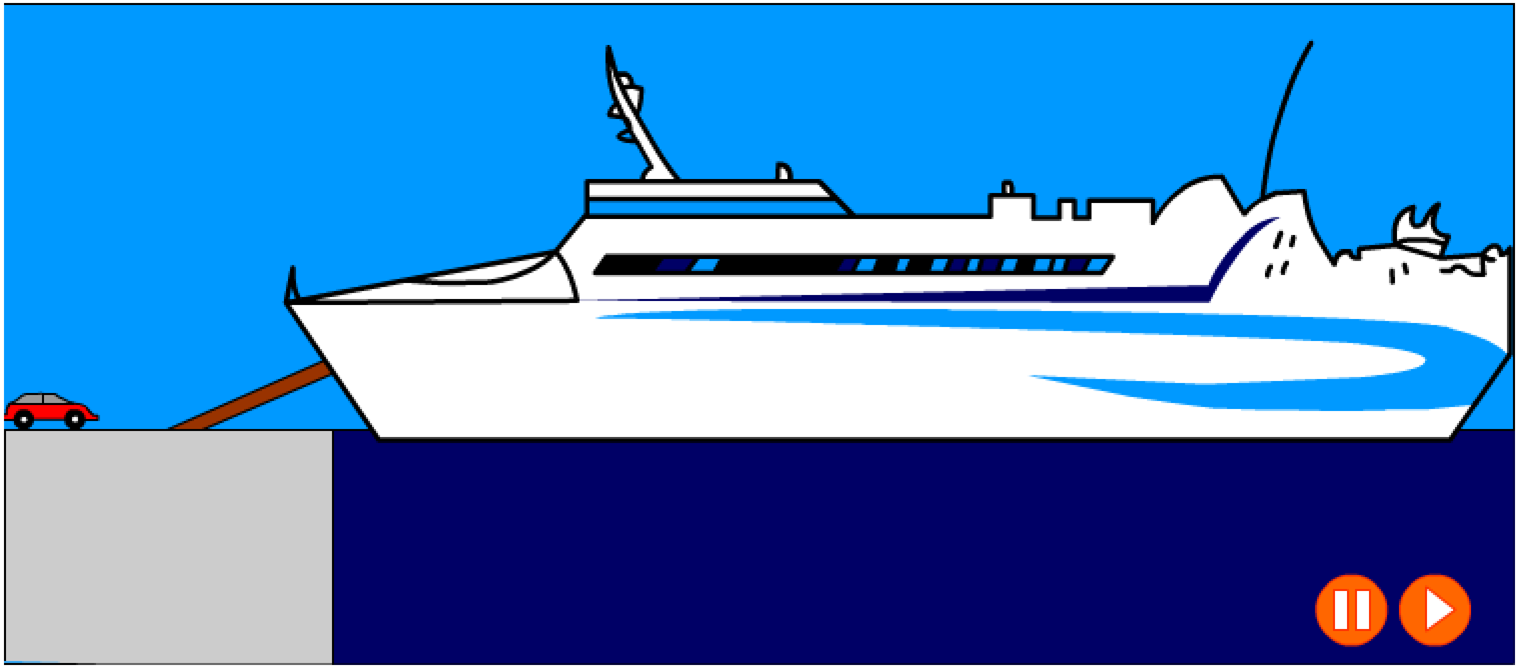
Forces on a moving boat.

What forces are acting on this moving boat?



Changing forces on a ferry.

An empty ferry arrives at port and is loaded with travellers.



What happens to the weight of the ship? **It increases.**

What happens to the upthrust on the ship? **It increases.**

Which force is now largest – weight or upthrust?

The increase in upthrust equals the increase in weight, so both forces remain equal and balanced.

Forces and motion.

If the forces on an object are **balanced**, the object will continue to do what it is already doing without change.

- If the object is **stationary,** it will **remain stationary**.
- If the object is **moving,** it will **continue to move** at the same speed and in the same direction.

If the forces on an object are **unbalanced**, two things about the object can change:

- The **speed** – the object may speed up or slow down.
- The **direction** of motion.

<u>Unbalanced forces and motion.</u>

If an object is stationary and unbalanced forces act on it, what will happen to the object?

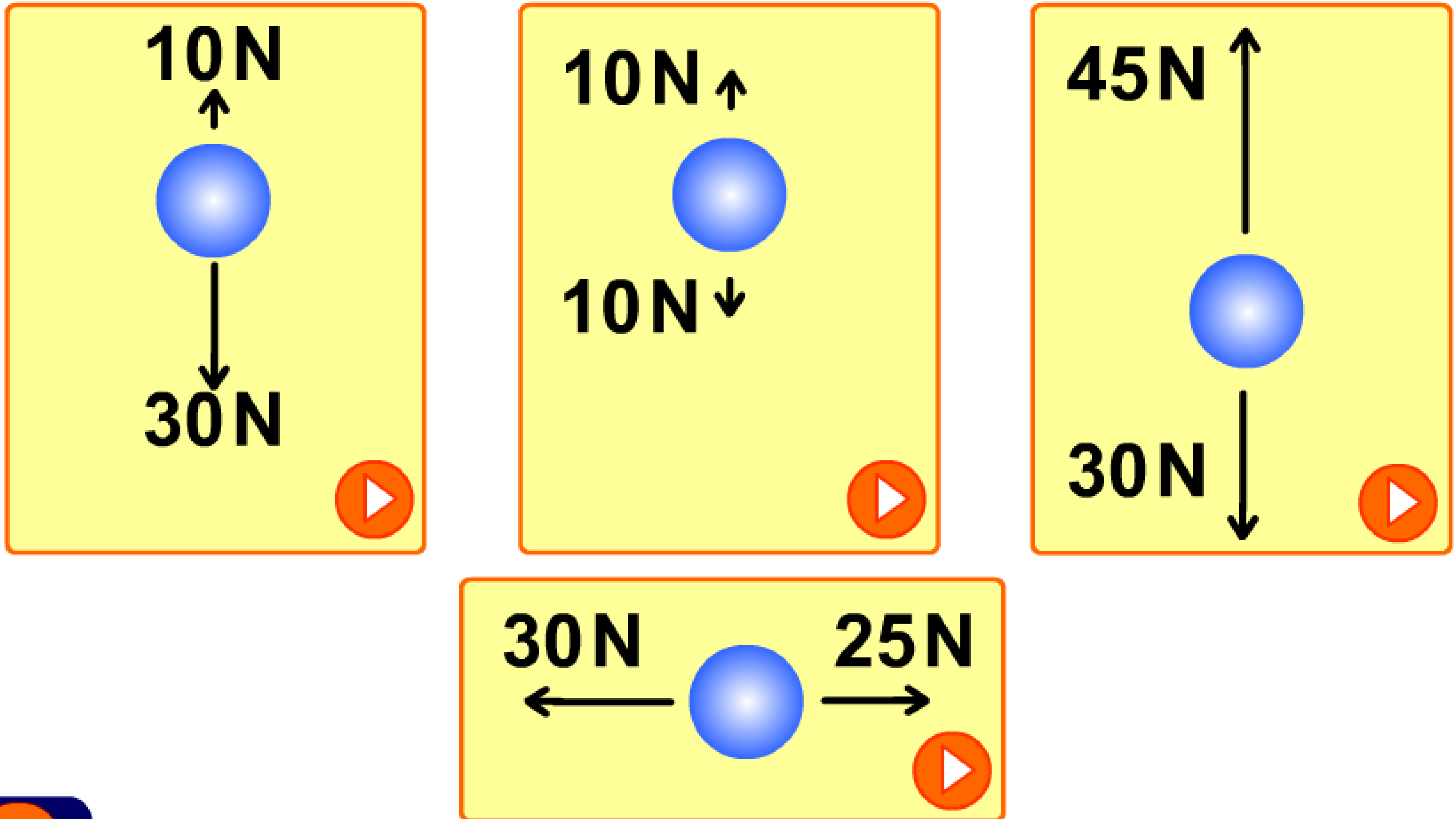
- **The object will start to <u>move</u> – its speed and direction have changed.**

If an object is moving and unbalanced forces act on it, what can happen to the object?

- **The <u>speed</u> of the object can change.**
  It might speed up or slow down.
- **The <u>direction</u> of the object can change.**

Balanced or unbalanced forces?

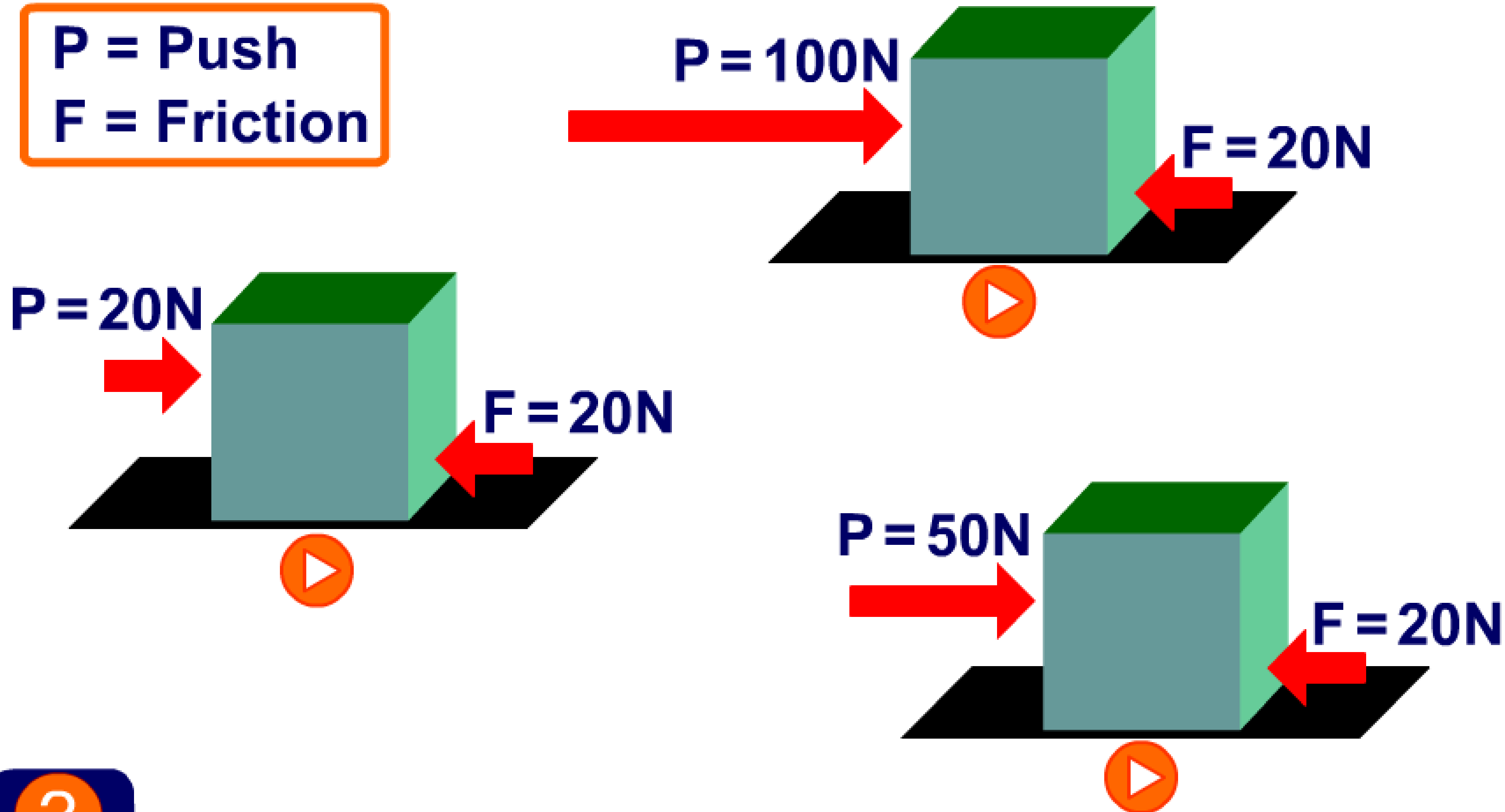
In which direction will each stationary object move?



Friction and movement.

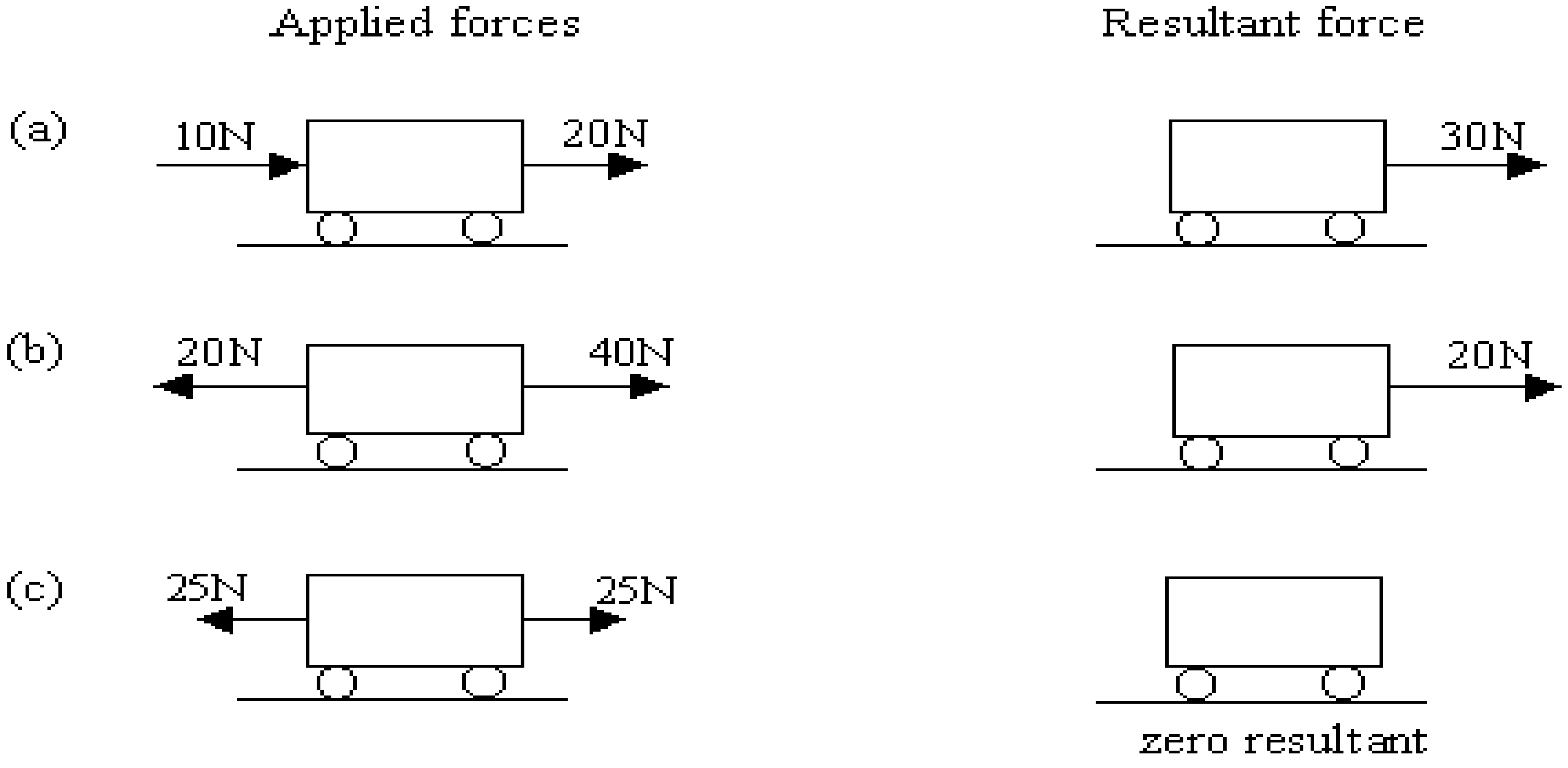
What is the resultant force on each block?

P = Push
F = Friction



Resultant force.

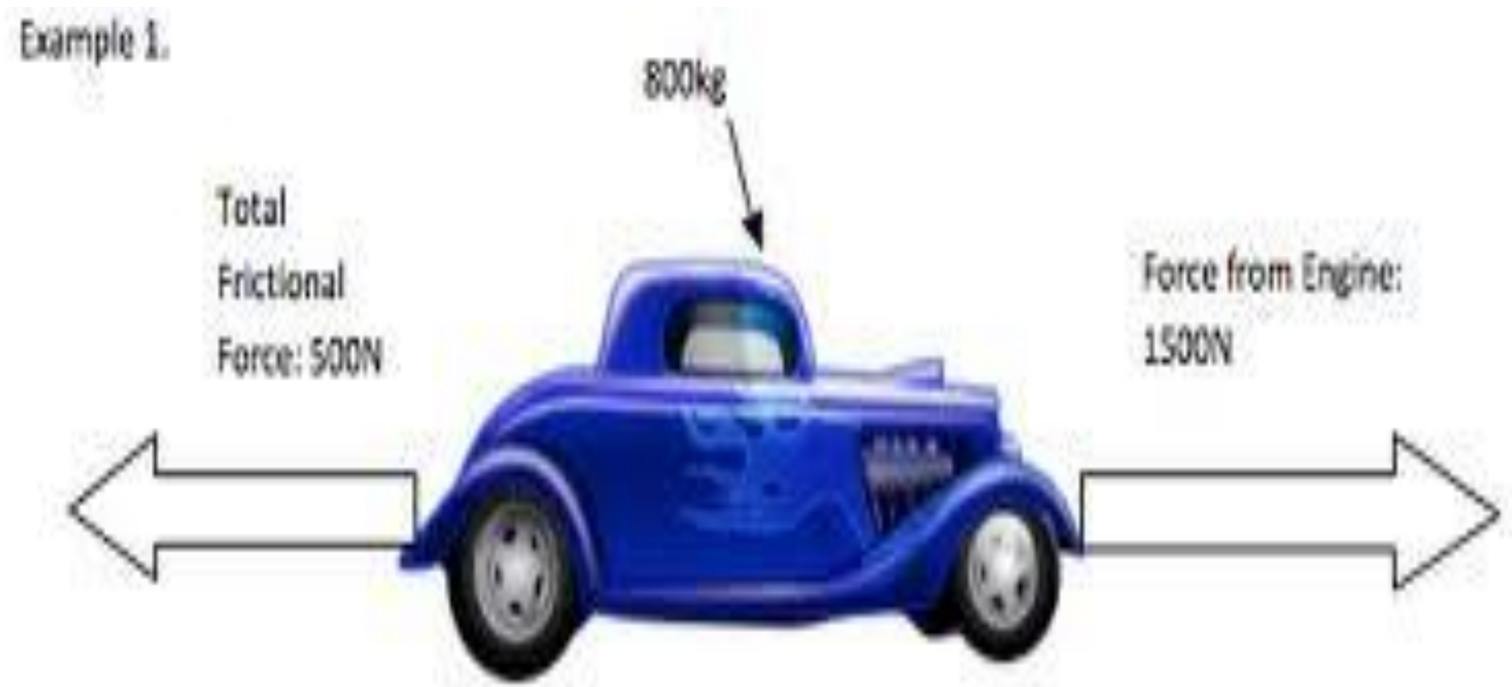
- The resultant force is the single force that can replace all the other forces.



Calculating acceleration.

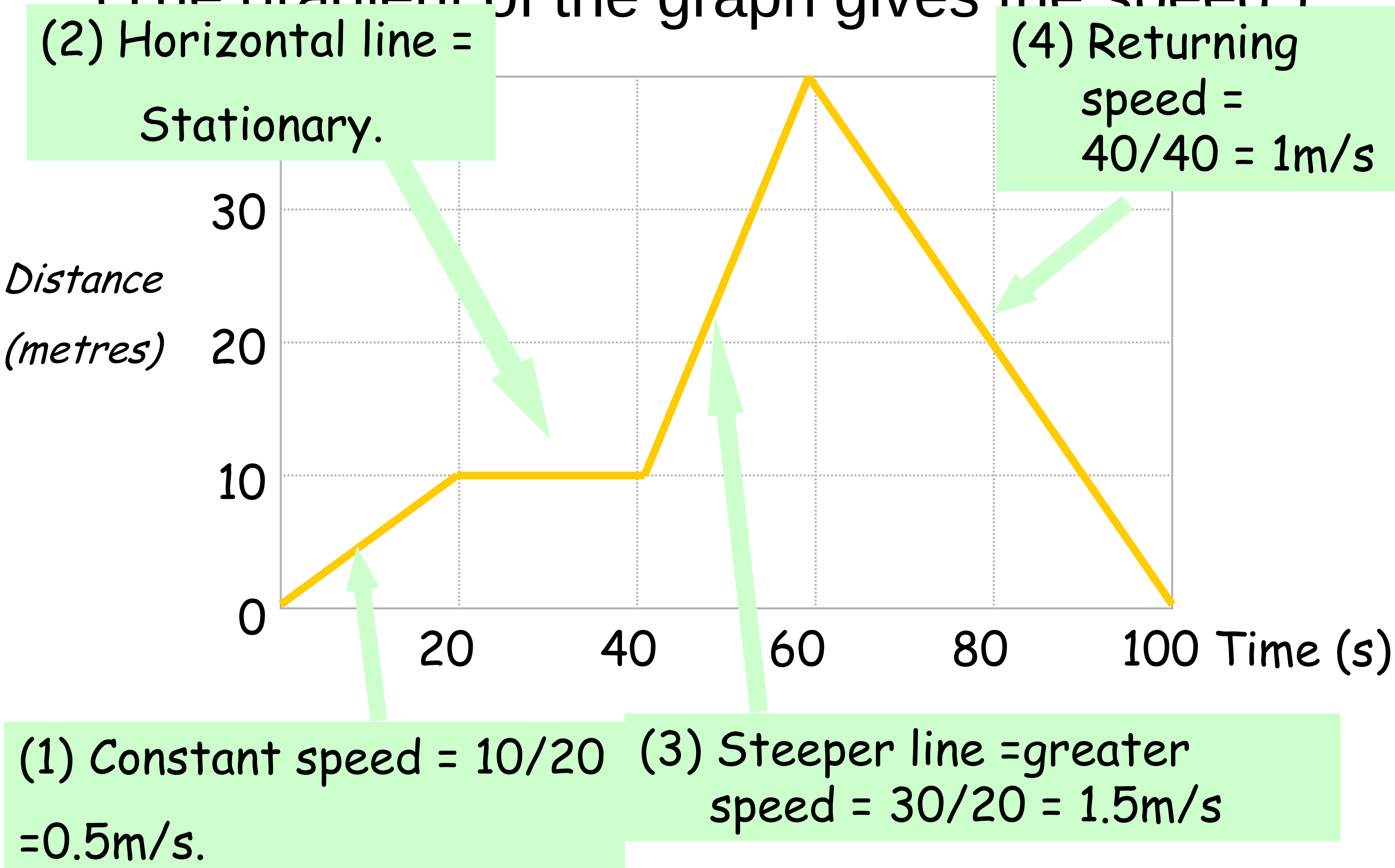
(Acceleration is calculated using the resultant force.)

- Resultant force = 1500N – 500N = 1000N to the right.
- Acceleration = $\frac{\text{Resultant force}}{\text{mass}} = \frac{1000\text{N}}{800\text{kg}} = 1.25\text{m/s}^2$



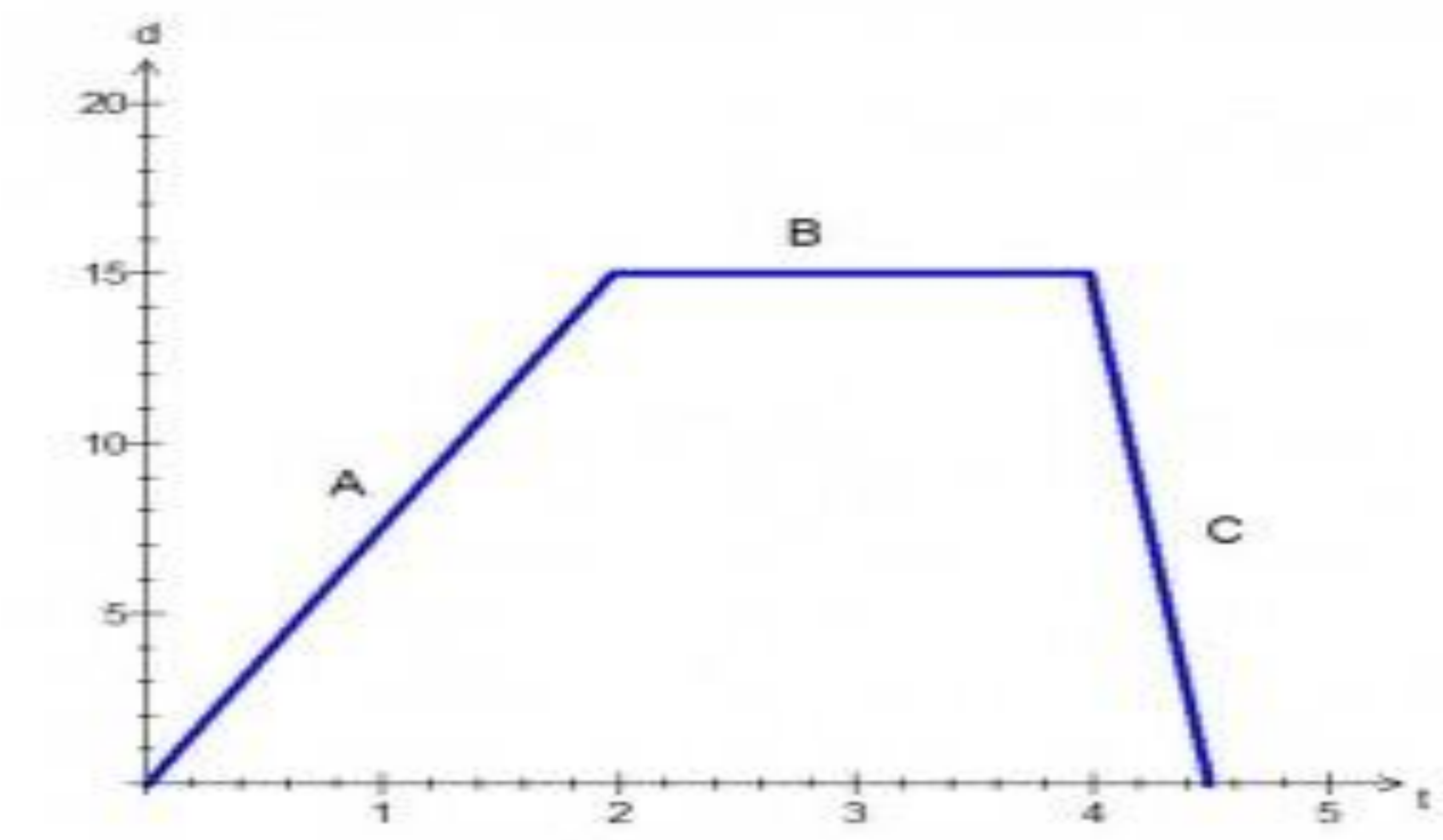
Distance-time graphs.

(The gradient of the graph gives the speed.)



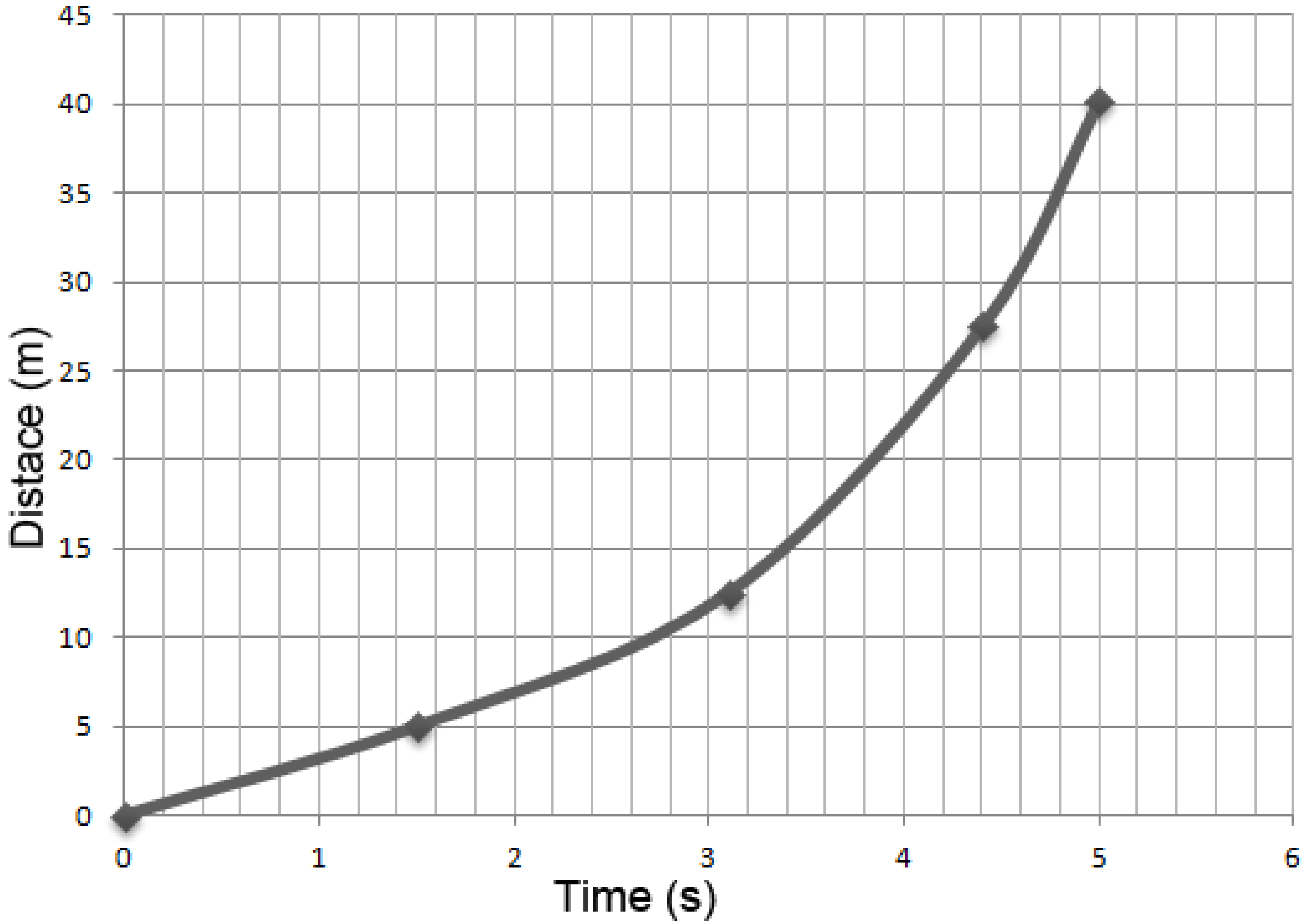
Calculating speed from a distance-time graph.

- A: (0 to 2s) 15/2 = 7.5m/s
- B: (2 to 4s) speed = 0, stationary.
- C: (4 to 4.5s) 15/0.5 = 30m/s



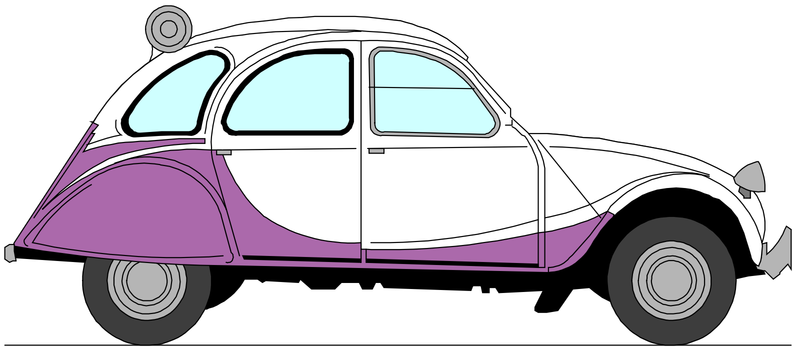
Calculating *average* speed.

- Average speed = $\frac{\text{total distance}}{\text{time taken}}$
- Average speed = 40/5 = 8m/s



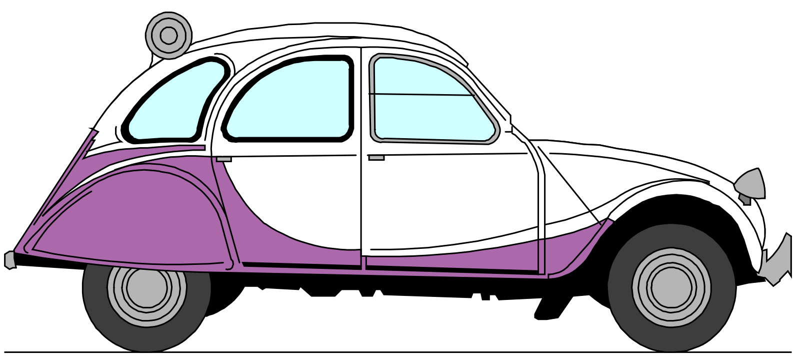
Speed vs. Velocity.

Speed is simply how fast you are travelling…



This car is travelling at a speed of 20m/s

Velocity is "speed in a given direction"…



This car is travelling at a velocity of 20m/s to the right.

Velocity-time graphs.

(The gradient gives the acceleration and the area gives the distance travelled.)

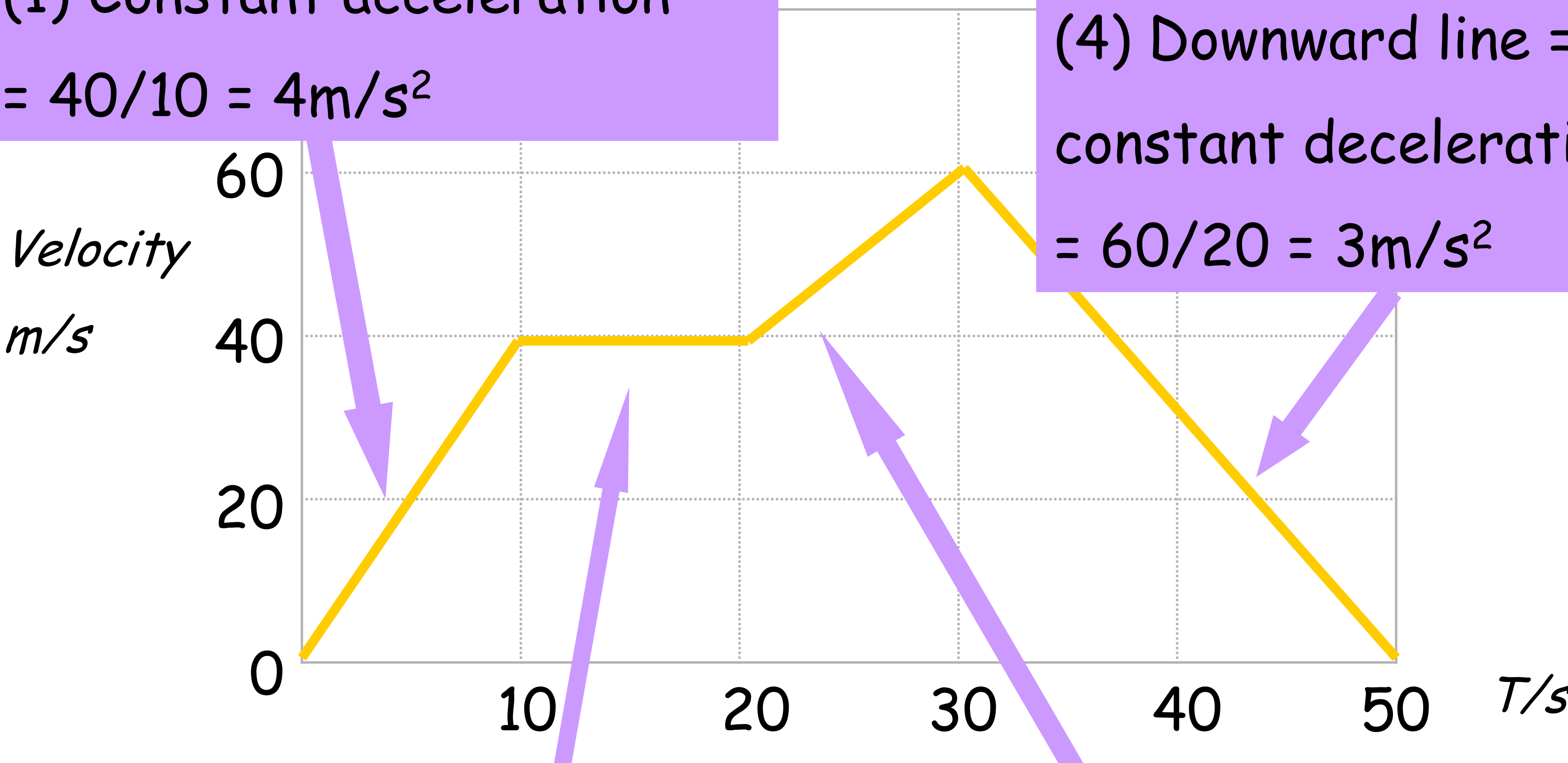
(1) Constant acceleration

= 40/10 = 4m/s^2

(4) Downward line =

constant deceleration

= 60/20 = 3m/s^2



(2) Horizontal line =

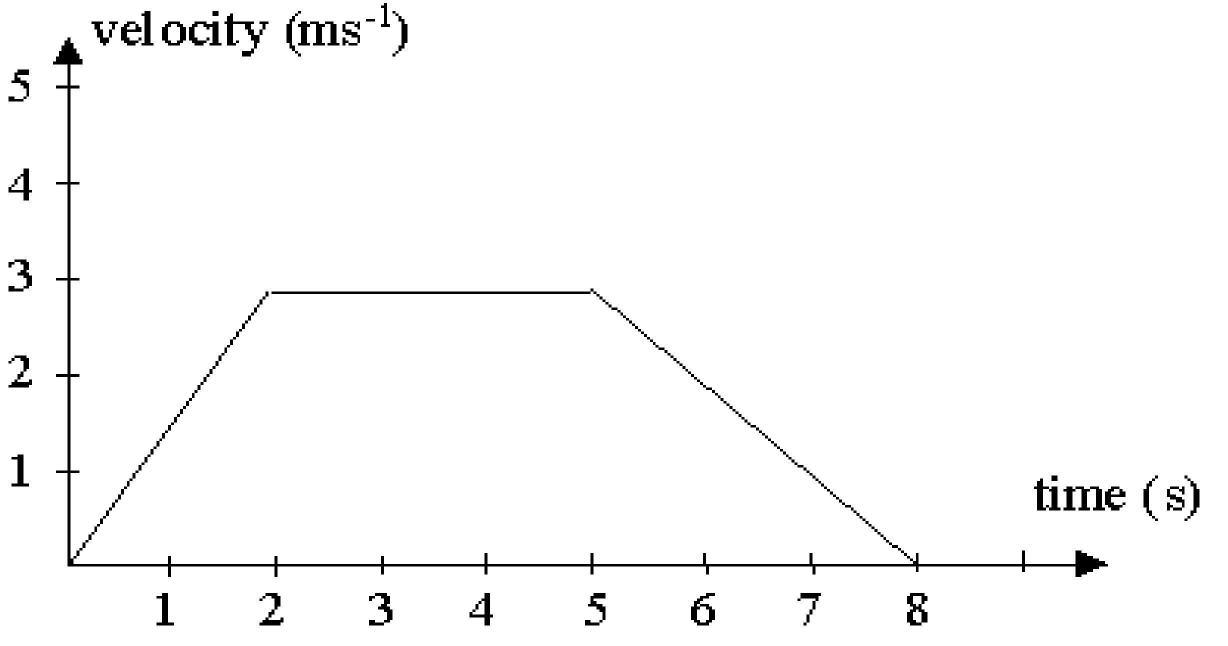
Constant speed = 40m/s

(3) Reduced acceleration

= 20/10 = 2m/s^2

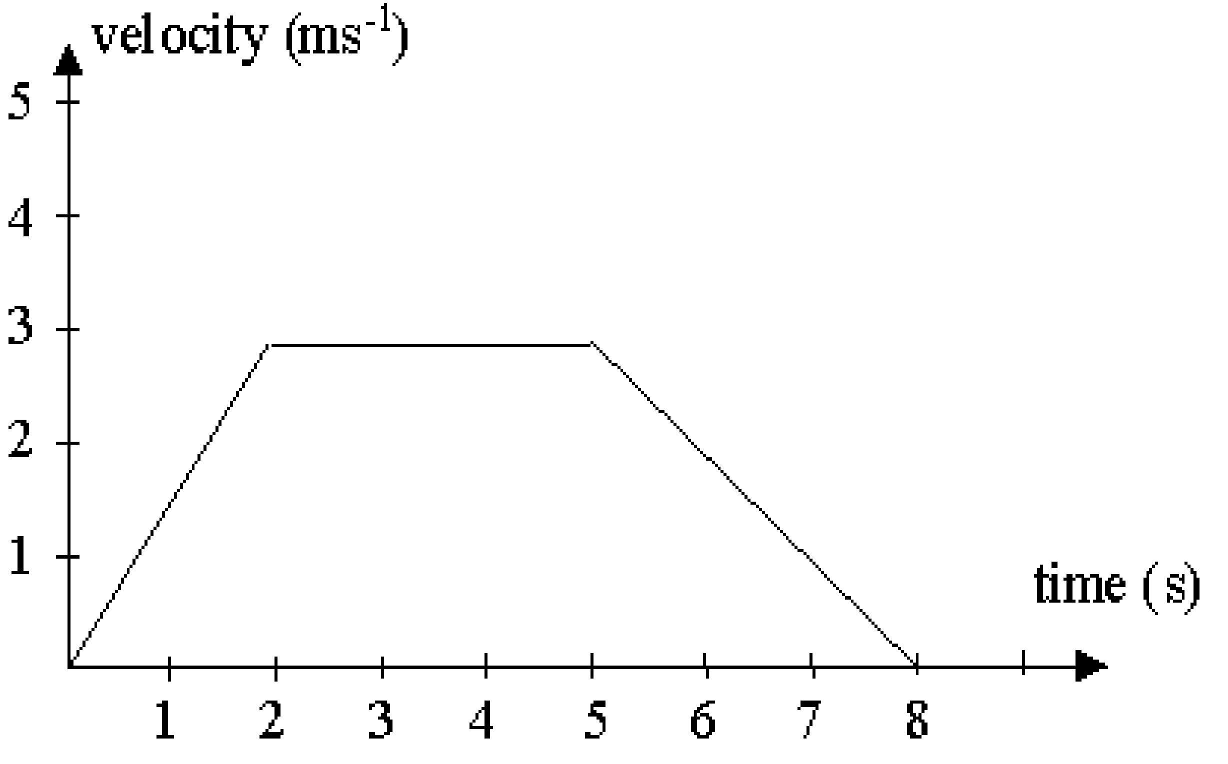
Area under a velocity-time graph.

- 0 to 2s: ½ x 2 x 3 = 3m
- 2 to 5s: 3 x 3 = 9m
- 5 to 8s: ½ x 3 x 3 = 4.5m
- Total distance = 3 + 9 + 4.5 = 16.5m

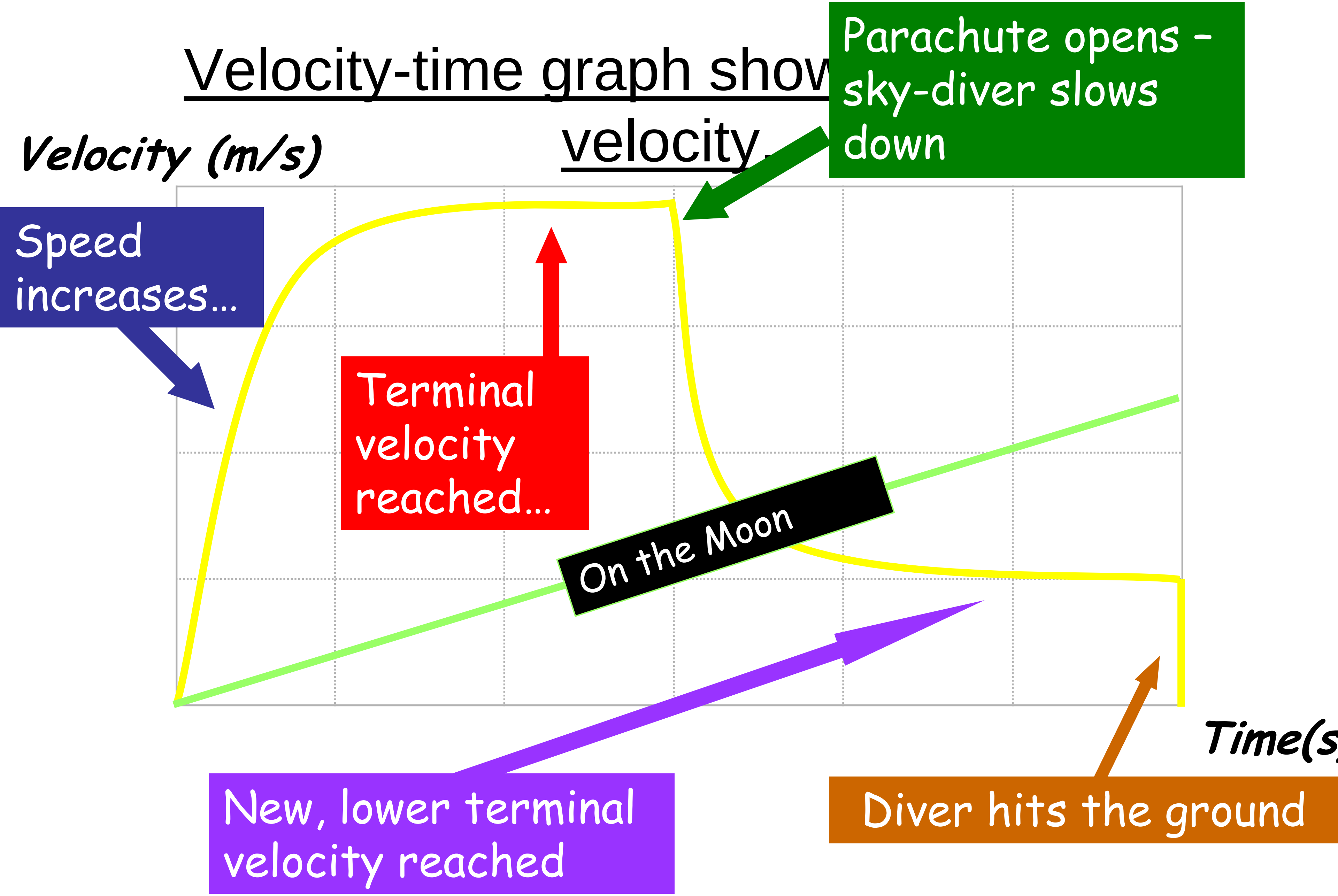


Gradient of a velocity-time graph.

- 0 to 2s: 3/2 = 1.5m/s^2
- 2 to 5s: acceleration = 0, constant speed (velocity).
- 5 to 8s: 3/3 = 1m/s^2 (deceleration)



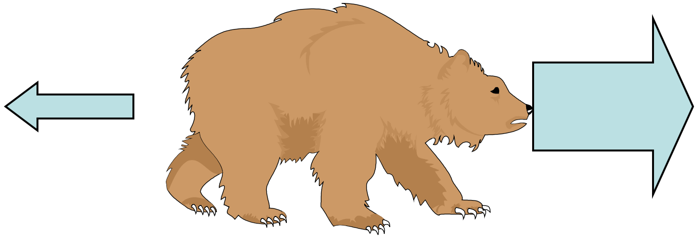
Velocity-time graph show... velocity.



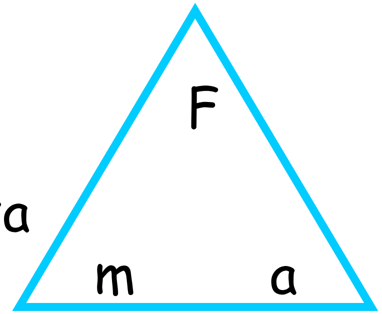
Newton's Laws of Motion.

These are my three laws of motion (summarised):

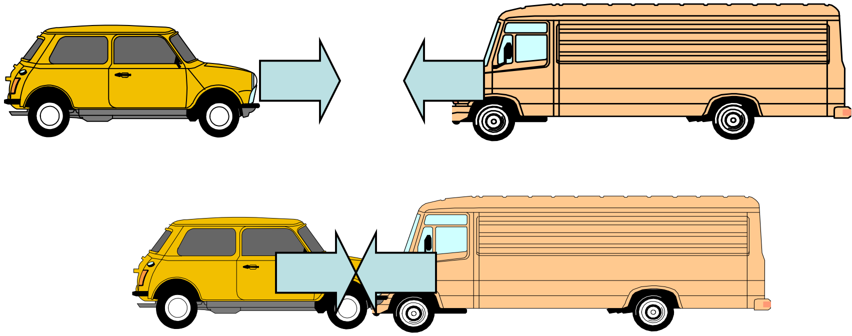
1) If an unbalanced force acts on an object that object will either accelerate or change direction:



2) That force is given by F=mxa



3) When a force acts on an object there is an equal force acting in the opposite direction ("Action and reaction are equal and opposite")



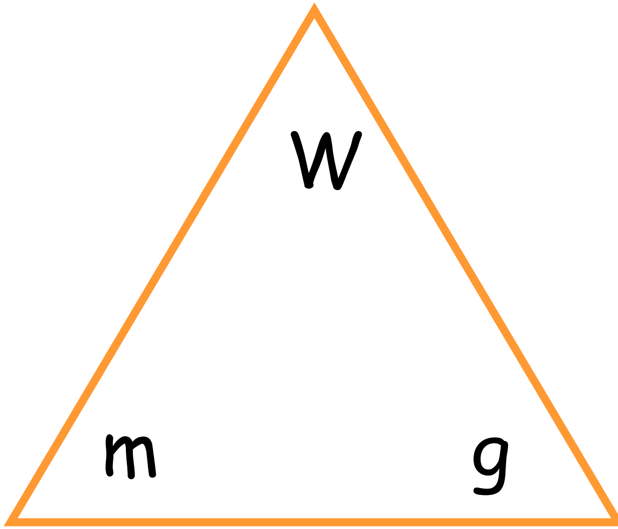
Weight and mass.

Earth's Gravitational Field Strength is 10N/kg. In other words, a 1kg mass is pulled downwards by a force of 10N.

Weight *(in N)*

mass (in kg)

gravitational field strength (in N/kg)

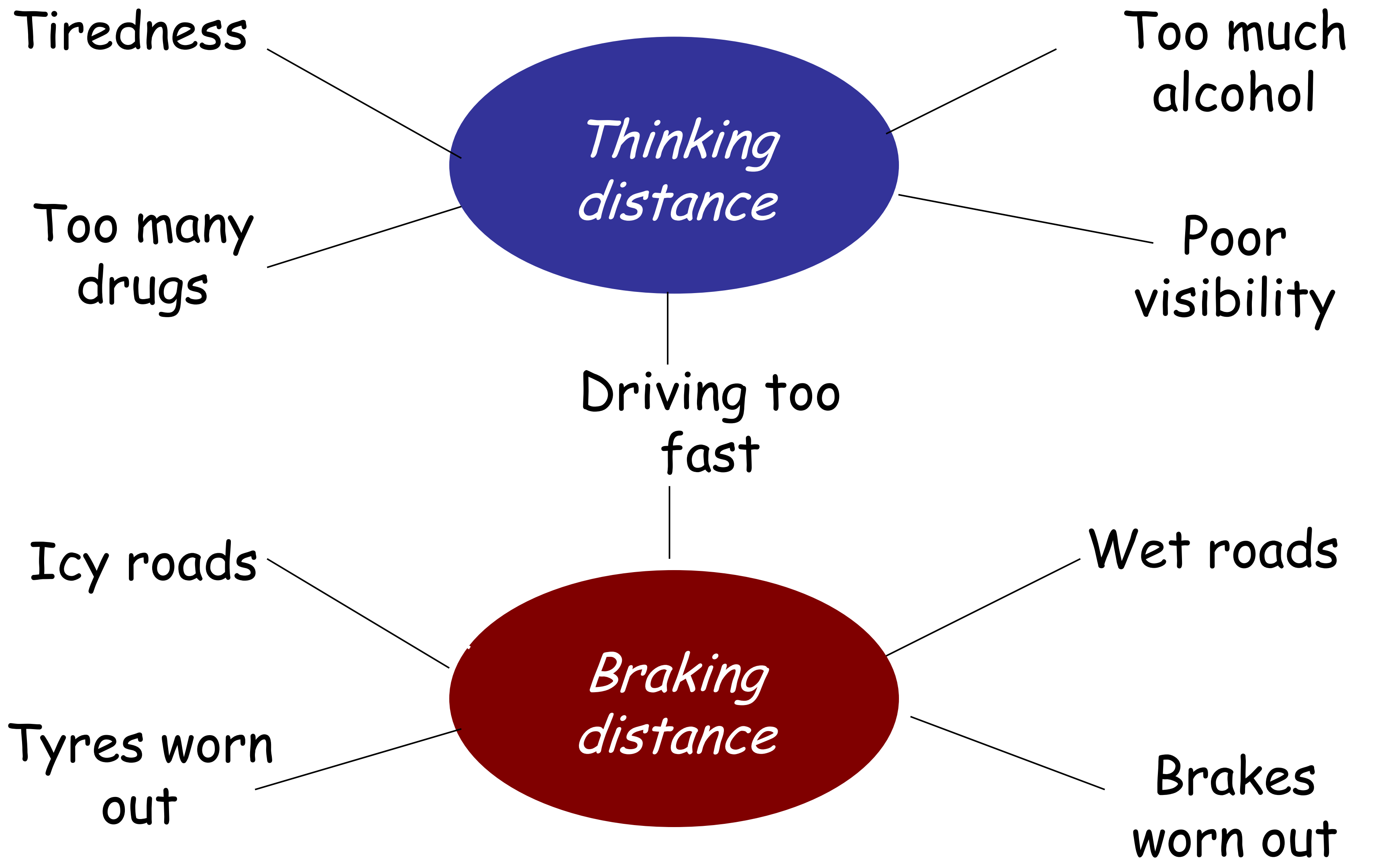


$W = m \times g$

1) What is the weight on Earth of a book with mass 2kg?
2) What is the weight on Earth of an apple with mass 100g?
3) Dave weighs 700N. What is his mass?
4) On the moon the gravitational field strength is 1.6N/kg. What will Dave weigh if he stands on the moon?

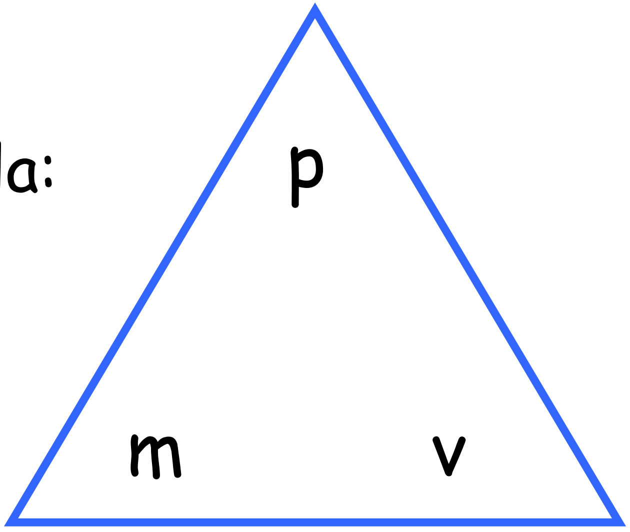
Stopping distance.

Stopping distance = thinking distance + braking distance



Momentum.

Any object that has both mass and velocity has MOMENTUM. Momentum (symbol “p”) is simply given by the formula:



Momentum = mass x velocity

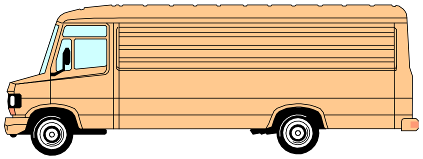
(in kgm/s) *(in kg)* *(in m/s)*

What is the momentum of the following?

1) A 1kg football travelling at 10m/s
2) A 1000kg Ford Capri travelling at 30m/s
3) A 20g pen being thrown across the room at 5m/s
4) A 70kg bungi-jumper falling at 40m/s

A past exam question:

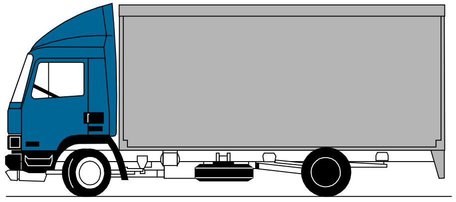
Two lorries are travelling in the same direction along a motorway.



Lorry A

Mass = 20,000kg

Speed = 14m/s



Lorry B

Mass = 30,000kg

Speed = 20m/s

1) Calculate the momentum of Lorry A as it travels along the motorway.
2) Calculate the momentum of Lorry B as it travels along the motorway.

(3 marks)

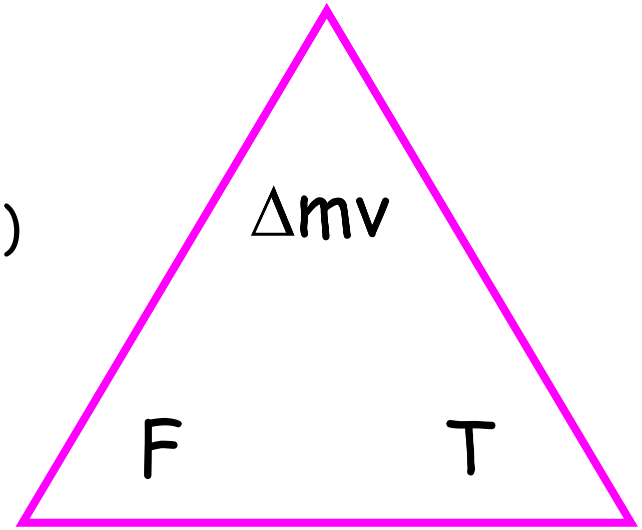
3) Lorry B collides with Lorry A and they stick together. Calculate the common speed of the lorries immediately after the collision.

(3 marks)

Newton's 2nd Law.

Instead of F=m x a Newton actually said that the force acting on an object is that object's rate of change of momentum. In other words…

$$\text{Force (in N)} = \frac{\text{Change in momentum (in kgm/s)}}{\text{Time (in s)}}$$



For example, David Beckham takes a free kick by kicking a stationary football with a force of 40N. If the ball has a mass of 0.5kg and his foot is in contact with the ball for 0.1s calculate:

1) The change in momentum of the ball,

2) The speed the ball moves away with

Calculating gravitational potential energy.

When an object falls or is raised, it is useful to calculate the **change** in gravitational potential energy (E_p).

To do this, the change in height is used in the E_p equation:

E_p = mass x g x height

E_p = weight x height

Change in E_p = weight x change in height

- Change in E_p is measured in **joules** (**J**).
- Mass is measured in **kilograms** (**kg**).
- Weight is measured in **newtons** (**N**).
- Change in height is measured in **metres** (**m**).

Gravitational potential energy problem.

A parachutist of weight 600 N jumps from a plane, which is 2000 m above the ground.
How much gravitational potential energy will the parachutist have lost when she reaches the ground?

$$E_p = \text{weight} \times \text{height}$$

$$\text{change in } E_p = \text{weight} \times \text{change in height}$$

$$= 600\text{ N} \times 2000\text{ m}$$

$$= \underline{1\,200\,000\text{ J}}$$

Gravitational potential energy problems.

You will need this equation to answer the following questions about gravitational potential energy:

GPE = weight x height

Click "start" to begin.

start

Calculating kinetic energy.

The kinetic energy (E_k) of an object depends on its mass and its velocity.

The equation for calculating kinetic energy is:

kinetic energy = ½ x mass x velocity²

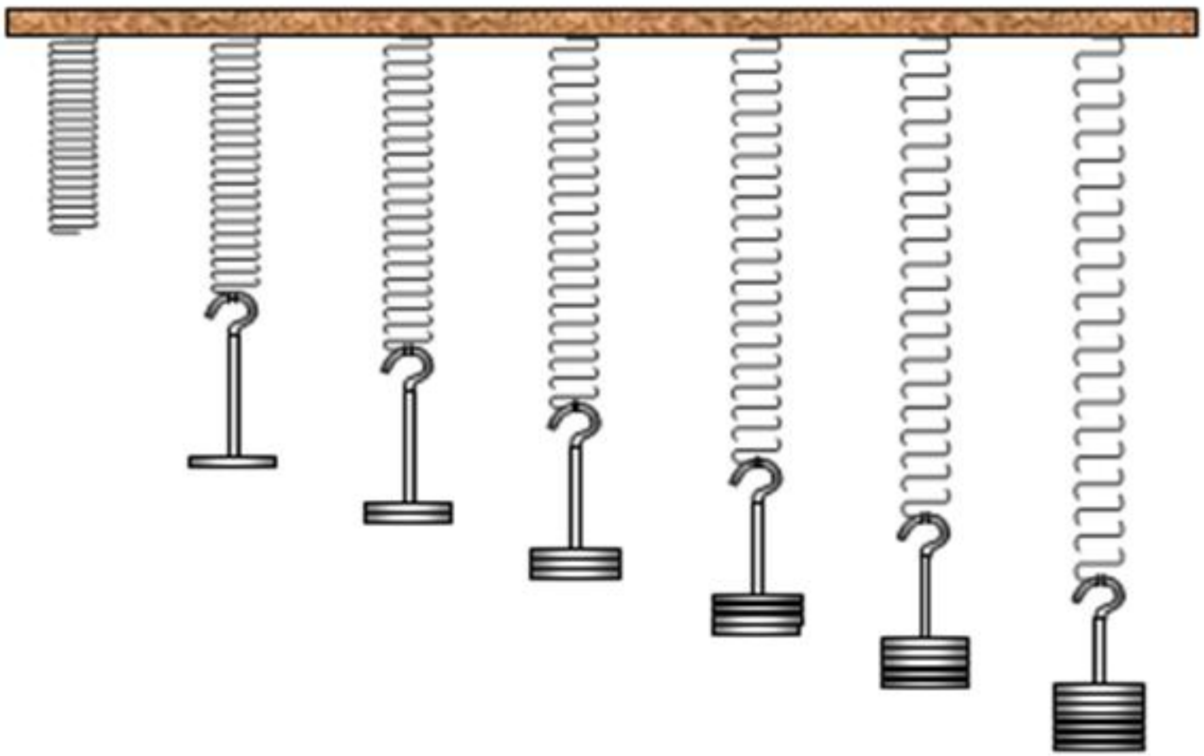
$$E_k = \frac{1}{2}mv^2$$

What are the units of kinetic energy, mass and velocity?

- Kinetic energy is measured in **joules** (**J**).
- Mass is measured in **kilograms** (**kg**).
- Velocity is measured in **metres per second** (**m/s**).

Forces and Elasticity.

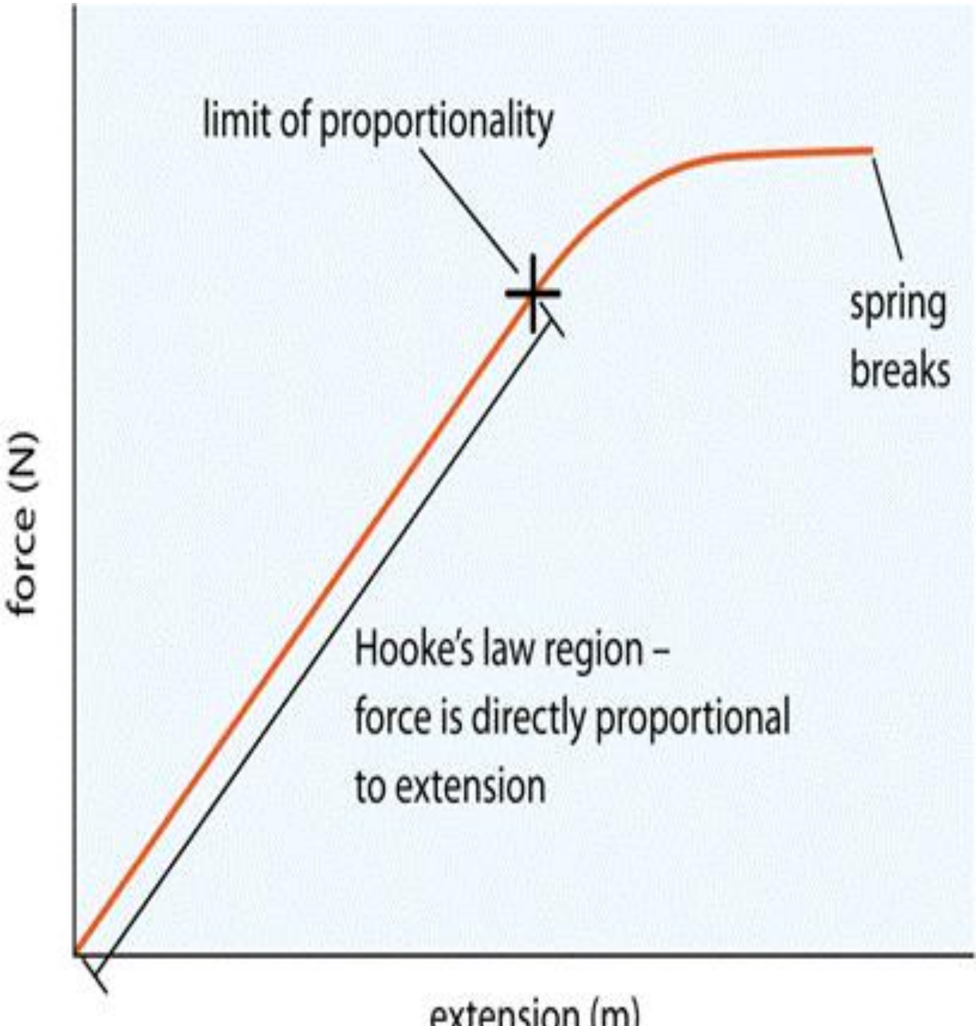
- Extension = original length – stretched length.
- Force = weight added.
- Force (N) = spring constant (N/m) x extension (m).
- F = k x e



Hooke's Law.

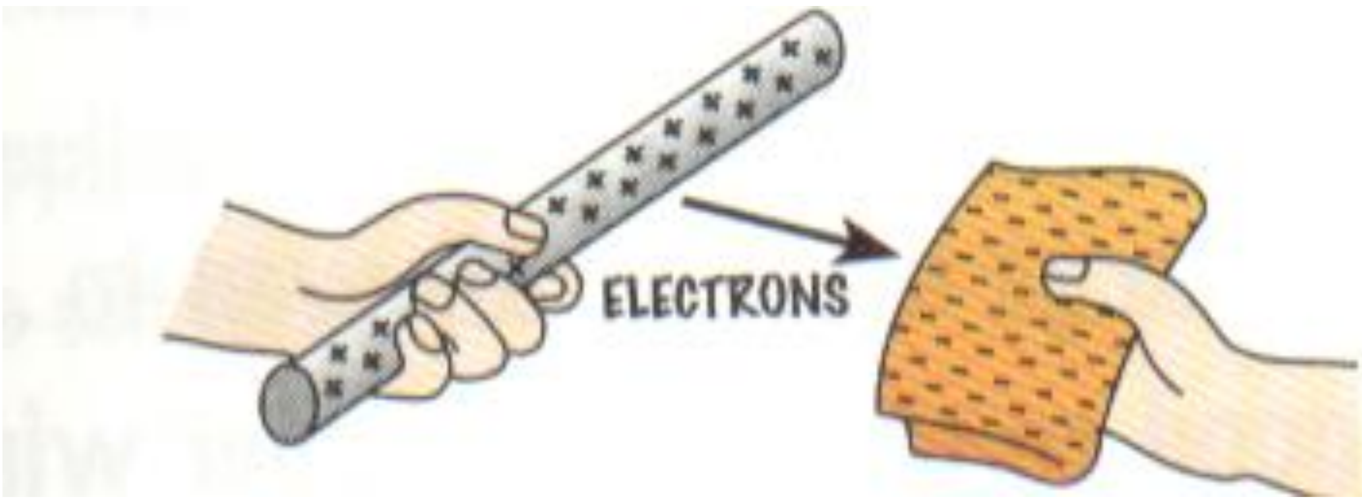
- Force and extension are proportional up to the limit of proportionality.
- Beyond this limit the

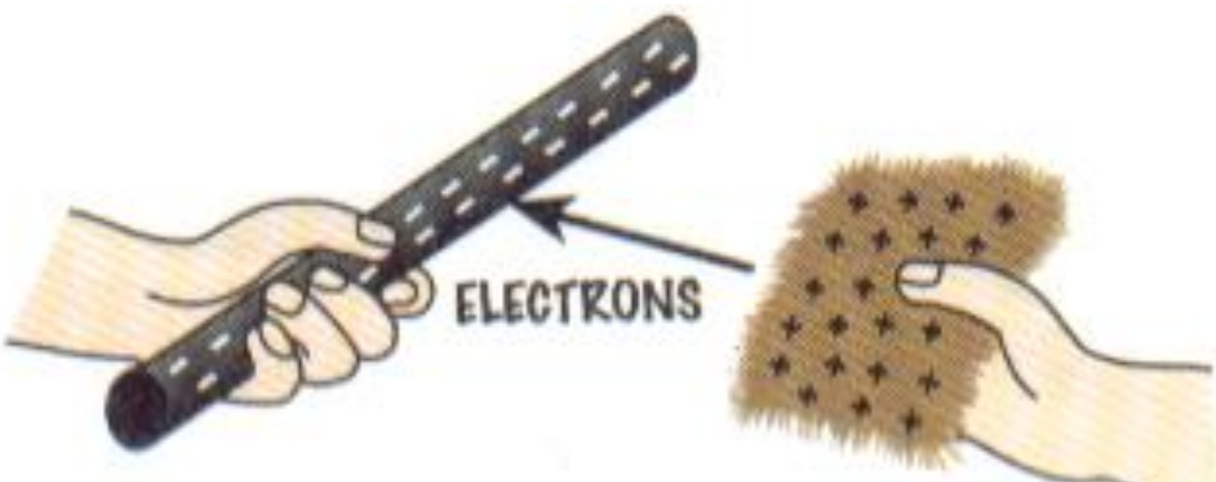
spring will be permanently stretched. When the force is removed the spring will be longer than it was at the start.



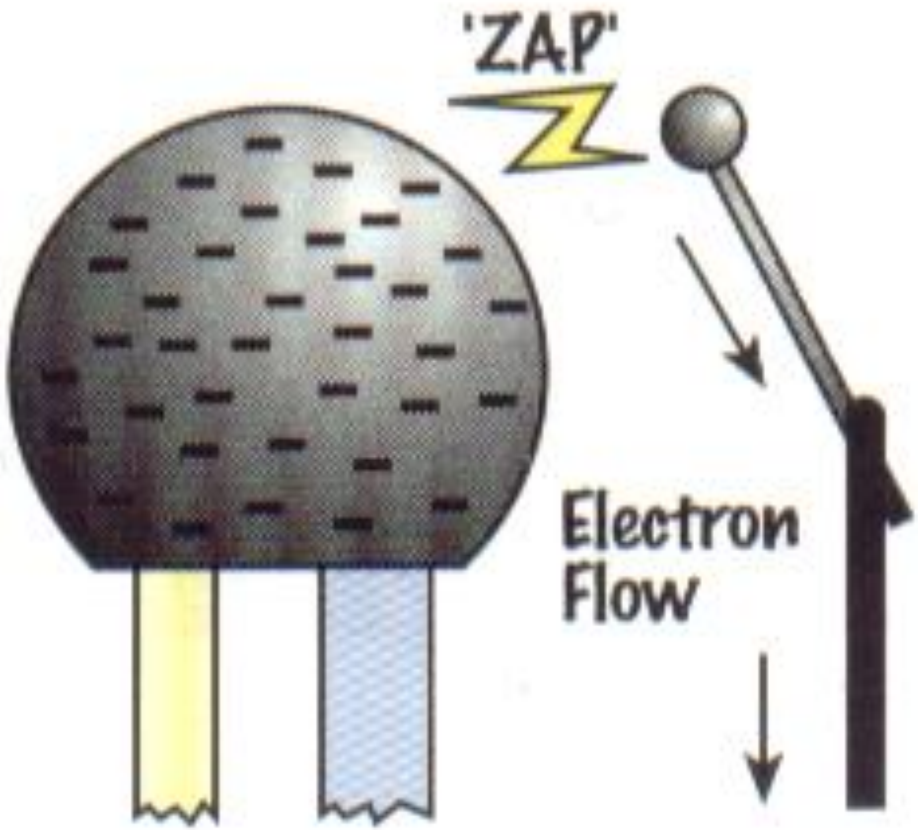
Static electricity.

Static electricity is when charge "build up" on an object and doesn't move, e.g. rubbing a rod:



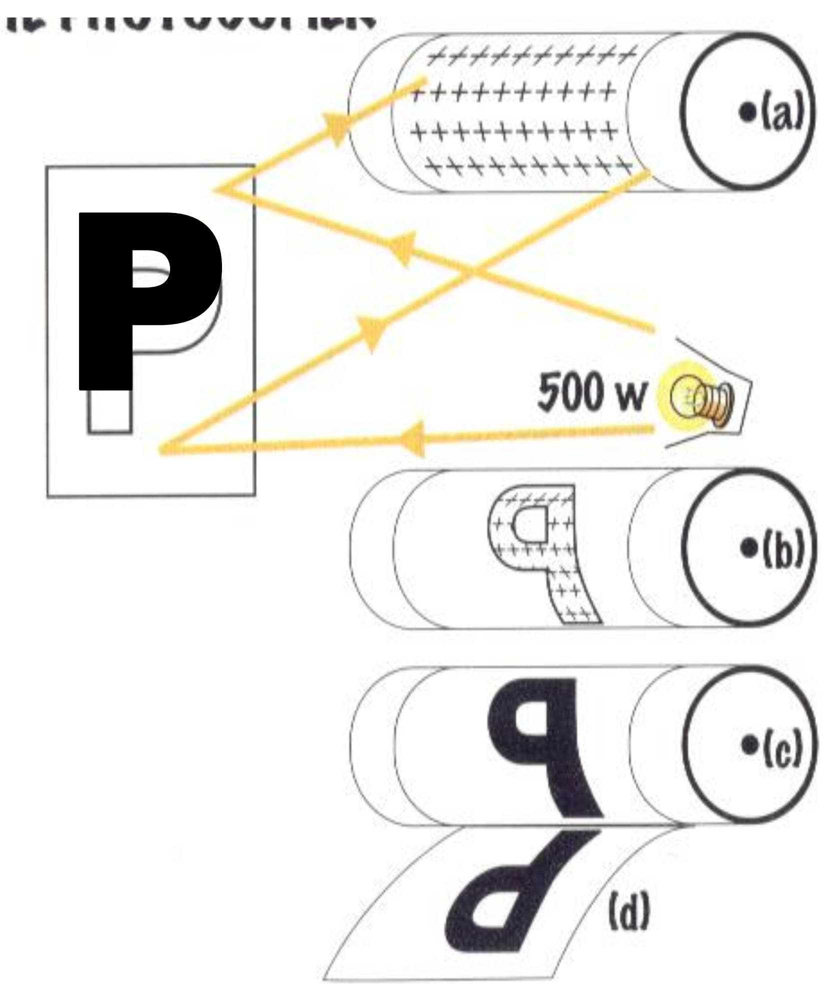


Van de Graff generators.



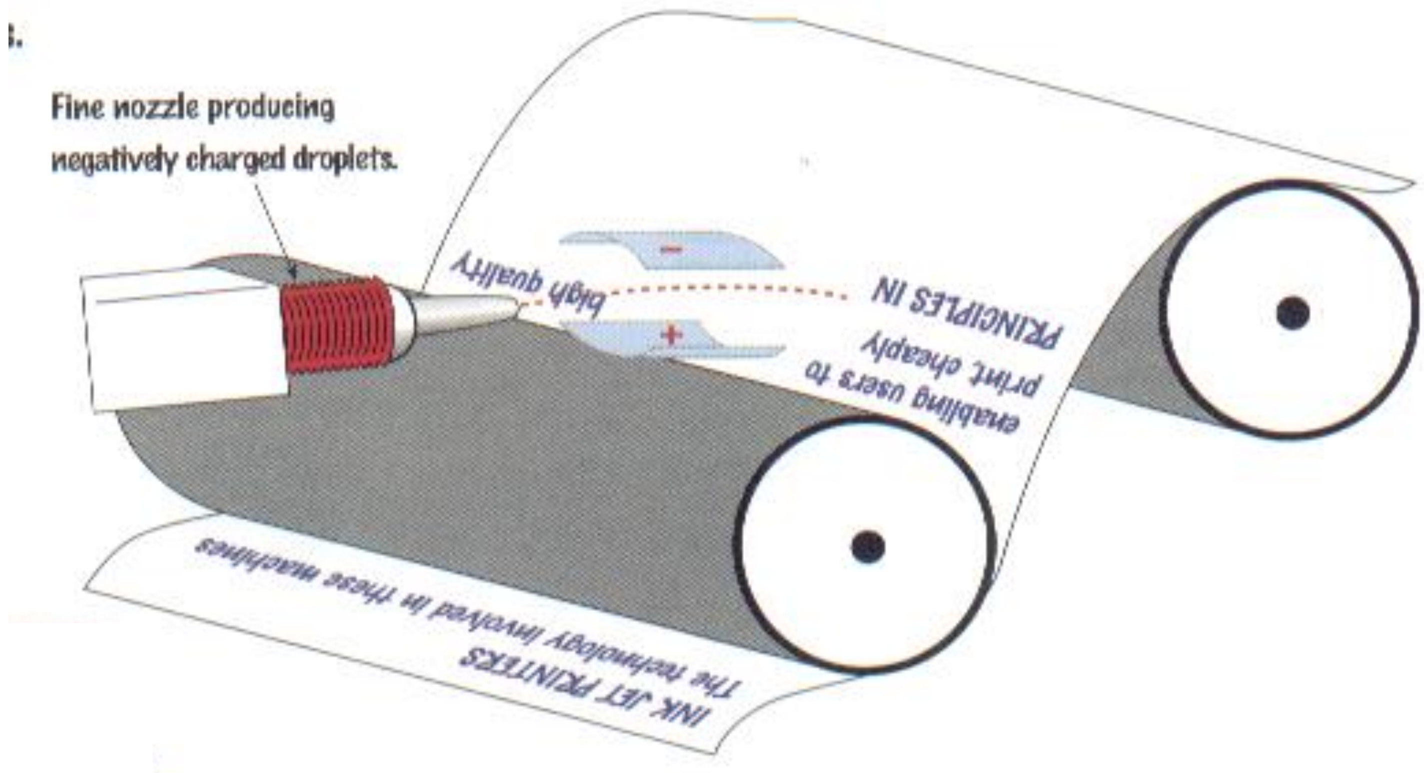
A charge builds up on the dome due to electrons being "rubbed on" by the belt. If a big enough charge is built up then the voltage becomes high enough to ionise the air molecules and the electrons "jump" down to Earth – this is an electric current.

Use of static (1) Photocopiers.



Photocopiers use static electricity. They work by: 1) Copying an image of the page onto a charged plate, 2) Light then causes the charge to leak away, leaving an “electrostatic impression” of the page, 3) The charges left on the plate attract small drops of black powder, 4) The powder is transferred from the plate onto the paper, 5) The paper is heated to “fix” the powder.

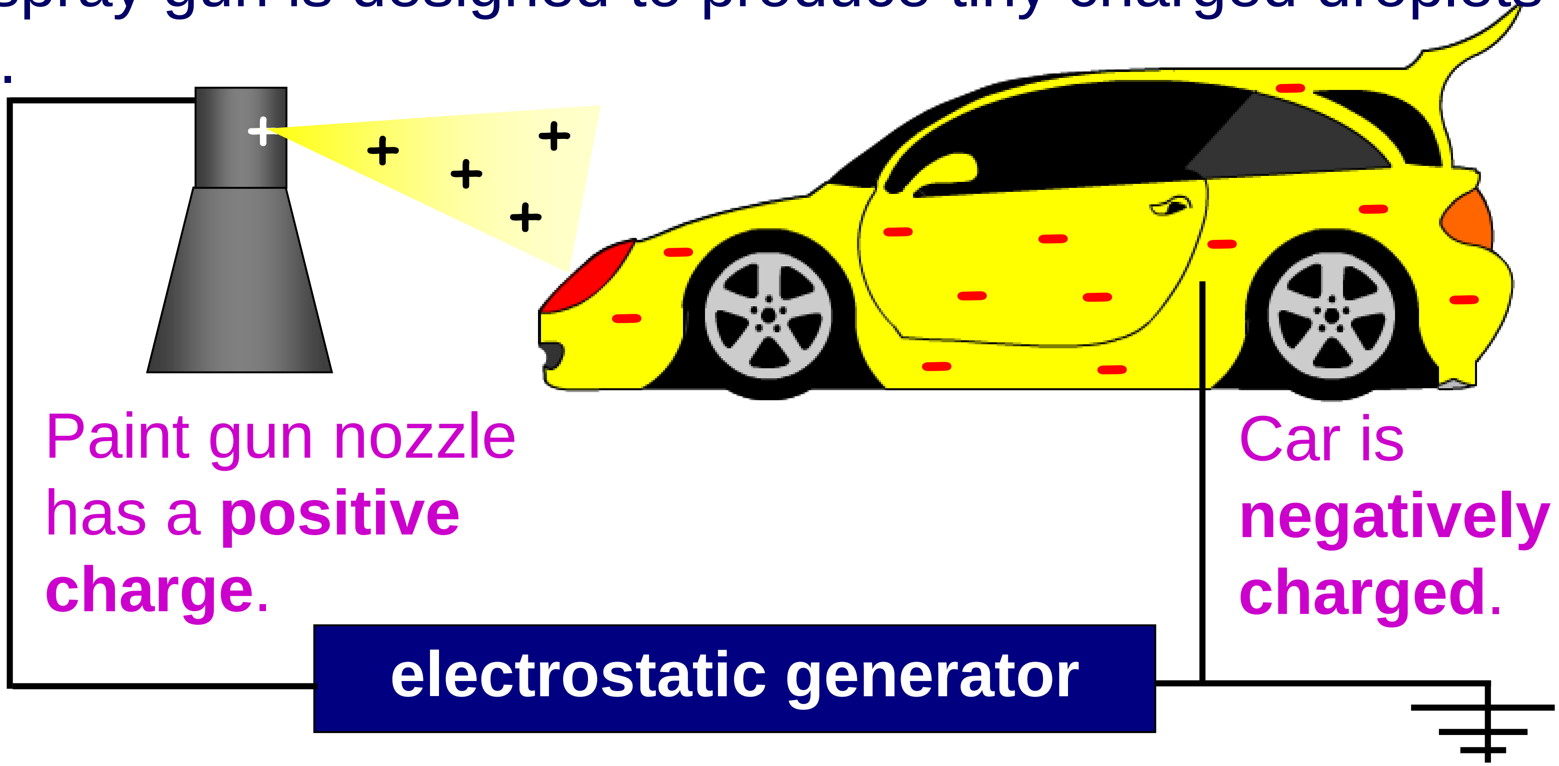
(2) Printers.



Inkjet printers work by spraying charged drops of ink onto a page. The droplets can be directed using two oppositely charged plates. The voltage on these plates can be easily swapped or varied. The inkjet cartridge can also moved across the page by the printer

(3) An electrostatic paint spray.

The spray gun is designed to produce tiny charged droplets of paint.



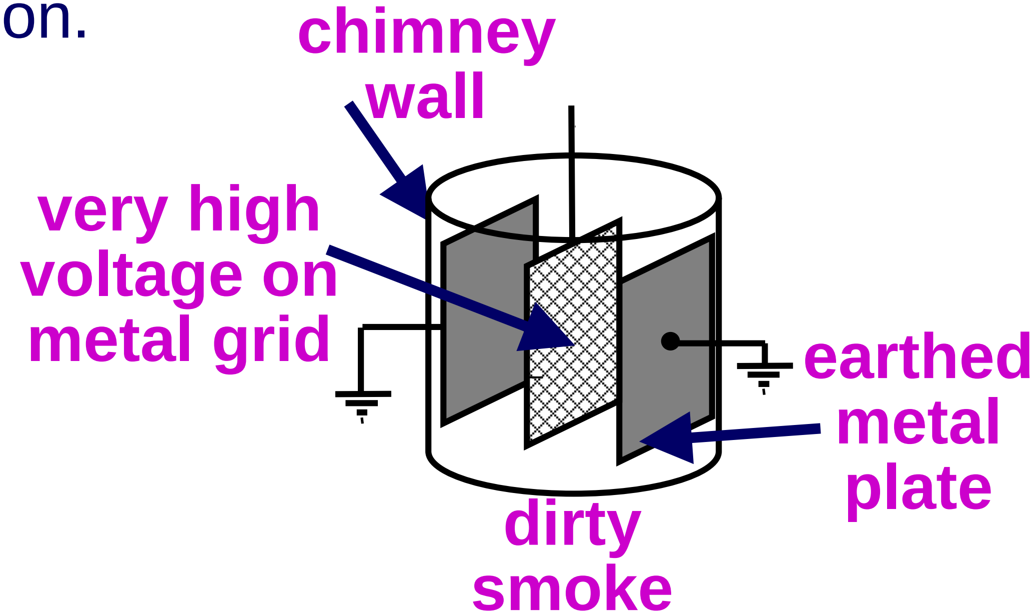
The charged droplets repel each other and spread out.
The positive droplets are attracted to the negative car.
This ensures an even coat of paint as well as less paint being wasted.

(4) Smoke precipitator.

Static electricity can be used to reduce pollution in the chimney of a power station.

A metal grid at a very high voltage runs down the middle of the chimney.

Earthed metal plates run down the inside of the chimney.



Dirty smoke particles become charged in the electric field. These charged particles are attracted to the earthed metal plates where they lose their charge and then fall back down the chimney.

The result is clean smoke out of the top of the chimney.

Dangers of static.

During refuelling the fuel gains electrons from the pipe, making the pipe positive and the fuel negative. The resulting voltage may cause a spark, resulting in an explosion.

Solution: *Either earth the fuel tank with a copper rod or connect the tanker to the plane by a copper conductor.*

Circuit Symbols:

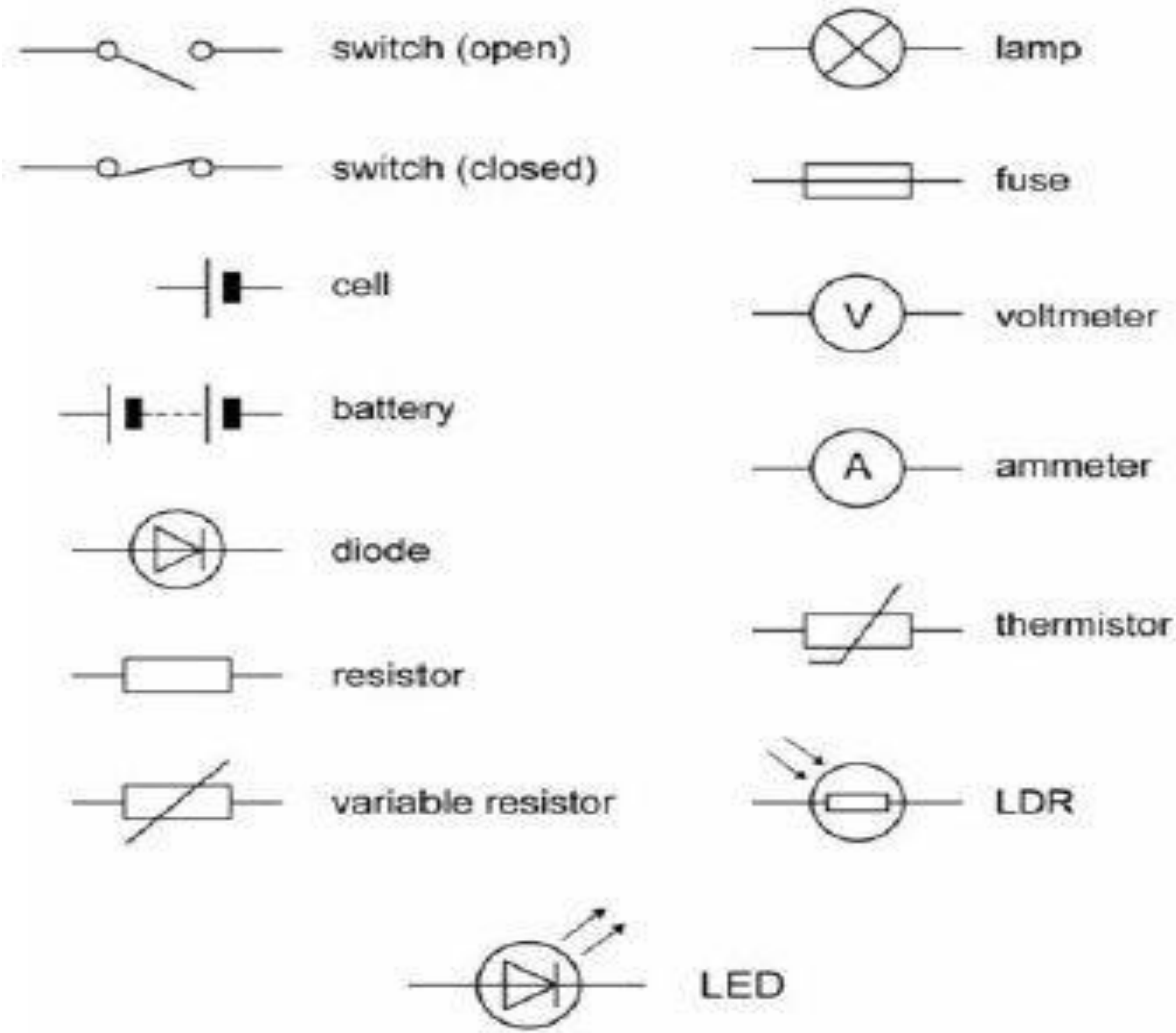
Need to know the circuit symbols (and what they do) for:

- Switch- turns the current on and off.
- Cell- the source of electrical energy.
- Battery- two or more cells.
- Diode- allows current to flow in one direction only.

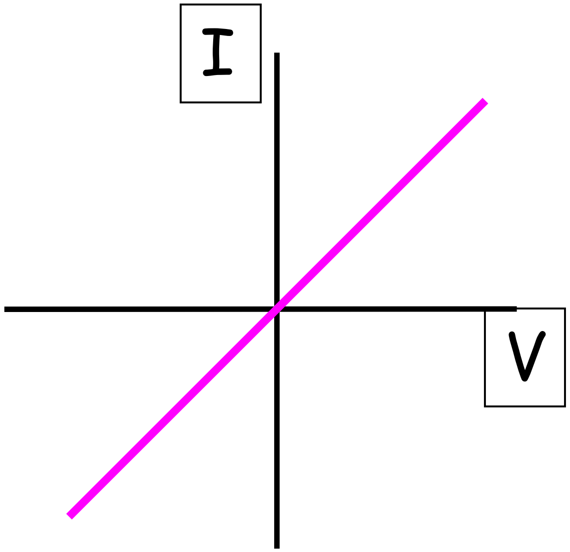
- Resistor- resists the flow of current.
- Variable resistor- alters the amount of current flowing.
- Lamp (or filament lamp)- usefully converts electrical energy into light energy. Resistance increases when temperature increases.
- Fuse- used in a plug. Melts when the current is too high.

- Voltmeter- measures the voltage (pd) across a component. Connected in parallel.
- Ammeter- measures the current through a component. Connected in series.
- Thermistor- resistance decreases when the temperature increases.
- LDR- light dependent resistor. The resistance decreases when the light intensity (brightness) increases.
- LED- emits light using a much smaller current than a filament lamp. Only works when current flows in the forward direction.

Circuit symbols.

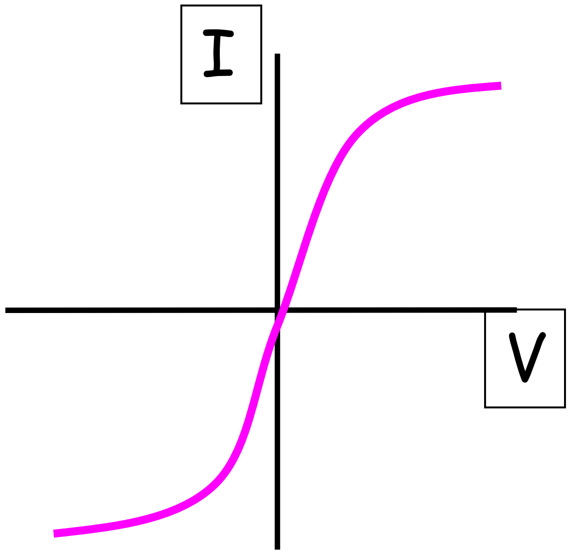


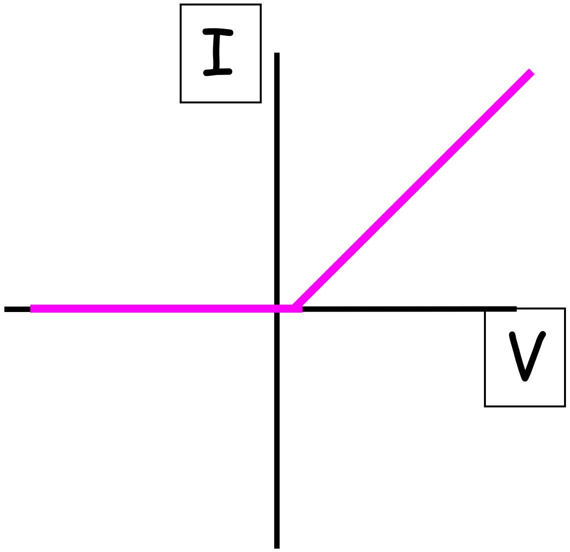
Current-voltage graphs.



1. Resistor

2. Filament lamp

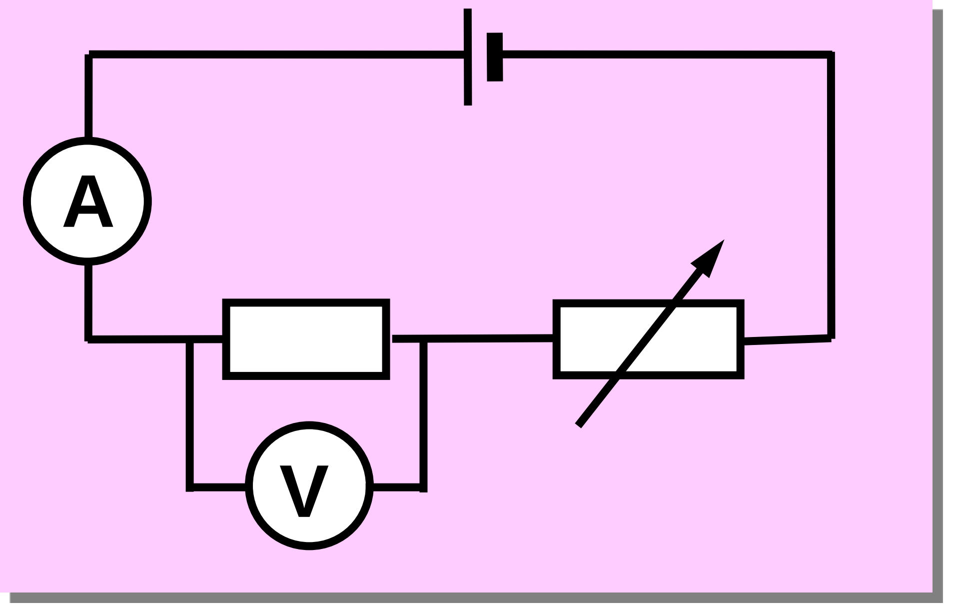




3. Diode

Explain the shape of each graph

The circuit used to obtain the I-V characteristics graphs:

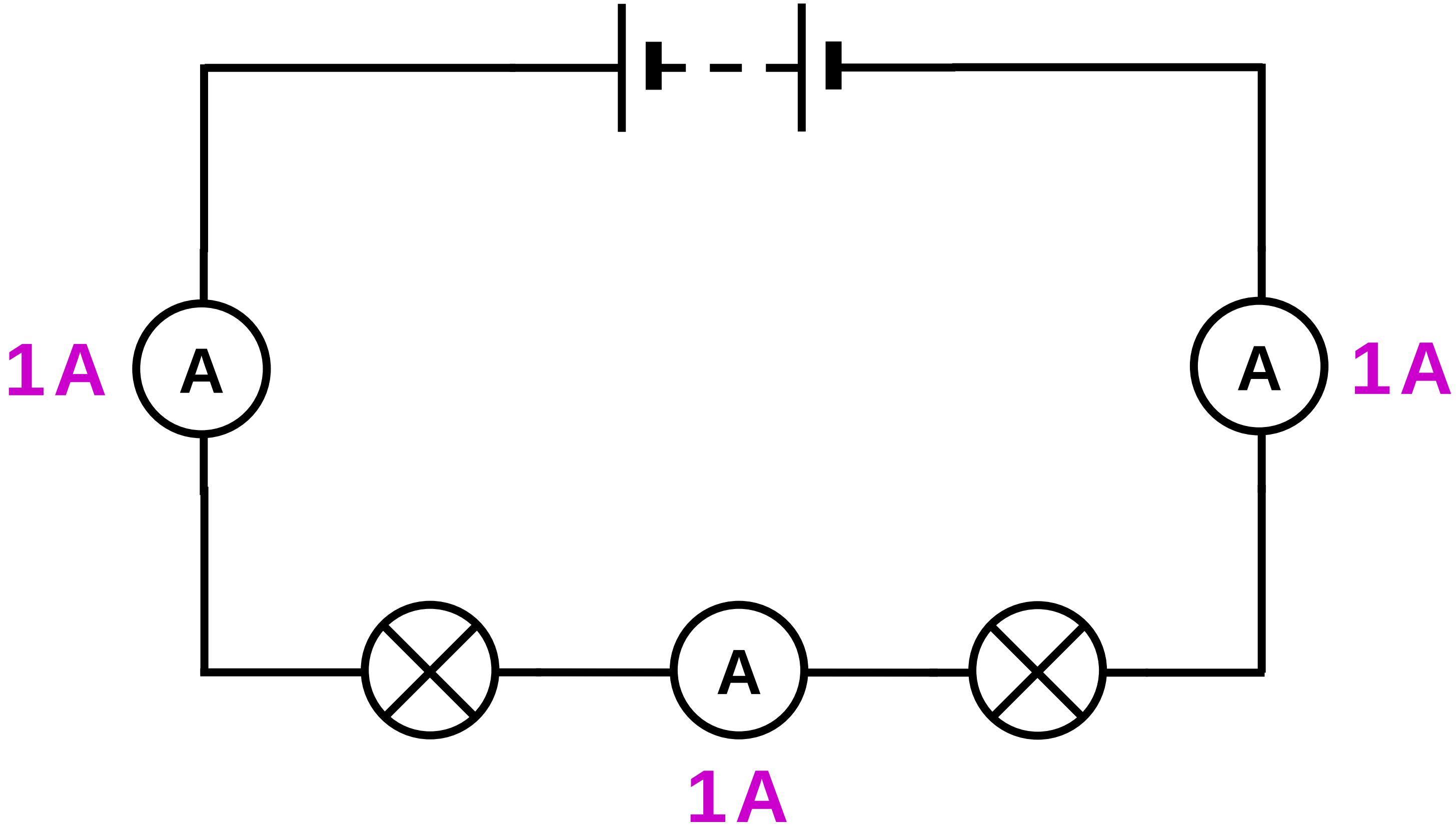


Slowly adjust the variable resistor to obtain current and voltage values for the resistor.

Repeat the experiment using the filament lamp then the diode in place of the resistor.
Plot the current-voltage graphs of the results.

Current in series circuits.

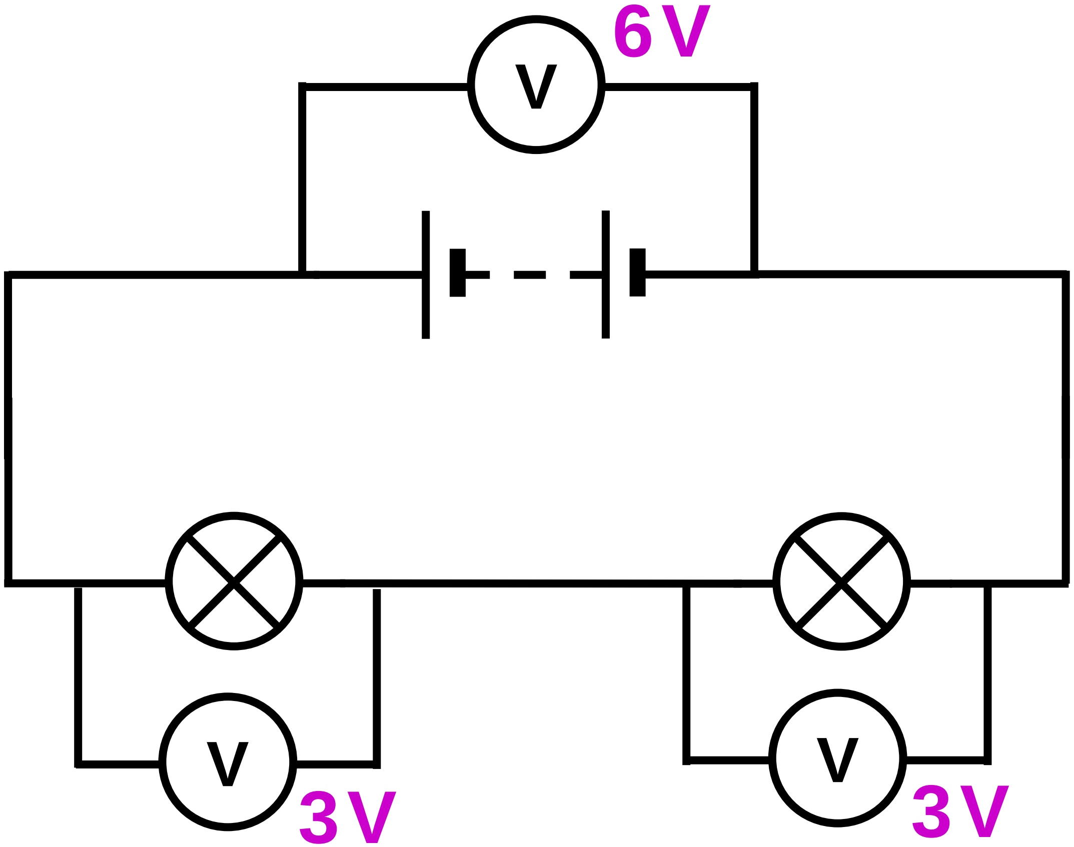
The current in a series circuit must flow through all parts of the circuit. Therefore, the size of the current is the same in all parts of a series circuit.



Potential difference in series circuits.

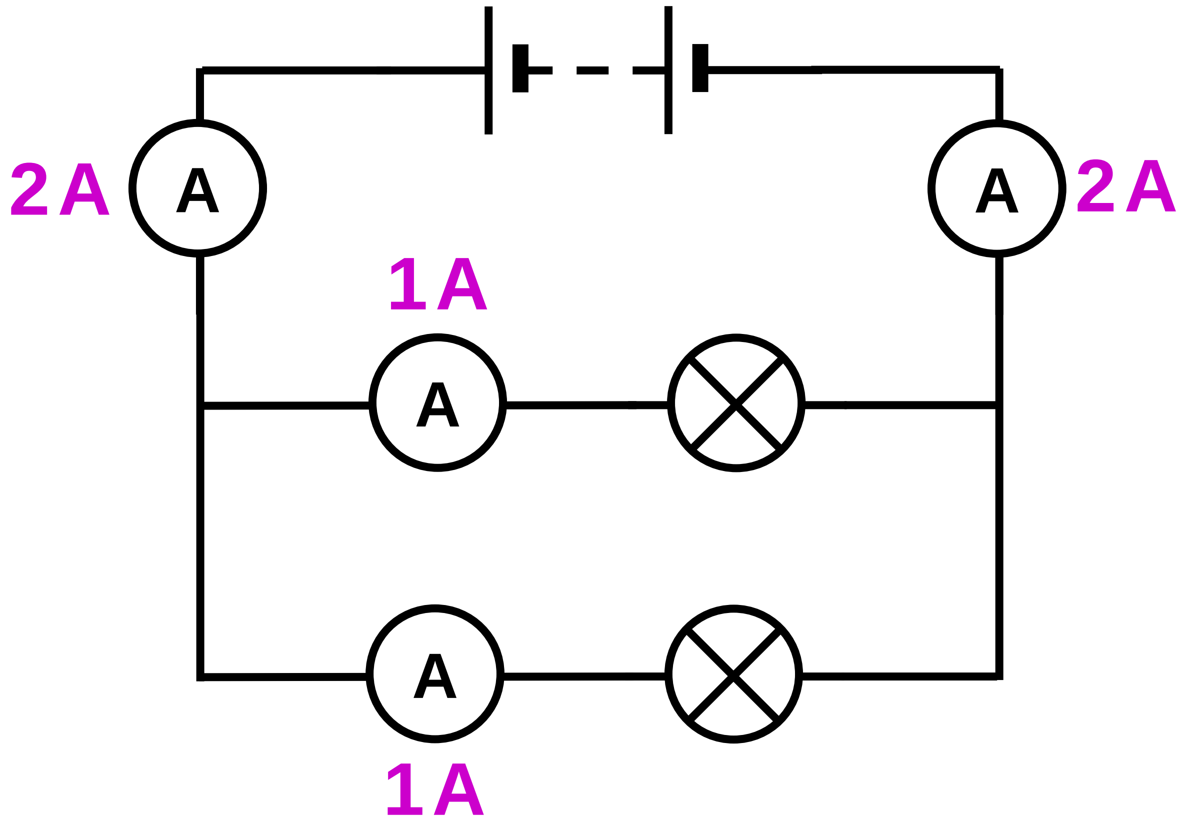
If the bulbs in a series circuit are identical, then the potential difference is shared equally between them.

As more bulbs are added, each bulb has less potential difference and becomes dimmer.



Current in parallel circuits.

The current in a parallel circuit divides at any point where the wires divide. If the bulbs are identical, an equal current will flow through each bulb.

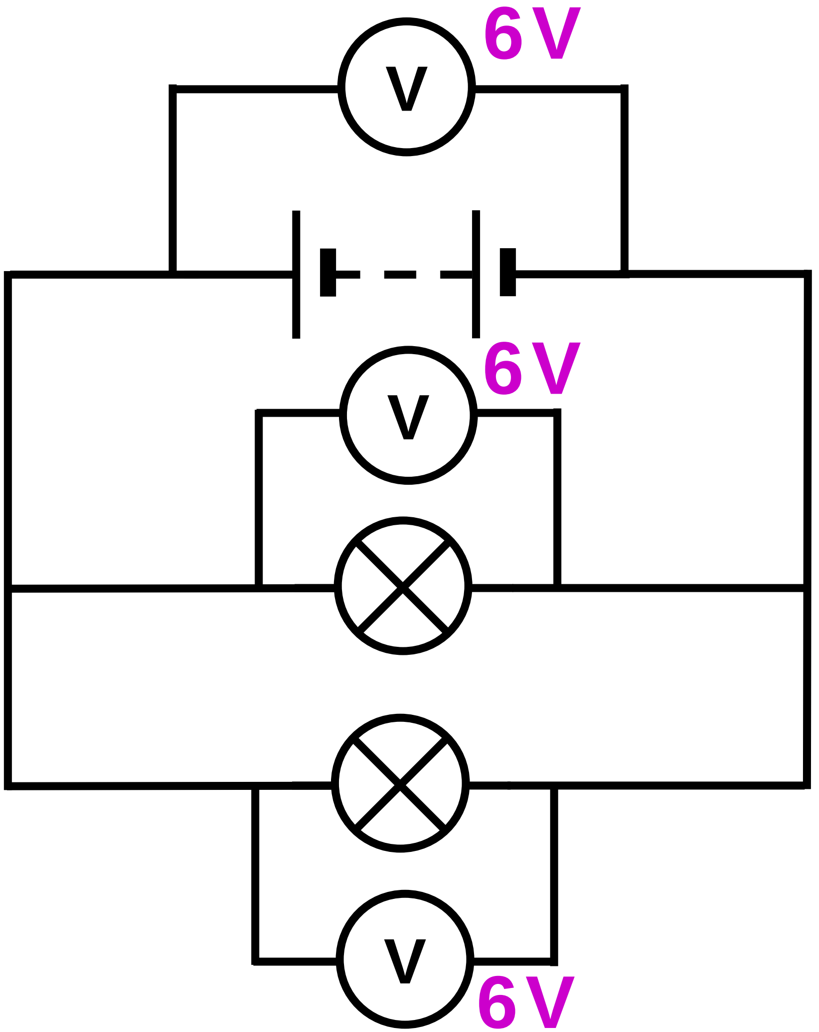


Potential difference in parallel circuits.

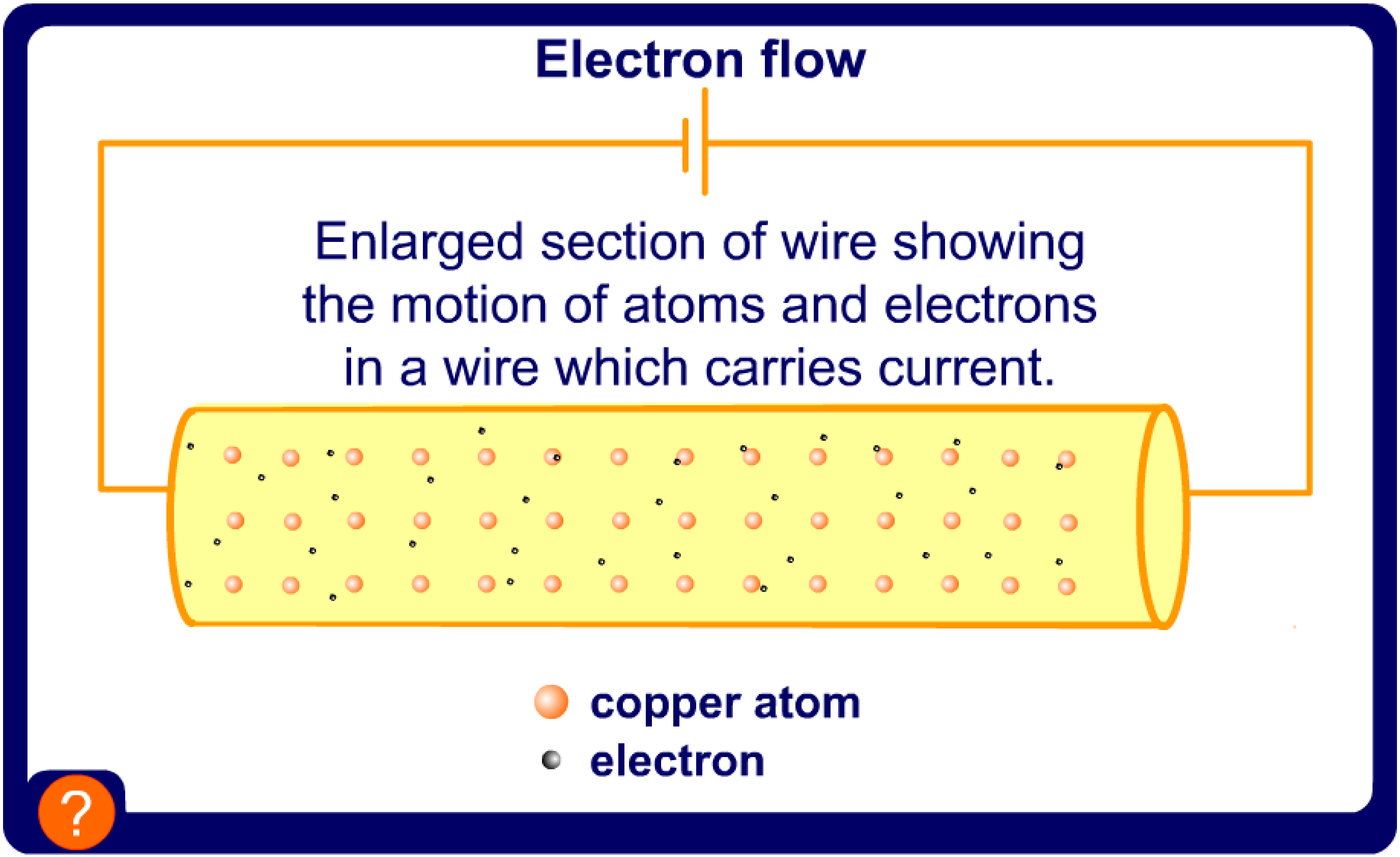
In a parallel circuit, the potential difference across each of the bulbs is the same as the potential difference across the battery.

This means that all the bulbs have the same brightness and are brighter than the same number of bulbs in a series circuit.

However, this also means that the battery will run down faster in the parallel circuit.



Electron flow in a wire.



Electron flow and resistance.

Electricity is the flow of electrons along a wire.

As the electrons move along the wire they collide with the metal atoms.

These collisions make the atoms vibrate more…
…which makes the metal hotter.

Resistance is a measure of how much a material tries to stop electricity passing through it.

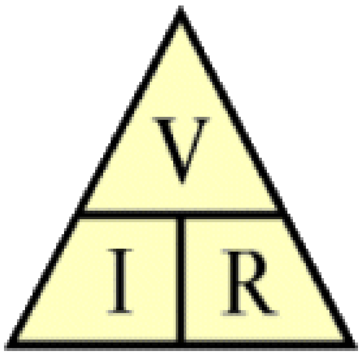
All wires and devices have some resistance, which is why electrical appliances always waste some energy as heat.

Resistance formula.

The resistance of a conductor can be calculated using:

$$\textbf{resistance} = \frac{\textbf{voltage}}{\textbf{current}}$$

$$R = \frac{V}{I}$$



This equation can also be written as:

$$\textbf{voltage} = \textbf{current x resistance}$$

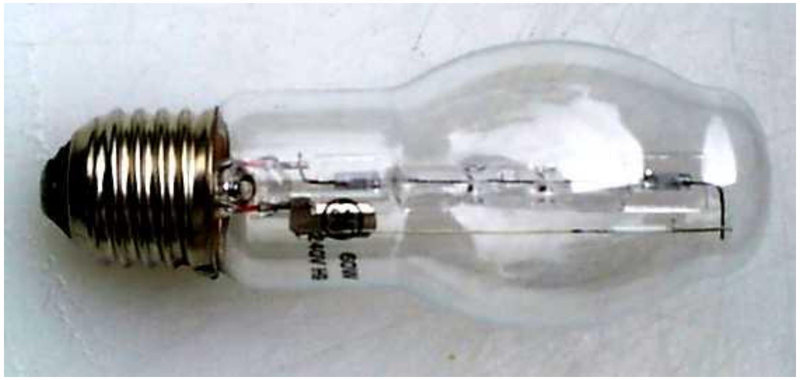
$$V = I \times R$$

What are the units of voltage, current and resistance?

- Potential difference is measured in **volts** (V).
- Current is measured in **amps** (A).
- Resistance is measured in **ohms** (Ω).

Calculating the resistance of a bulb.

A filament bulb has a current of 20 A running through it, with a potential difference of 100 V across it.



What is the resistance of the filament in the bulb?

$$V = IR$$

$$R = \frac{V}{I}$$

$$= \frac{100\,\text{V}}{20\,\text{A}}$$

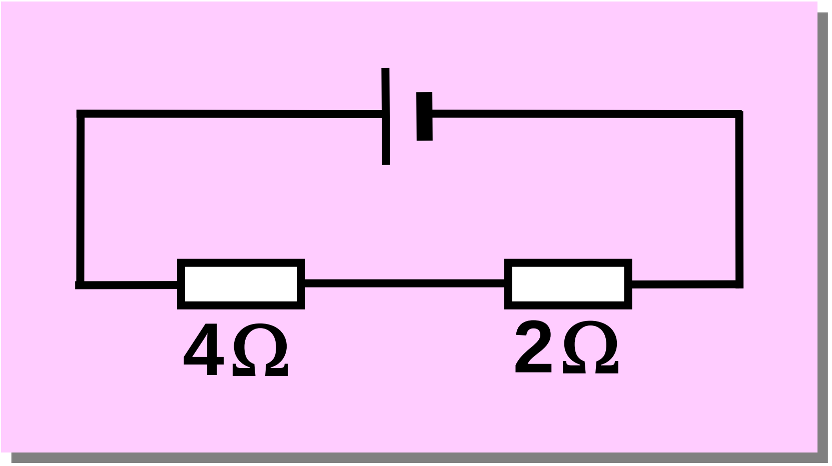
$$= 5\,\Omega$$

Resistors in series.

When resistors are connected in series, the total resistance can be calculated using:

Total resistance = $R_1 + R_2$

What is the total resistance for this circuit?



Total resistance

= $R_1 + R_2$

= 4Ω + 2Ω

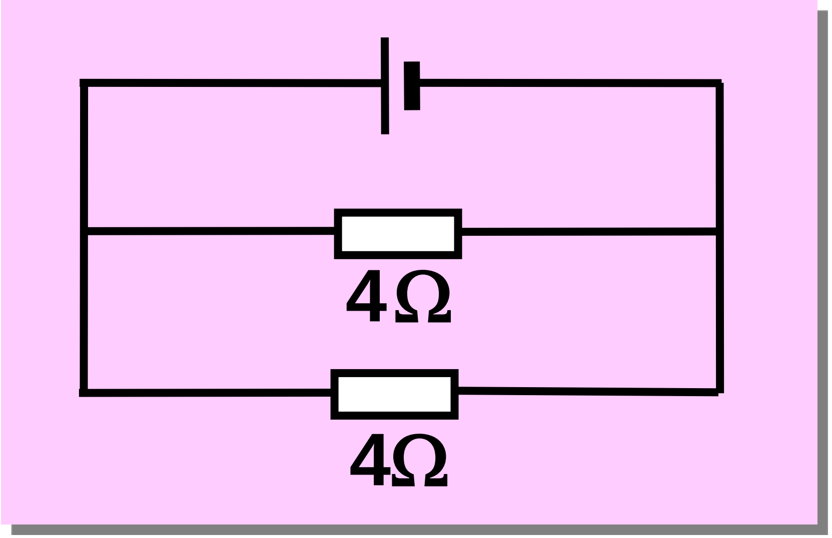
= 6Ω

Resistors in parallel.

When resistors are connected in parallel, the total resistance is less than the smallest single resistor.

To calculate the total you divide a single resistor by the number of resistors.

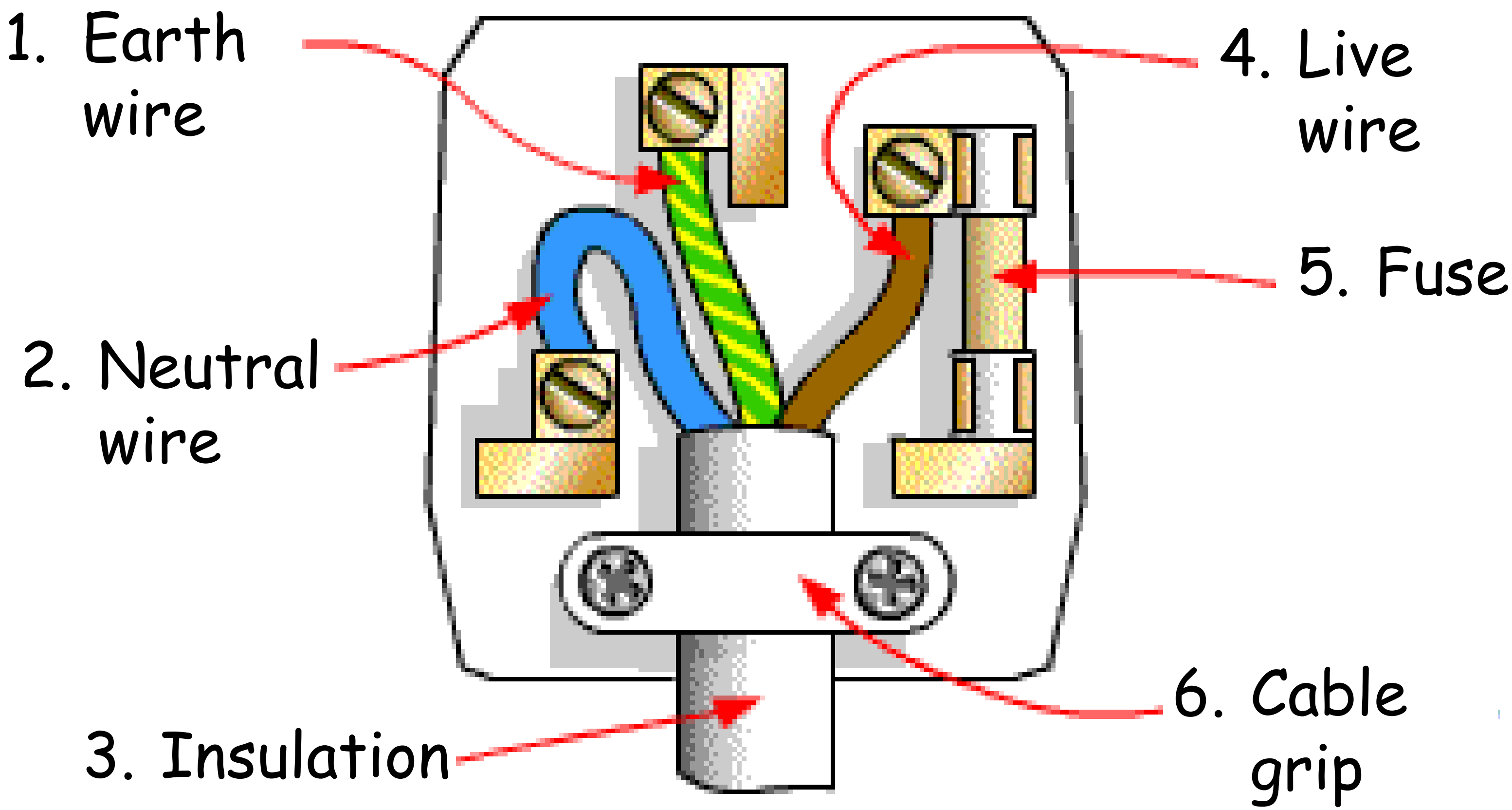
What is the total resistance for this circuit?



Total resistance

=4Ω/2 = 2Ω

Wiring a plug.



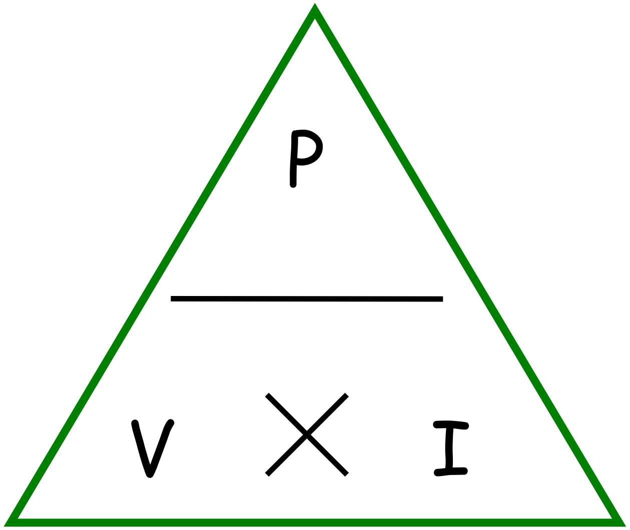
Earth wires.

Earth wires are always used if an appliance has a metal case. If there is a fault in the appliance, causing the live wire to touch the case, the current "surges" down the earth wire and the fuse blows (melts).

Power and fuses.

Power is "the rate of doing work". The amount of power being used in an electrical circuit is given by:

Power =	voltage x	current
in W	in V	in A

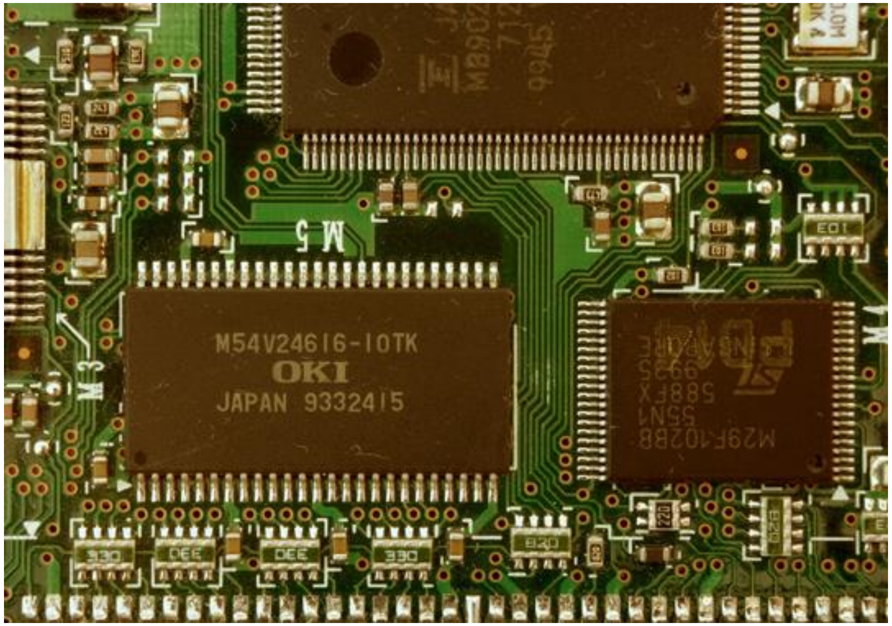


Using this equation we can work out the fuse rating for any appliance. For example, a 3kW (3000W) fire plugged into a 240V supply would need a current of 12.5 A, so a 13 amp fuse would be used (fuse values are usually 3, 5 or 13A).

What is direct current (d.c.)?

Direct current (**d.c**.) is an electric current that always flows in one direction.

Direct current is produced by cells and batteries.



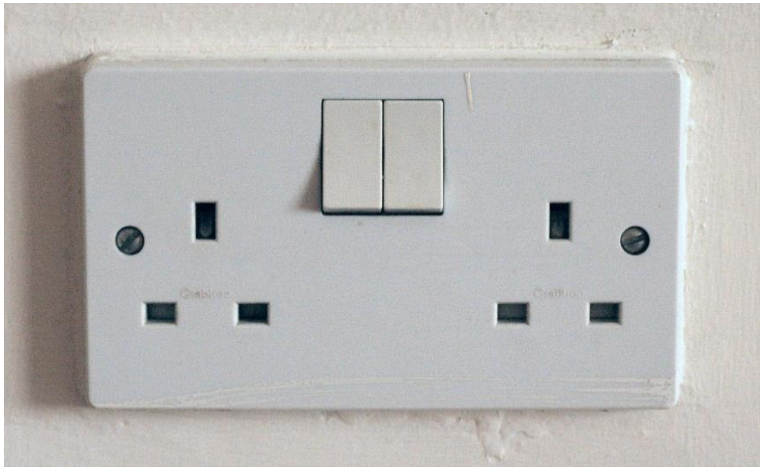
Electronic circuits such as those in computers and stereos need direct current electricity in order to work.

Direct current cannot be transferred efficiently over large distances.

What is alternating current (a.c.)?

Alternating current (**a.c.**) is an electric current that is constantly changing direction.

Alternating current is produced by most generators and is used in mains electricity.

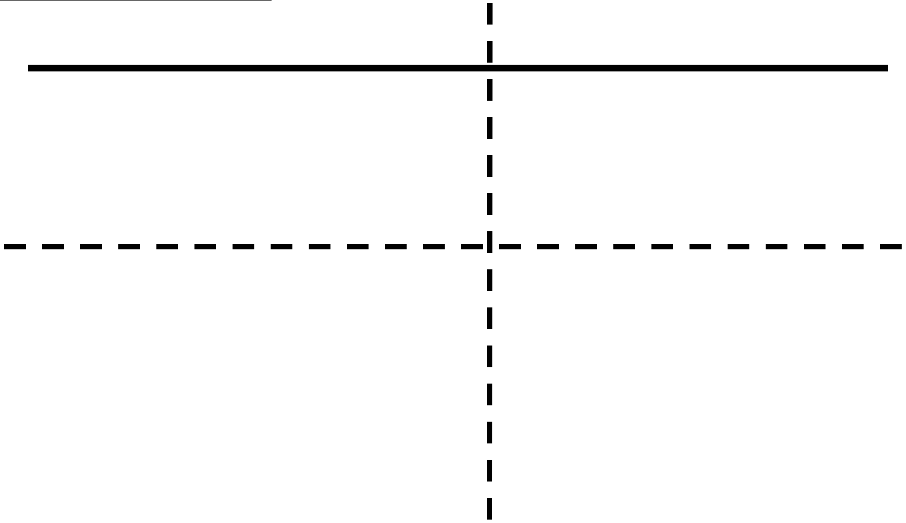


Motors often work using alternating current. The voltage of alternating current is easily changed with a transformer.

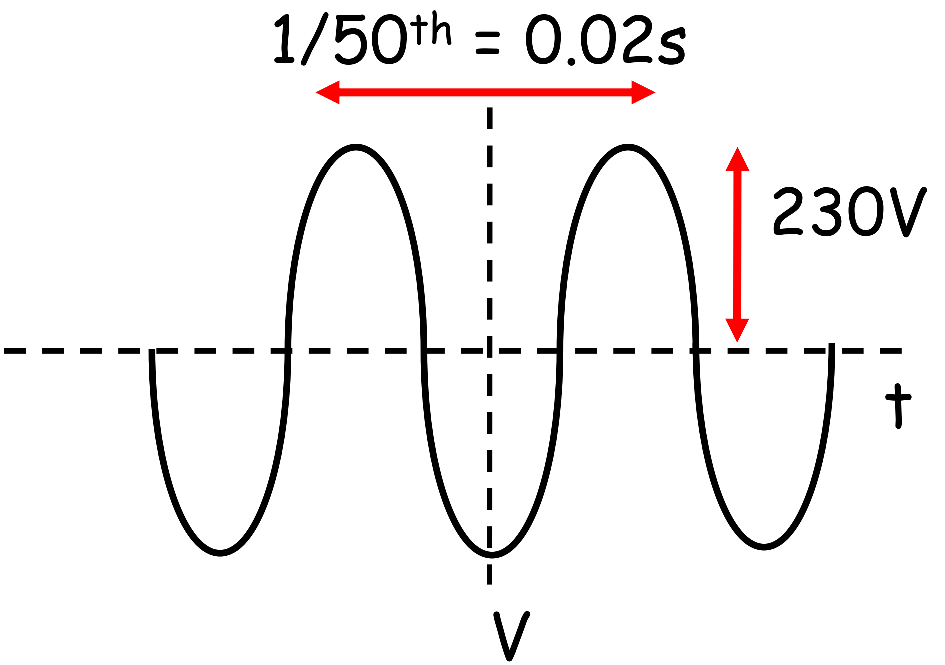
Alternating current can be transferred efficiently over large distances.

DC and AC.

DC stands for "Direct Current" – the current only flows in one direction:

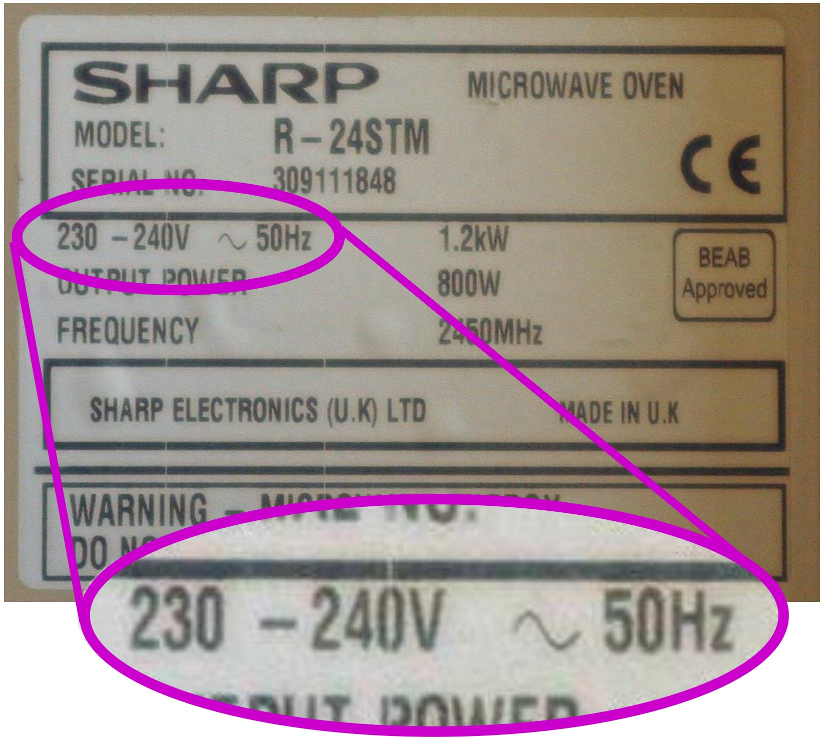


AC stands for "Alternating Current" – the current changes direction 50 times every second (frequency = 50Hz)



Mains electricity in the UK.

In the UK, the **frequency** of mains electricity is **50 hertz**: this alternating current flows backwards and forwards 50 times per second.



This frequency is the same at any point in the electricity supply system but the voltage varies in different parts of the national grid.

The **voltage** of mains electricity supplied to UK homes is **230 V**.

This is an effective voltage which is equal to the voltage of a d.c. supply that would produce the same heating effect. The peak (maximum) voltage is higher than this.

Converting units.

1 kV = 1000 V

1 kJ = 1000 J

1 kW = 1000 W

How many volts in **6 kV**? **6 000** **V**

How many joules in **12.3 kJ**? **12 300** **J**

How many watts in **0.6 kW**? **600** **W**

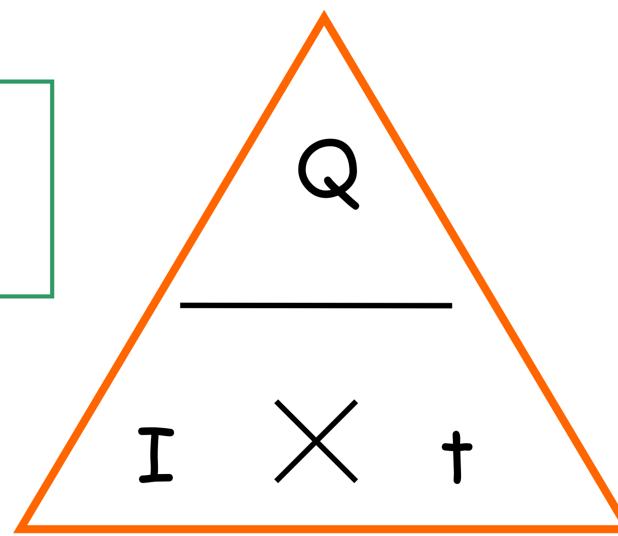
Charge (Q).

As we said, electricity is when electrons move around a circuit and carry energy with them. Each electron has a negative CHARGE. Charge is measured in Coulombs (C). We can work out how much charge flows in a circuit using the equation:

Charge = current x time

(in C) *(in A)* *(in s)*

coulombs



Energy and charge.

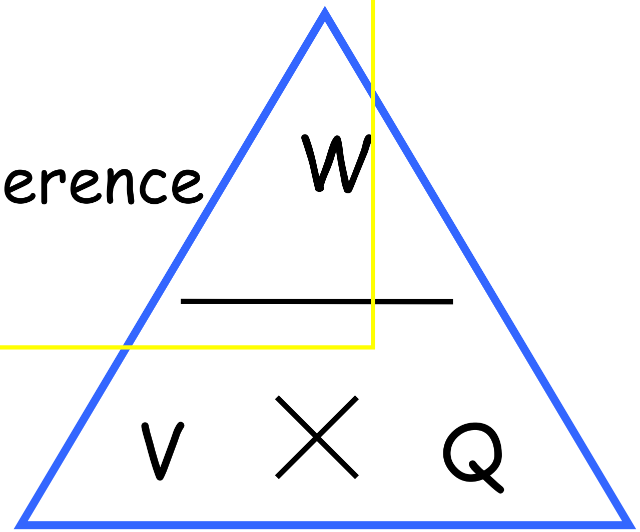
The amount of energy that flows in a circuit will depend on the amount of charge carried by the electrons and the voltage (potential difference) pushing the charge around:

Energy transferred = charge x potential difference

Since energy transferred = work done:

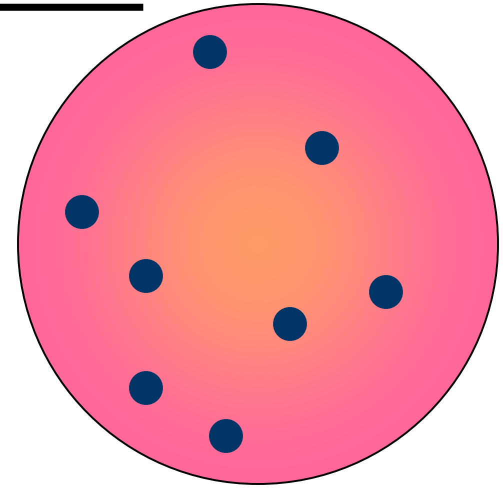
Work done (W) = charge x potential difference

(in J) *(in C)* *(in V)*



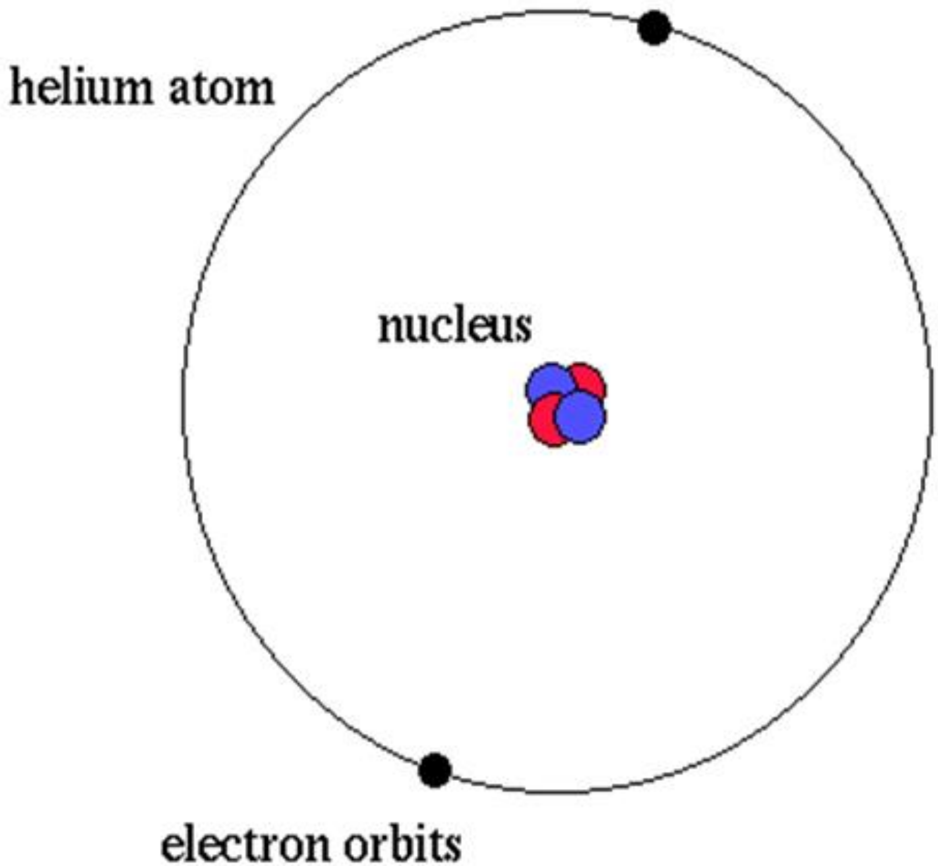
Structure of the atom.

A hundred years ago people thought that the atom looked like a “plum pudding” – a sphere of positive charge with negatively charged electrons spread through it…



I did an experiment that proved this idea was wrong. I called it the “Rutherford Scattering Experiment”

Rutherford Atom



elementary particles

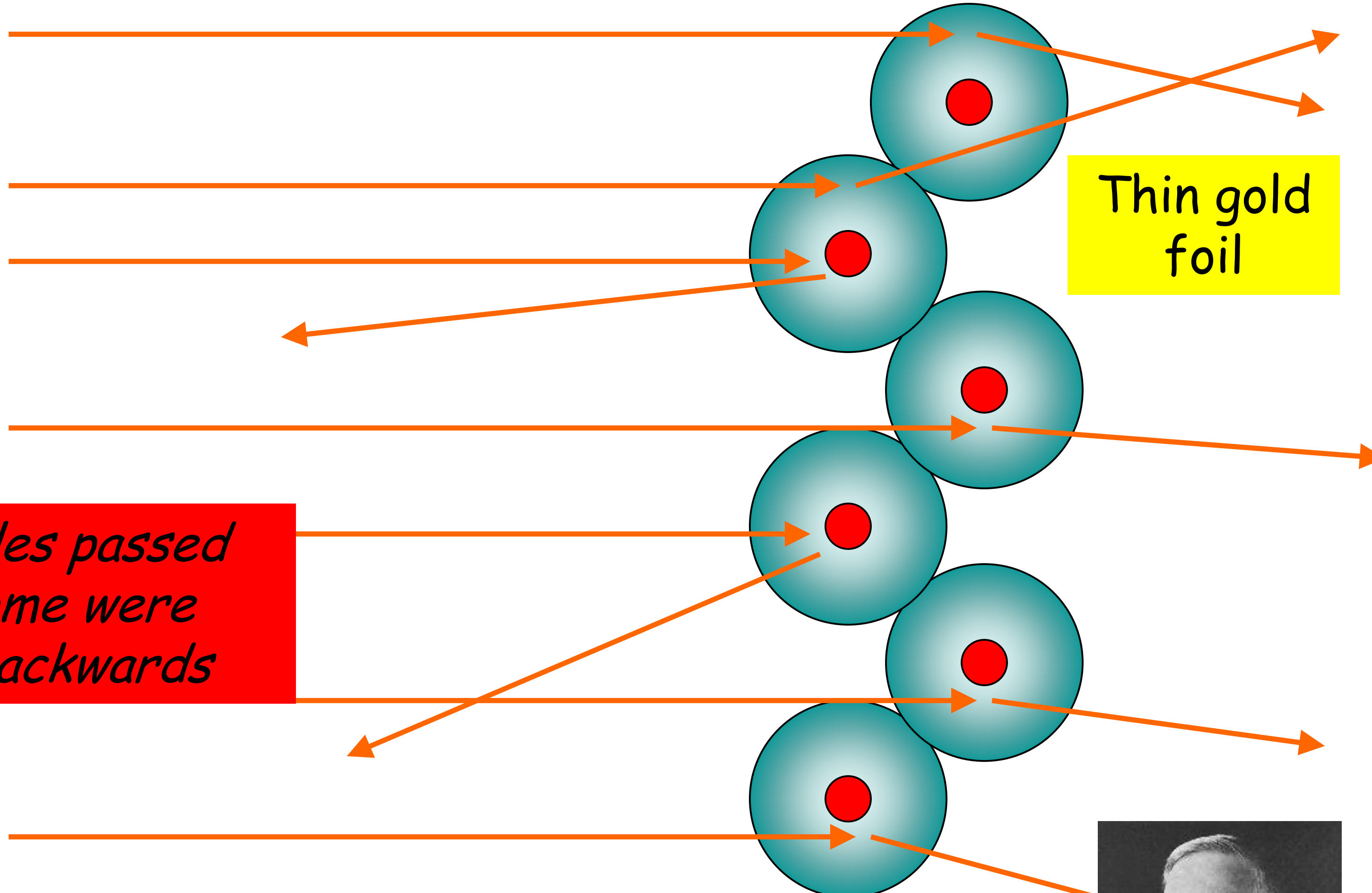
- electron (–)
- proton (+)
- neutron (0)

where the mass of the electron is 1/2000 the mass of the proton

and the mass of the proton equals the mass of the neutron

The Rutherford Scattering Experiment.

Alpha particles *(positive charge)*



Some particles passed through, some were deflected backwards

Conclusion *– atom is made up of a small central nucleus surrounded by electrons orbiting in shells*

Rutherford's conclusions.

Observation	Conclusion
Most alpha particles went straight through the foil.	Atoms are mostly space.
A few were deflected through large angles.	The nucleus is very small compared to the size of the atom and it contains most of the mass and all the positive charge.
A very few were reflected straight back.	

Notation exercise:

Name the elements below and calculate how many protons (P), neutrons (N) and electrons (E) they have.

12	75	127
C	**As**	**I**
6	33	53

carbon **P = 6**
N = 6
E = 6

arsenic **P = 33**
N = 42
E = 33

iodine **P = 53**
N = 74
E = 53

Isotopes and radioisotopes.

These atoms are all carbon – what is the difference between them?

They have different numbers of neutrons.

$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

What are atoms of the same element with different numbers of neutrons called?

Isotopes

What are isotopes that are unstable and emit radiation to become more stable called?

Radioisotopes

Radioactive particles:

Alpha (α): made of 2 protons and 2 neutrons.

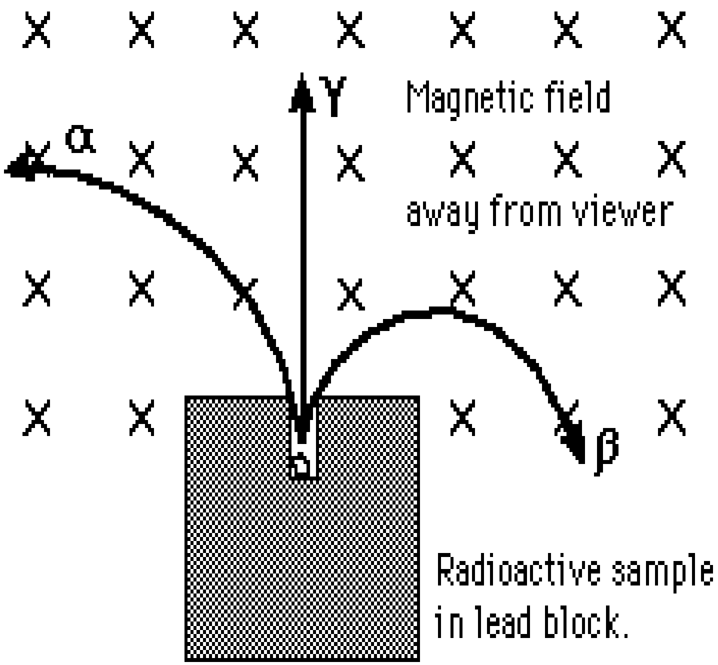
Beta (β): fast moving electron.

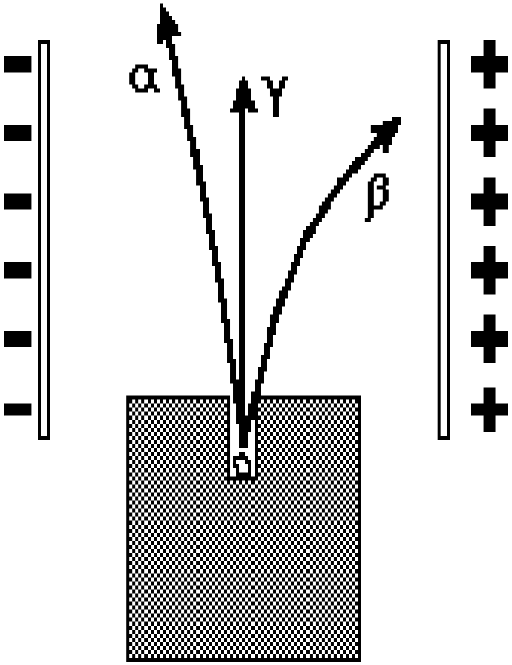
Gamma (γ): short wavelength electromagnetic waves.

Type of Radiation	Alpha particle	Beta particle	Gamma ray
Symbol	α or ${}^{4}_{2}\alpha$ or ${}^{4}_{2}He$	β or β^{-}	γ (can look different, depends on the font)
Mass *(atomic mass units)*	4	1/2000	0
Charge	+2	-1	0
Speed	slow	fast	very fast (speed of light)
Ionising ability	high	medium	0
Penetrating power	low	medium	high
Stopped by:	paper	aluminium	lead

Magnetic and electric fields.

- Alpha and beta particles are charged, so they are affected by magnetic and electric fields.
- Gamma is uncharged so is not affected by these fields.





Hazards:

Ionising radiation is harmful to living cells.

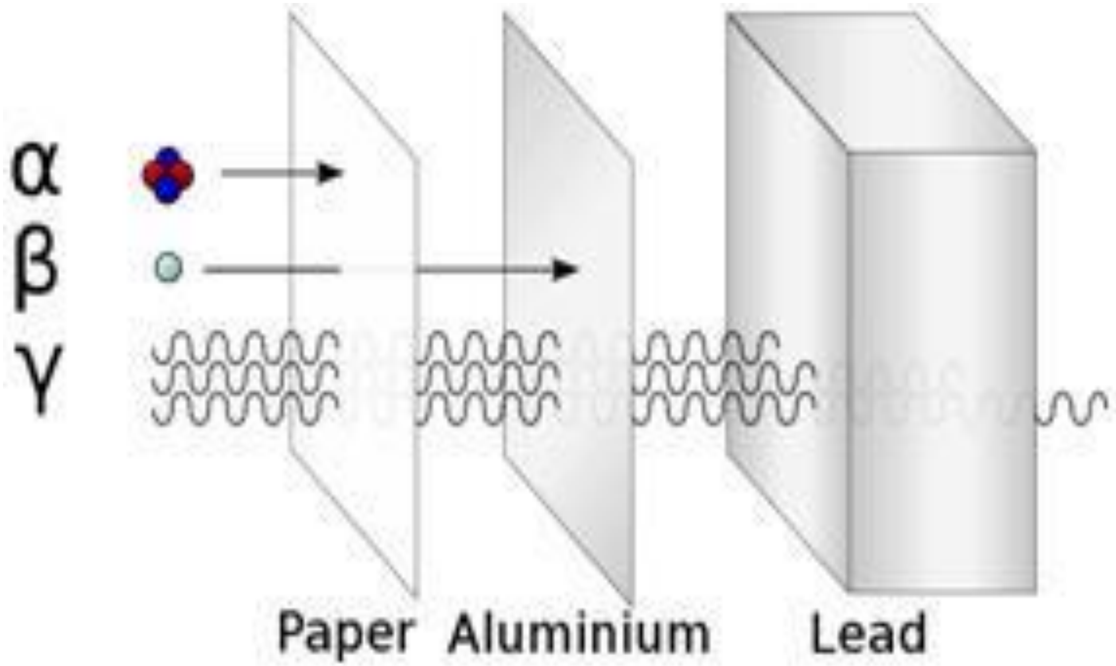


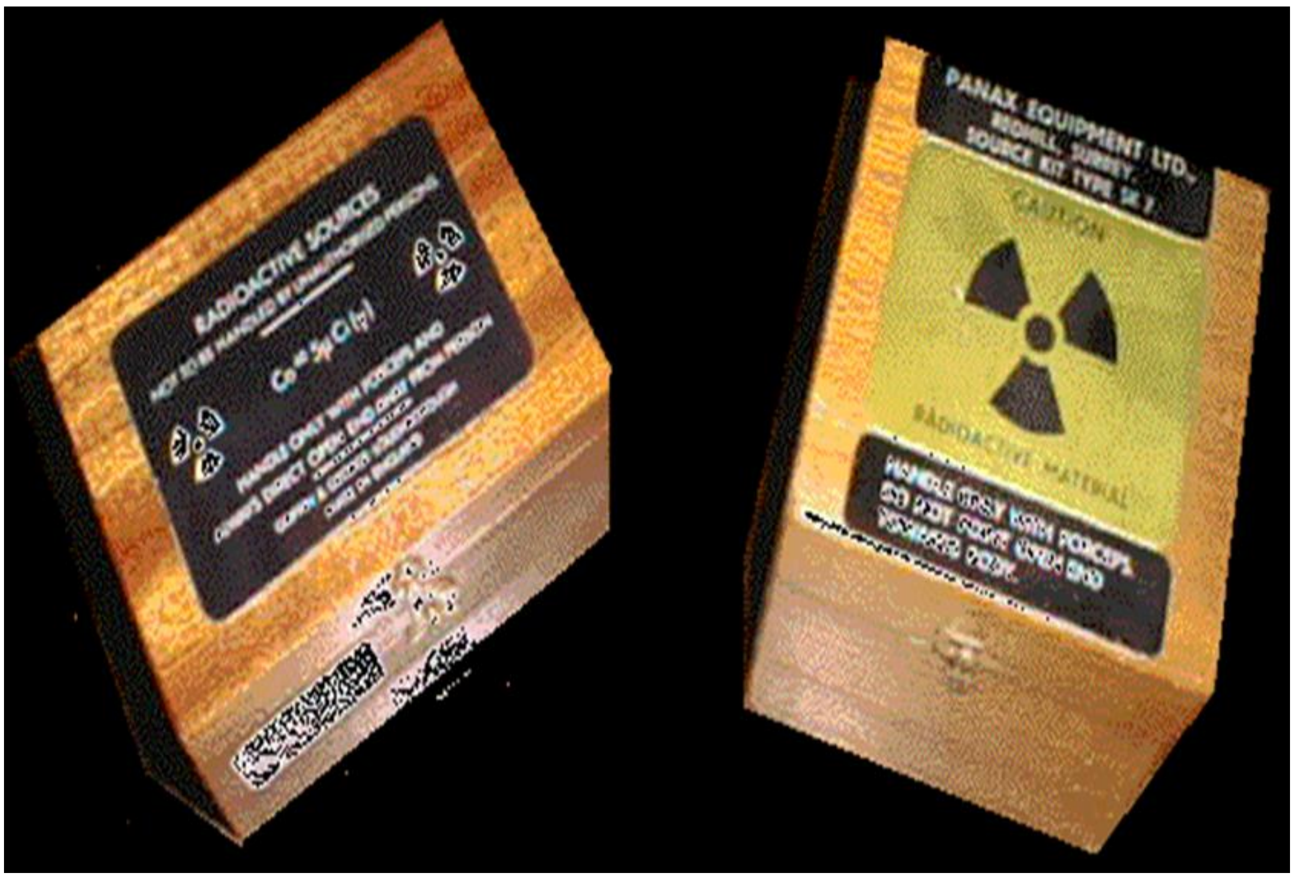
Figure 1. Each of the three forms of radiation has different energy levels, giving them differing abilities to pass through various materials.

Radioactivity Safety.

- Lower doses of radiation can cause cells to divide uncontrollably. This is cancer.
- Higher doses can kill cells leading to radiation sickness.
- How harmful the radiation is depends on how much exposure a person has had as well as the type of radiation.
- Beta and gamma are the most dangerous outside the body, because they can get to the organs.
- Alpha is most dangerous inside the body because it is highly ionising in a very localised area.

Safety precautions.

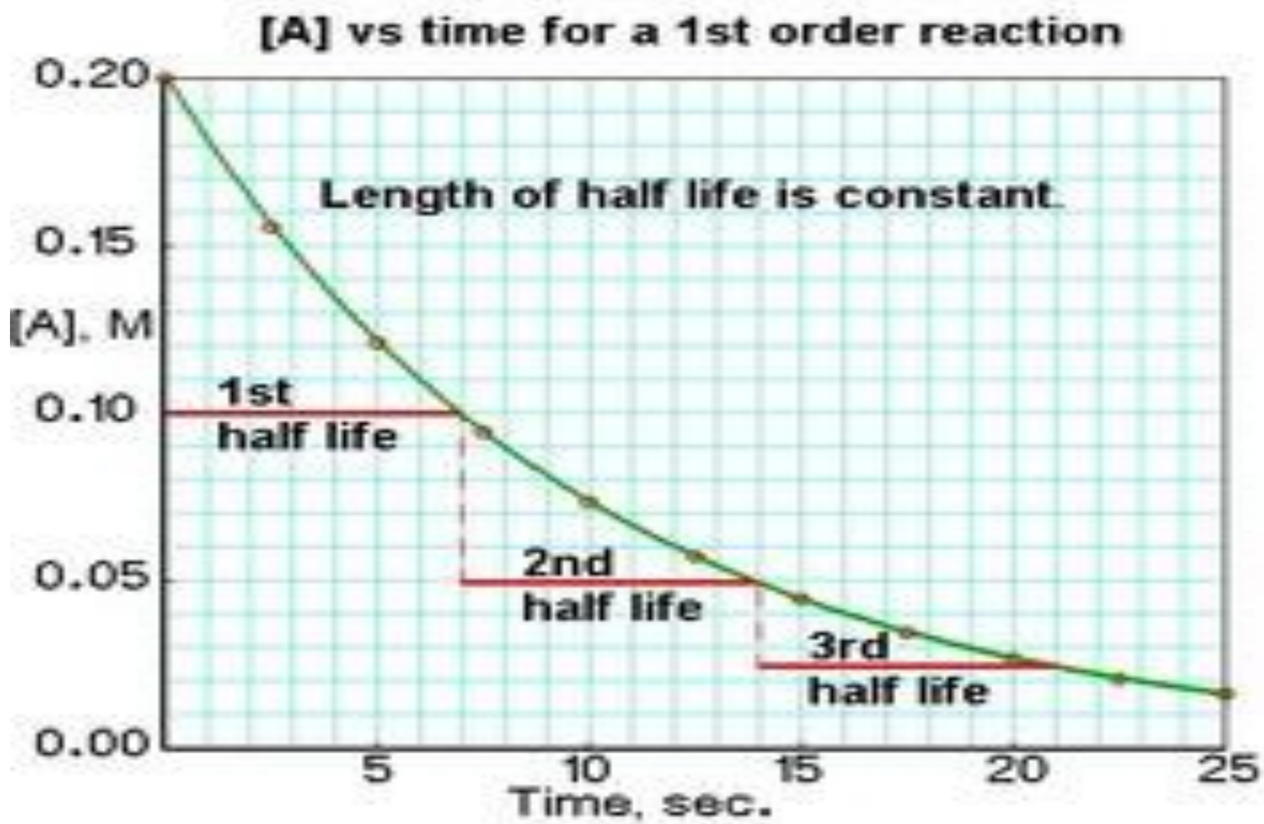
- Always handle with tongs and keep at arms length.
- Never point the source at yourself or anyone else.
- Store in a lead lined box.



Half life

- The unit for measuring radioactivity is the becquerel (Bq). 1 Bq means one nucleus decaying per second.
- Half-life is the average time it takes for the number of nuclei in a radioactive substance to halve.

Half-life = 7s.



Uses of Radiation.

The uses of radioactive sources depends on:

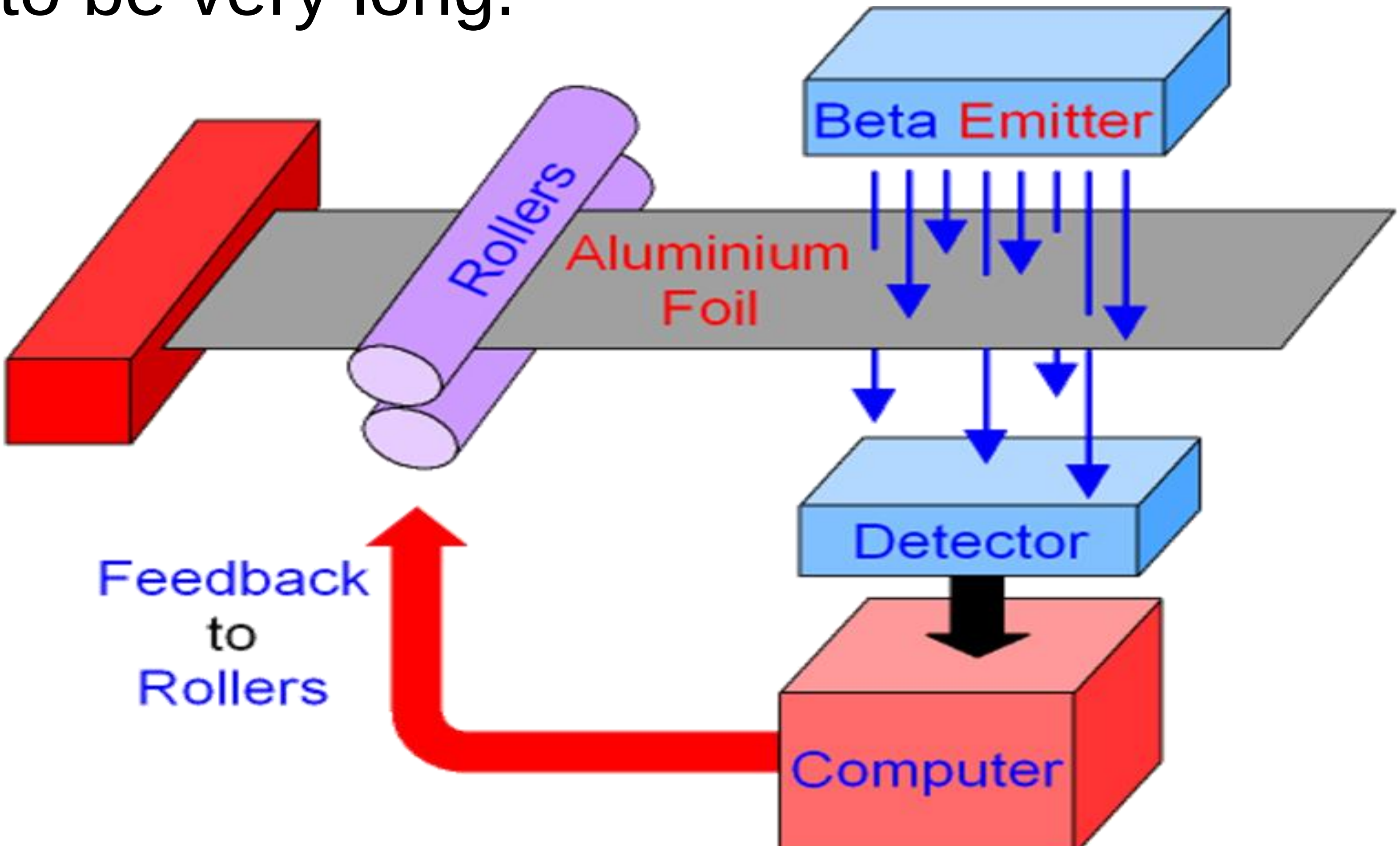
- The type of radiation emitted (α, β, γ)
- The half-life of the radioactive source.

Alpha:

Smoke detectors use alpha radiation. The Half-life is 100's of years.

Beta:

Monitoring the thickness of aluminium foil uses beta radiation. The half-life also needs to be very long.



Gamma:

Radioactive tracers use gamma radiation. The half-life is short (6 hours).

Gamma radiation.

Since gamma radiation can kill living cells it is also used for:

- Sterilising food and surgical instruments by killing harmful microbes.
- Treating cancer

by killing the cancer cells.

Alpha decay.

What is emitted?	alpha particle (helium nuclei)
Description of decay:	2 neutrons and 2 protons are emitted from the nucleus.
Example of decay:	$^{238}_{92}\mathbf{U} \rightarrow {}^{234}_{90}\mathbf{Th} + {}^{4}_{2}\alpha + \mathbf{energy}$
Effect on mass number and atomic number:	Mass number decreases by 4. Atomic number decreases by 2.

Beta decay.

What is emitted?	High-energy electron
Description of decay:	1 neutron in the nucleus decays into a proton and a high-energy electron, which is emitted.
Example of decay:	$^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\beta$ + energy
Effect on mass number and atomic number:	Mass number stays the same. Atomic number increases by 1.

Gamma decay.

(Gamma radiation is always emitted during alpha/beta decay)

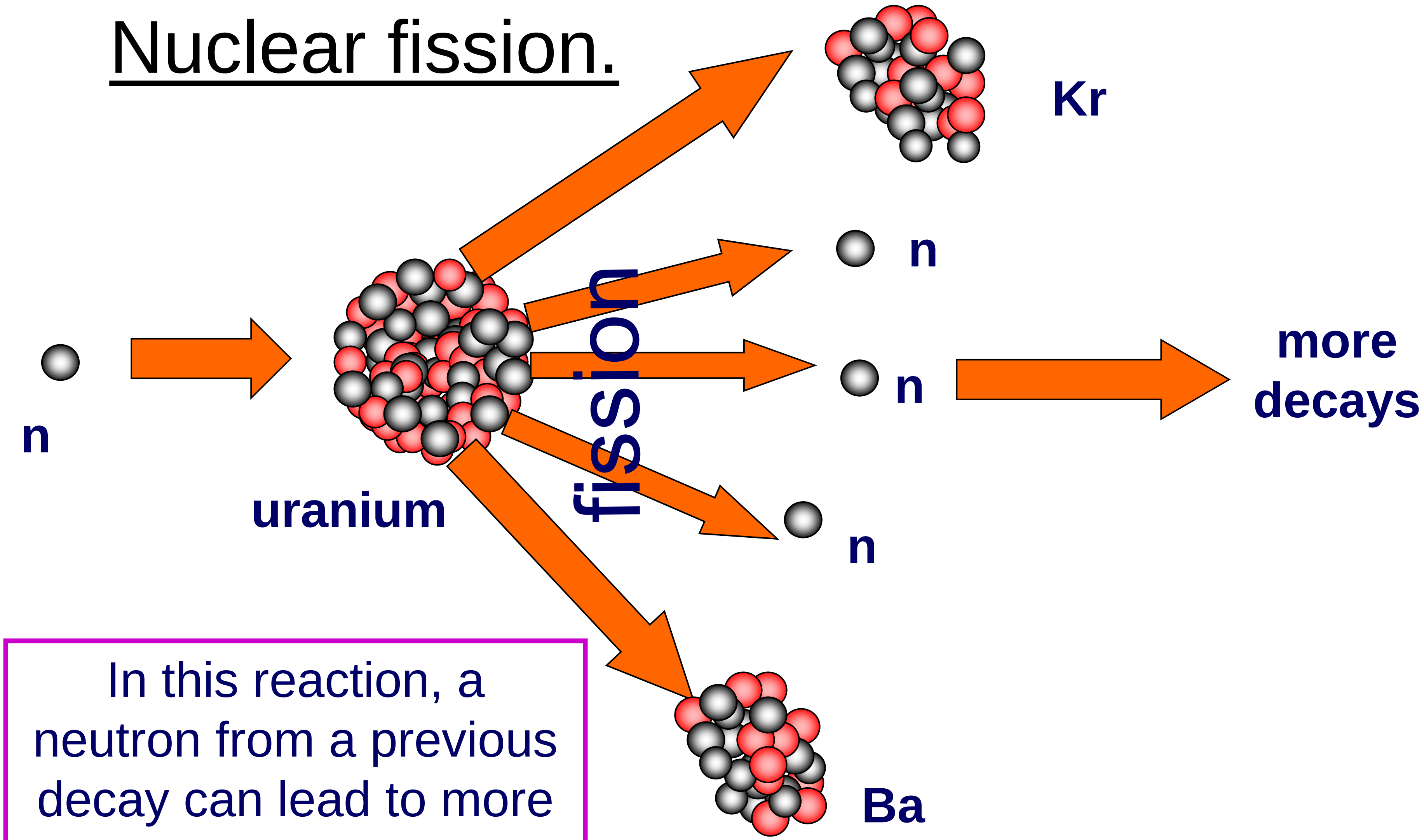
What is emitted?	High-energy electromagnetic radiation
Description of decay:	nucleus changes shape into a more stable shape, resulting in gamma radiation being emitted
Effect on mass number and atomic number:	Mass number and atomic number stay the same.

Background radiation.

The sources of radiation for a particular location are shown:

Source	Percentage of total radiation
Rocks	55%
Air	25%
Cosmic	15%
Building materials	5%

Nuclear fission.

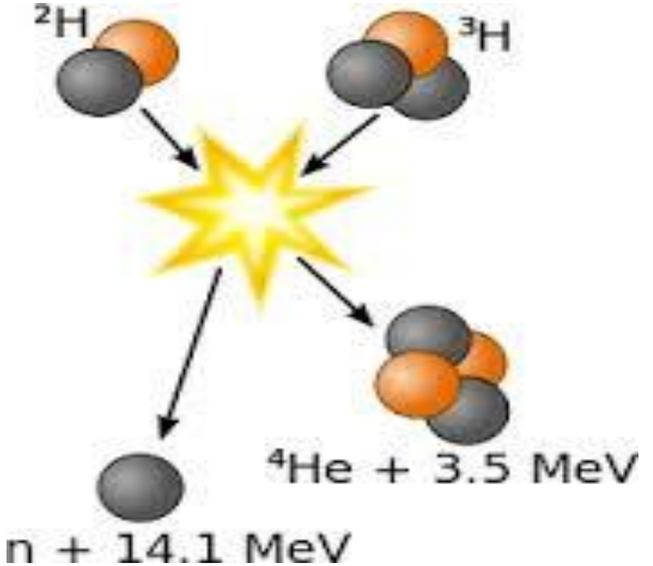


In this reaction, a neutron from a previous decay can lead to more and more decays.

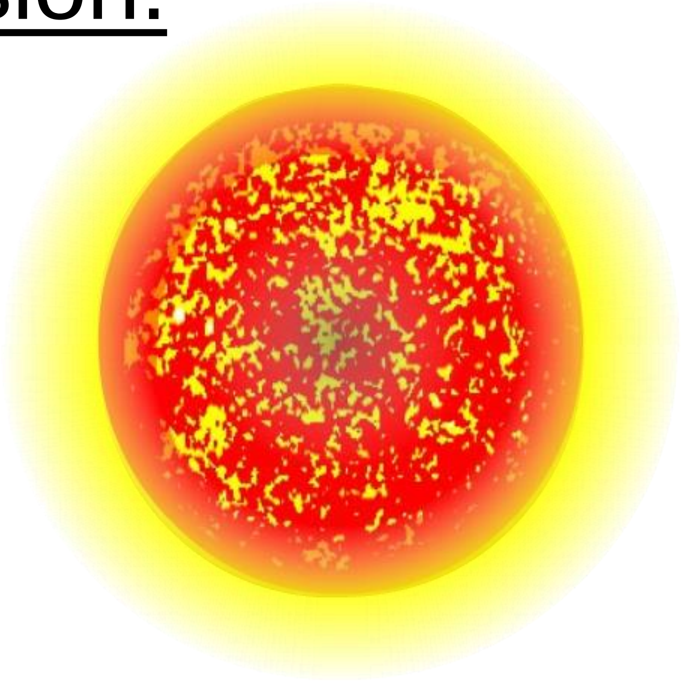
This is called a **chain reaction**.

Nuclear fusion.

- Nuclear fusion is when two light nuclei join together to create a larger nucleus.
- Nuclear fusion produces large amounts of energy.
- For fusion to occur a lot of energy is needed to overcome electrostatic repulsion forces.
- Fusion occurs in stars because of the high core temperatures (millions of ^{o}C).



Nuclear fusion.



In nuclear fusion reactions, lighter atomic nuclei are joined together (fused) to form heavier atomic nuclei.

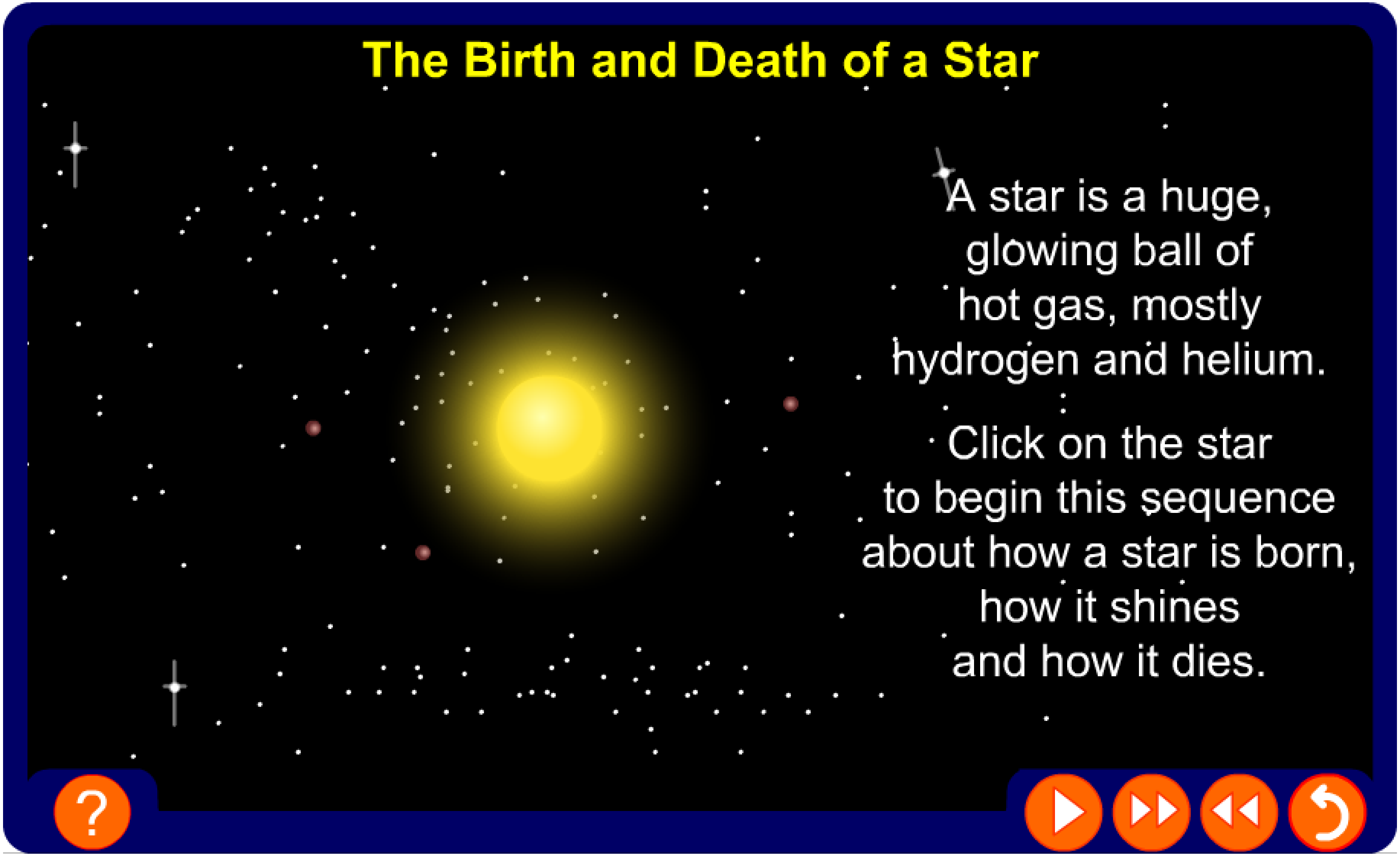
This process releases massive amounts of energy.

In our Sun, a typical star, hydrogen is being fused to form helium. This provides the energy for life on Earth.

When all the hydrogen is used up, other elements will be fused together to make even heavier elements.

Not all elements are made in this way. The heaviest elements, some of which are found in your body, can only be made when stars explode.

The life cycles of stars.



Comparing the life cycles of stars.