GCSE Physics

Paper 6

Note to teachers

- This presentation contains revision material for all of the Paper 2 Physics examinations
  - Material that is only needed for Higher Tier pupils has titles highlighted in green (Sets 1 and 1.5)
  - Material that is only needed for Separate Science pupils has titles highlighted in yellow
  - Everything else is needed by everybody!
- Lots of the slides have automatic animation, wait for this to run through before clicking!

SP8/CP7
Energy - forces doing work

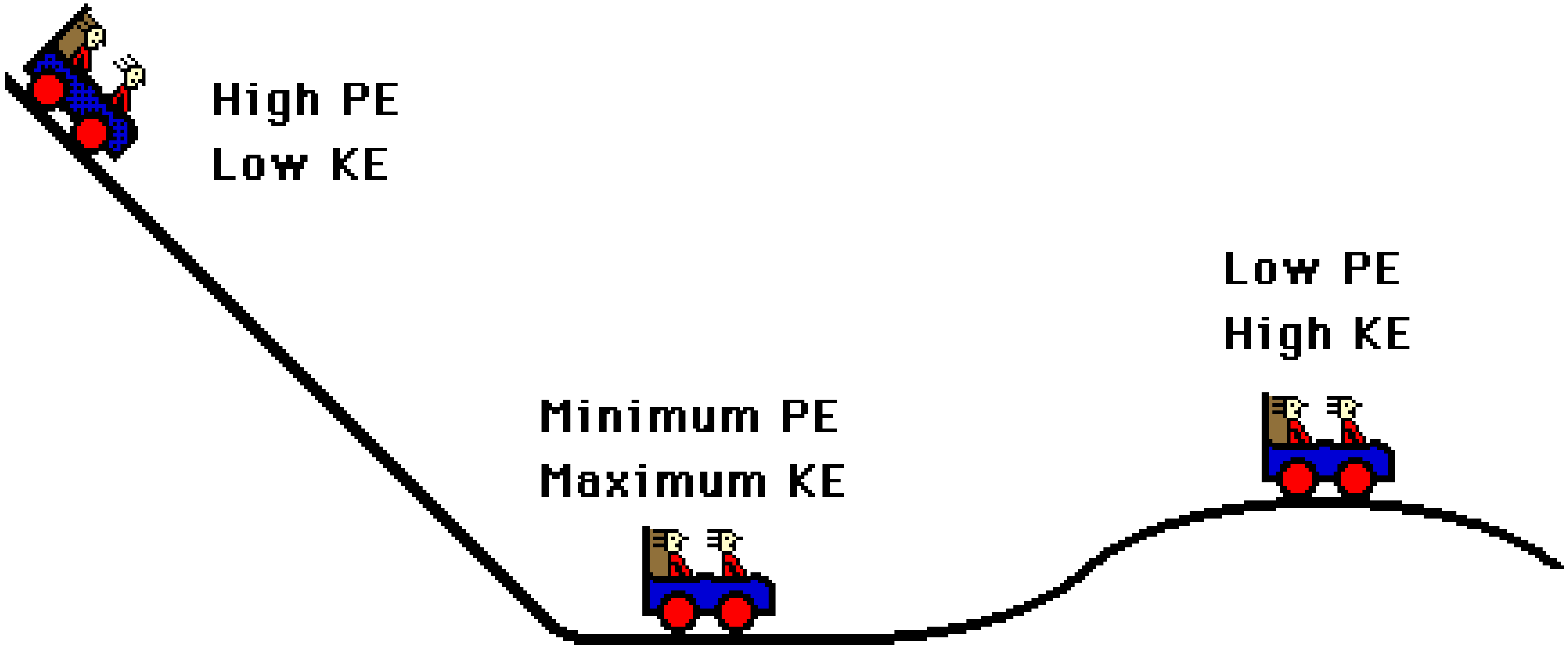
The one with lots of energy equations (easy marks!)
and the LAW OF CONSERVATION OF ENERGY.

LO – GCSE Physics Revision

Brain empty

- Write down everything you know about energy changes in a mechanical system such as a roller coaster

Energy is conserved



As a coaster car loses height, it gains speed; PE is transformed into KE. As a coaster car gains height it loses speed; KE is transformed into PE. The sum of the KE and PE is a constant.

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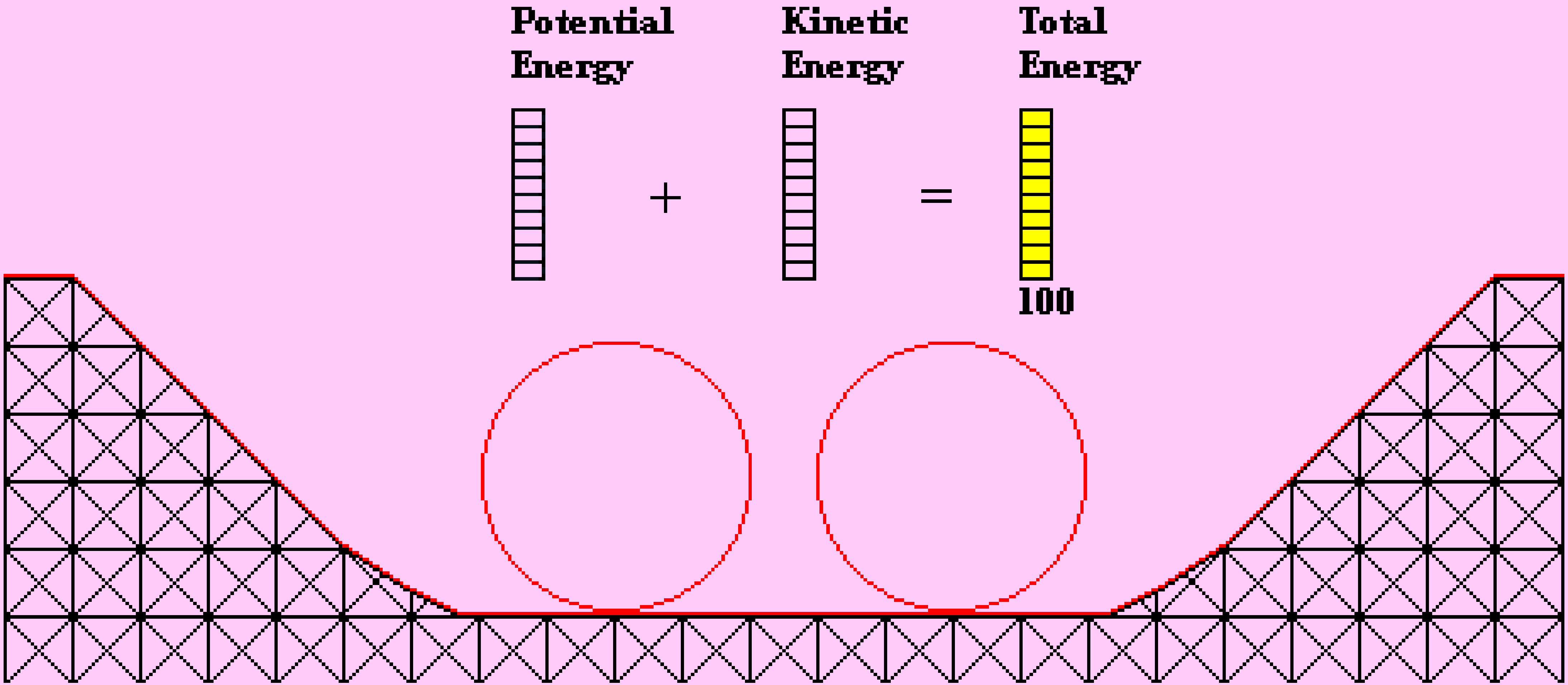
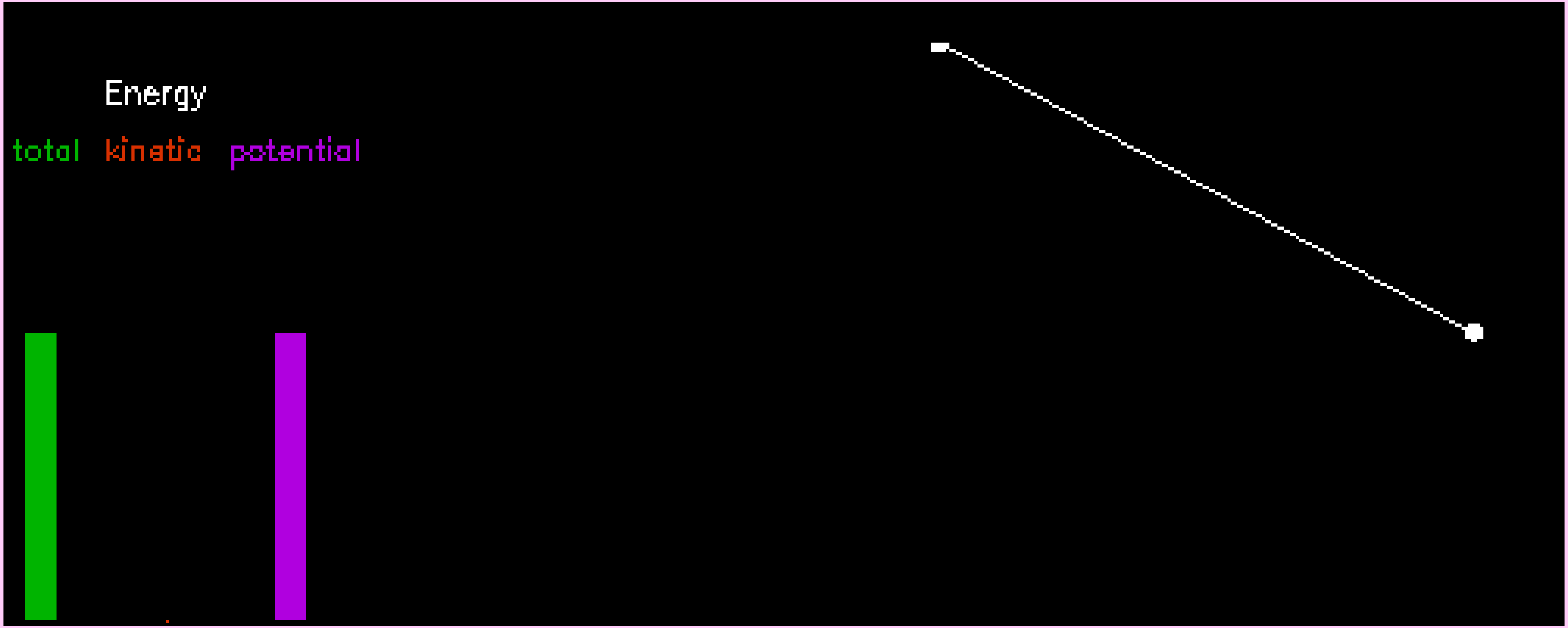
Energy is conserved



Energy is conserved



Energy is conserved

Gravitational Potential Energy

Gravitational potential energy is the energy stored in an object due to its position above the Earth's surface.

$$E_p = mgh$$

m = mass (kg)
g = gravitational field strength (N/kg)
h = height (m)
E_p = gravitational potential energy (J)

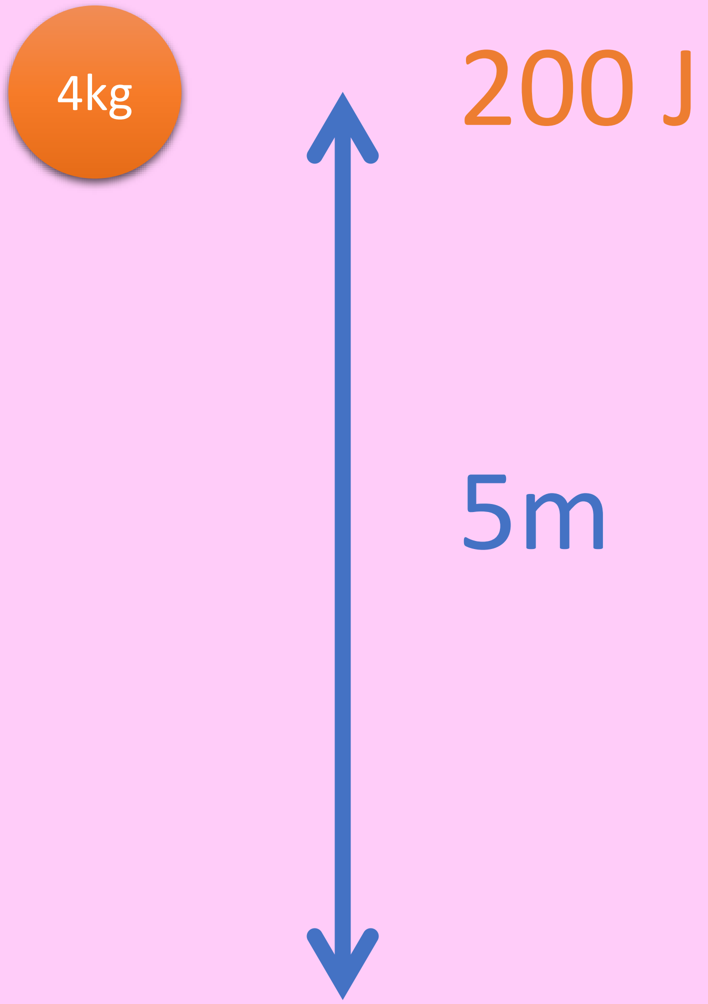
Energy is conserved

Kinetic Energy

Kinetic energy is the energy that objects possess due to their motion.

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

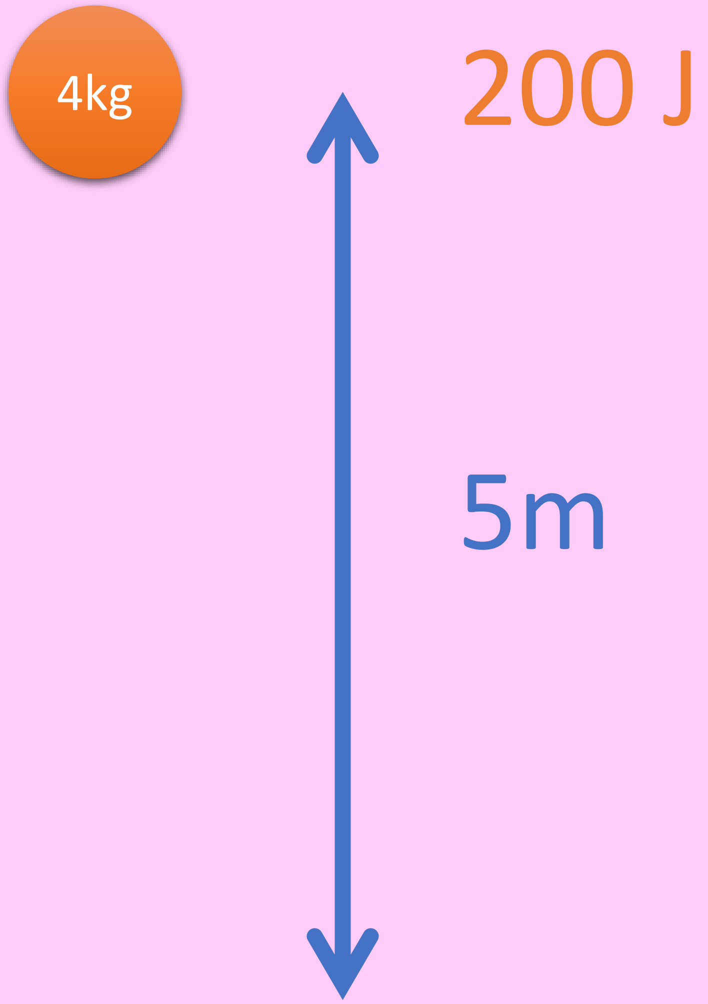
m = mass (kg)
v = velocity (m/s)
KE = Kinetic energy (J)



Energy is conserved

$$\times 200 = \frac{1}{2} \times 4 \times v^2$$

$$100 = v^2$$



Describe and explain…

- Why does a roller coaster car always go slower at the end of the ride than your calculations predict?

- What happens to an electric motor that is overloaded and stops turning?

- How can mechanical energy losses be reduced?

- How can electrical energy losses be reduced?

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Describe and explain…

- Why does a roller coaster car always go slower at the end of the ride than your calculations predict?
- Energy is lost as heat and sound because of friction
- What happens to an electric motor that is overloaded and stops turning?
- It overheats because no energy is transferred to kinetic, all is transferred to heat in the wires
- How can mechanical energy losses be reduced?
- Use a lubricant to reduce friction
- How can electrical energy losses be reduced?
- Use smaller loads; smaller electrical current; lower resistance wire (super-cooled); to reduce heat losses

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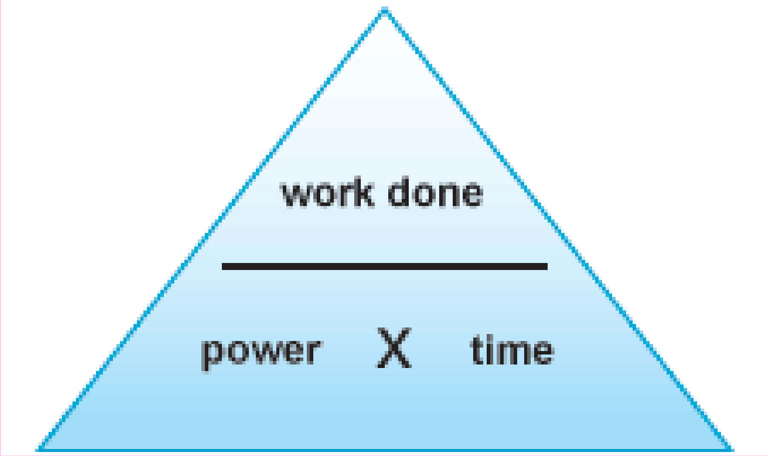
Who is more powerful?

A man of mass
75kg runs up stairs
20m high in 10s

E = mgh
E = 75 x 10 x 20
E = 15,000J

P = E/t
P = 15,000 / 10
P = 1500 Watts



A woman of mass
60kg runs up stairs
10m high in 4s

E = mgh
E = 60 x 10 x 10
E = 6,000J

P = E/t
P = 6,000 / 4
P = 1500 Watts

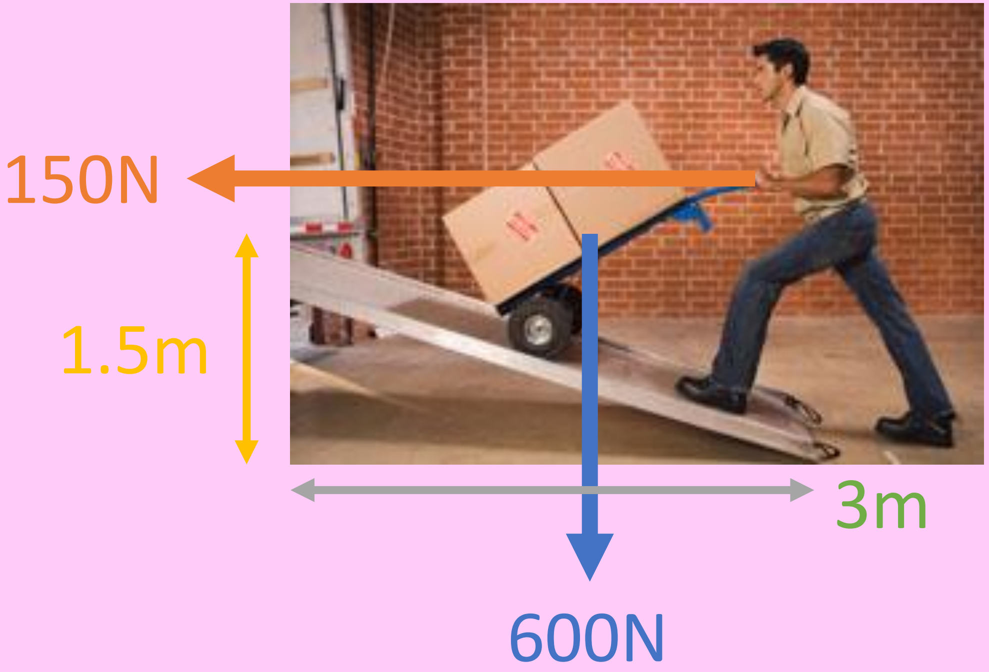
Calculate the work done lifting the boxes into the van.

E = F x d

E = 600 x 1.5

E = 900 J

The direction of the force and distance must be the same



SP9/CP8
Forces and their effects

The one with force diagrams for everyone
with scale drawings for Higher students
and turning effects of forces for Separate Science students

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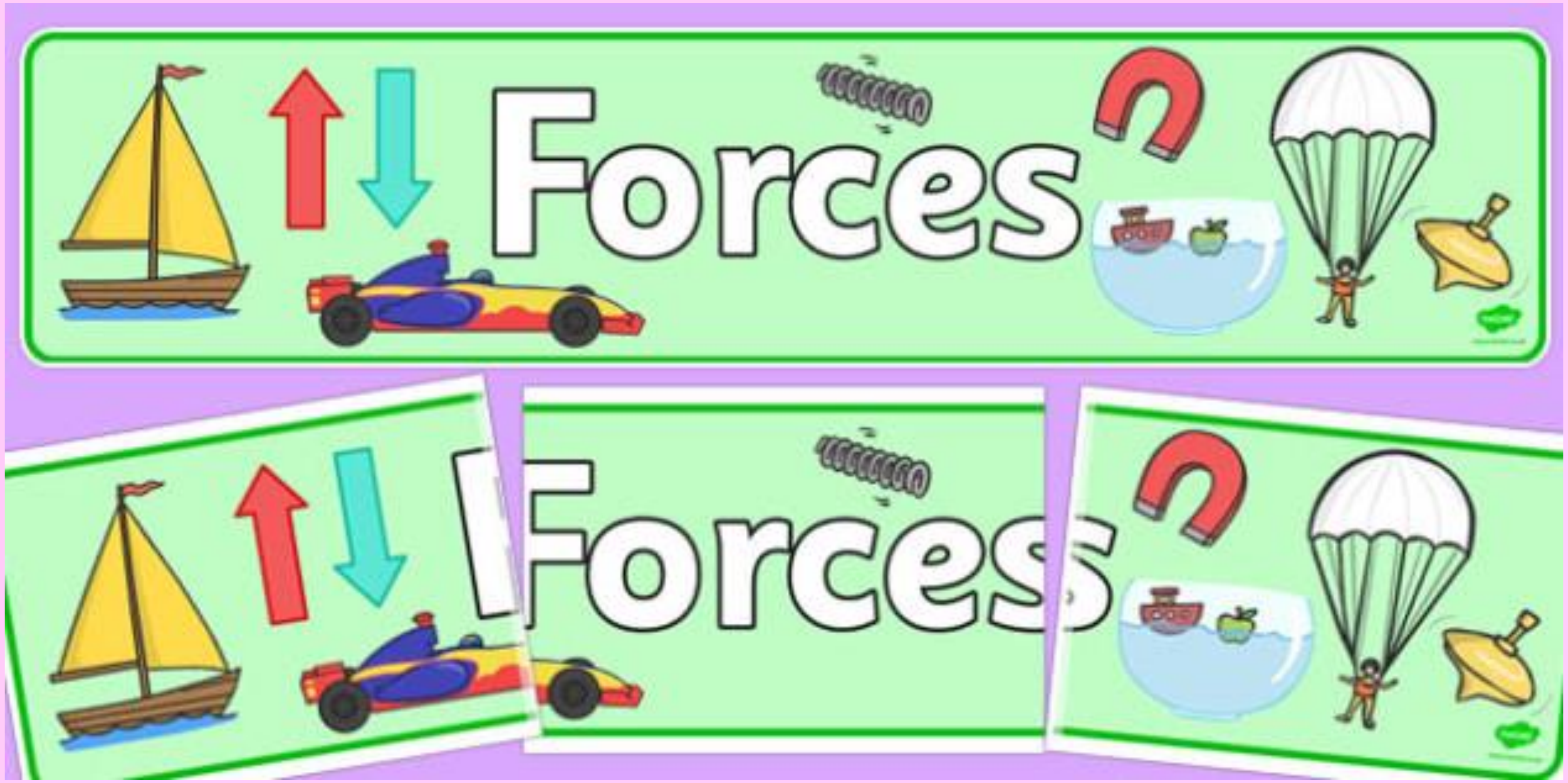
Brain empty

- Write down as many key words as you can remember that are linked to the idea of forces.



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Forces can be grouped into…

Types of Forces

Contact forces: interactions between objects that touch

Non-contact forces: attract or repel, even from a distance

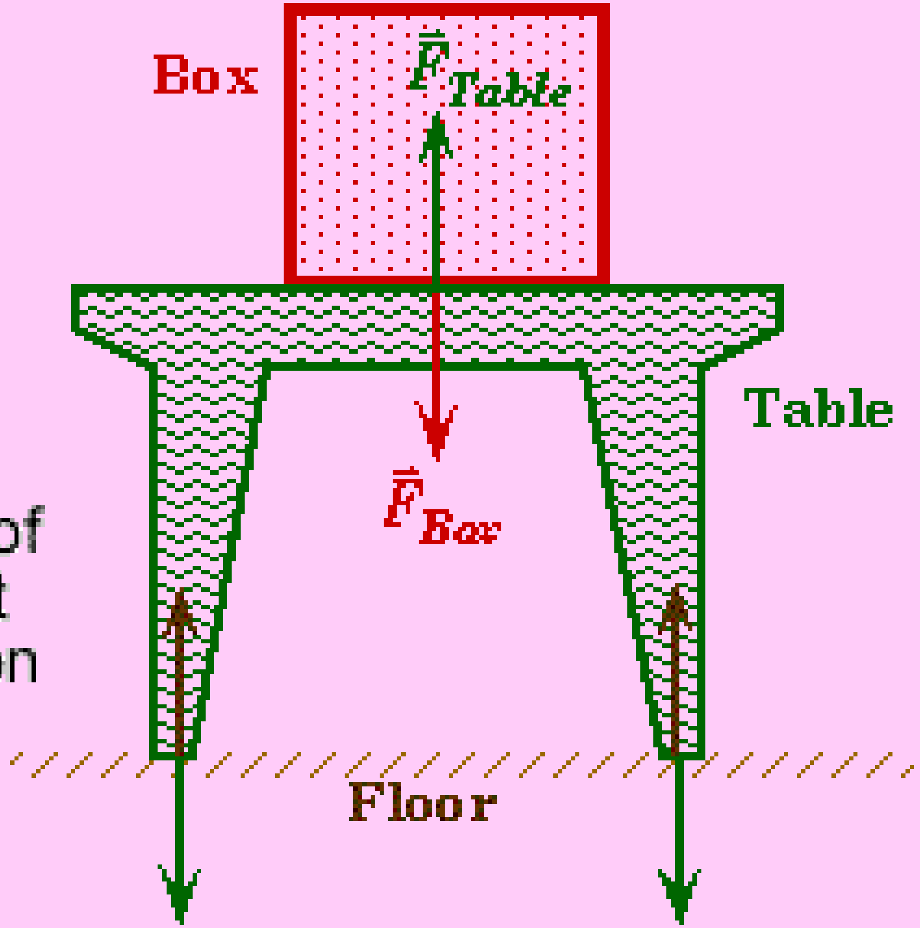
Can you list them?

Forces are vectors and can be drawn as arrows…

F_{Box} is the force exerted by the box on the table - i.e. the weight of the box

F_{Table} is the reaction force pushing up on the box

At the floor surface the weight of the table plus box is shared out by the legs and pushes down on the surface - the floor then pushes up with an equal but opposite reaction force.



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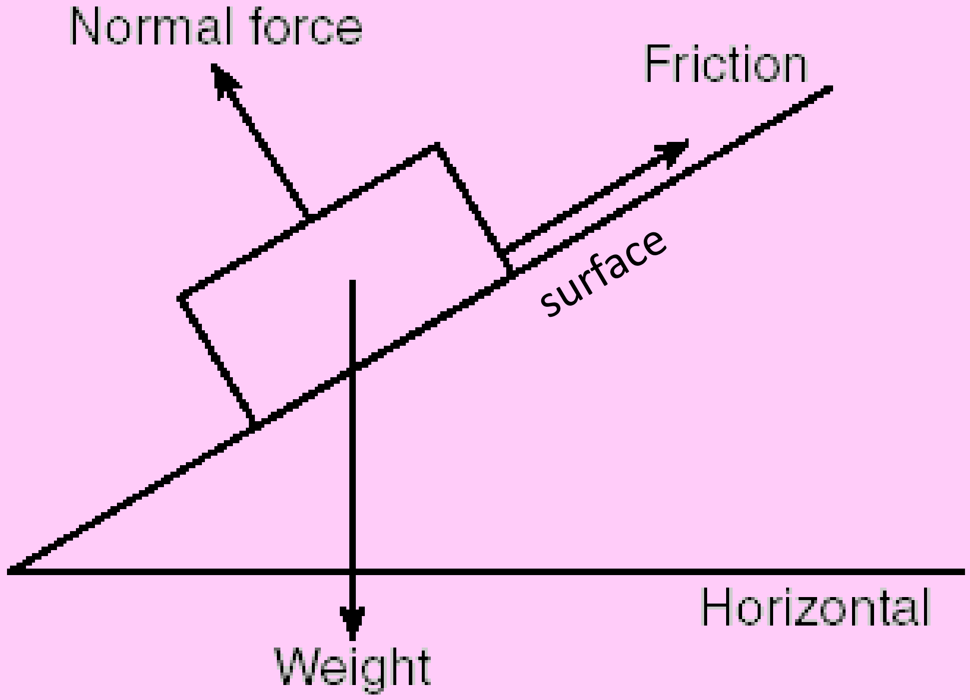
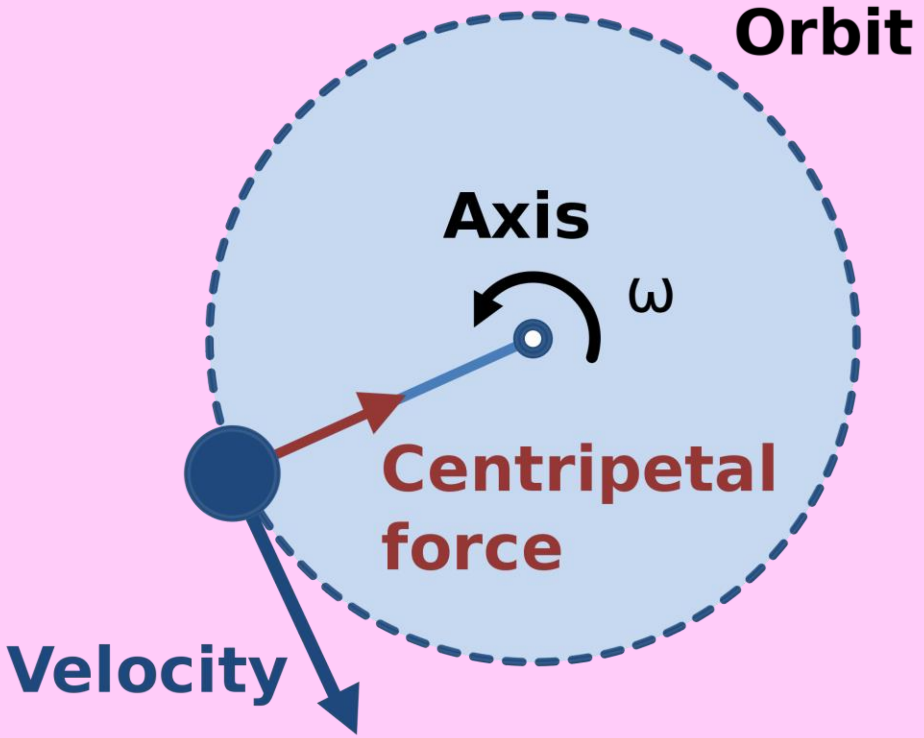
…and don't forget:

Normal reaction forces are at 90o to the surface



Centripetal forces act towards the centre of the turn



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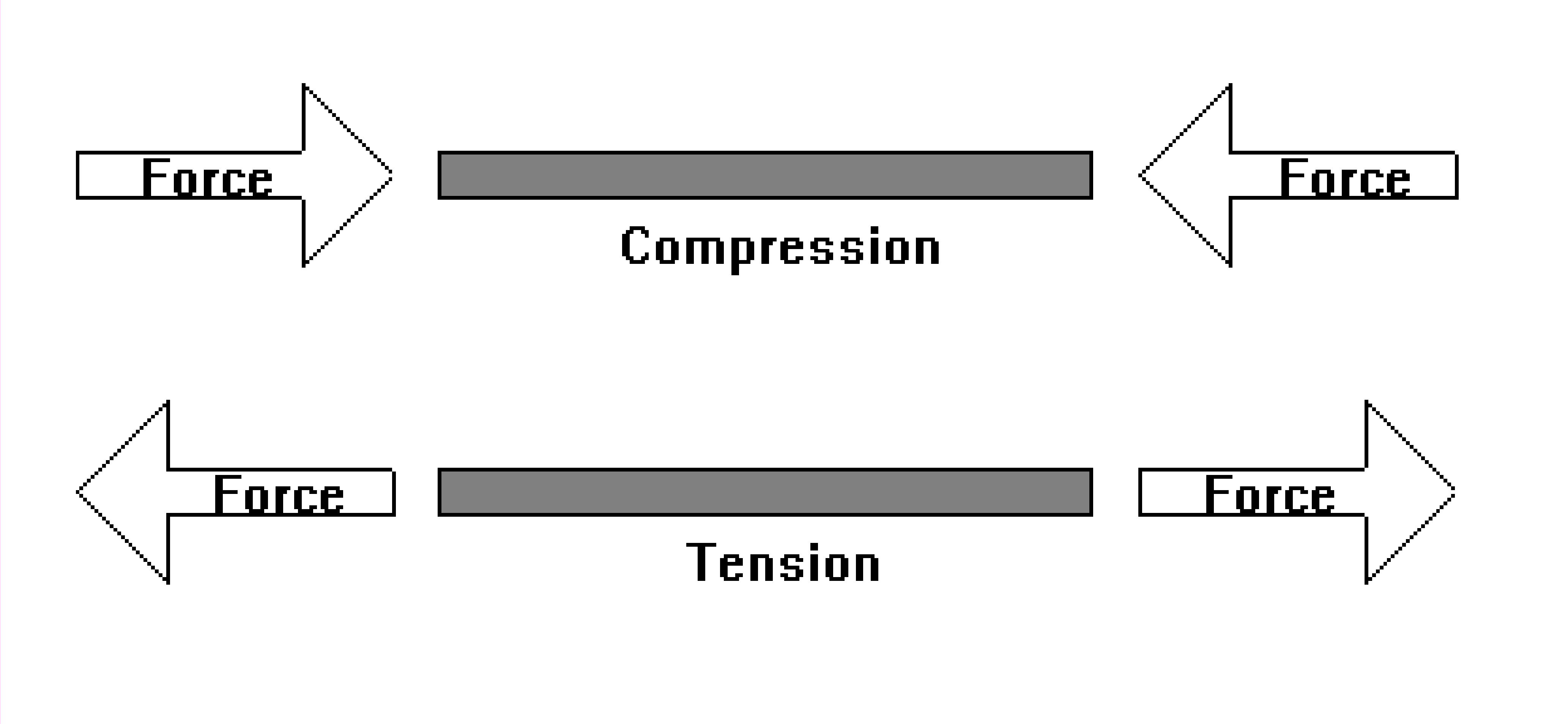
Or that:



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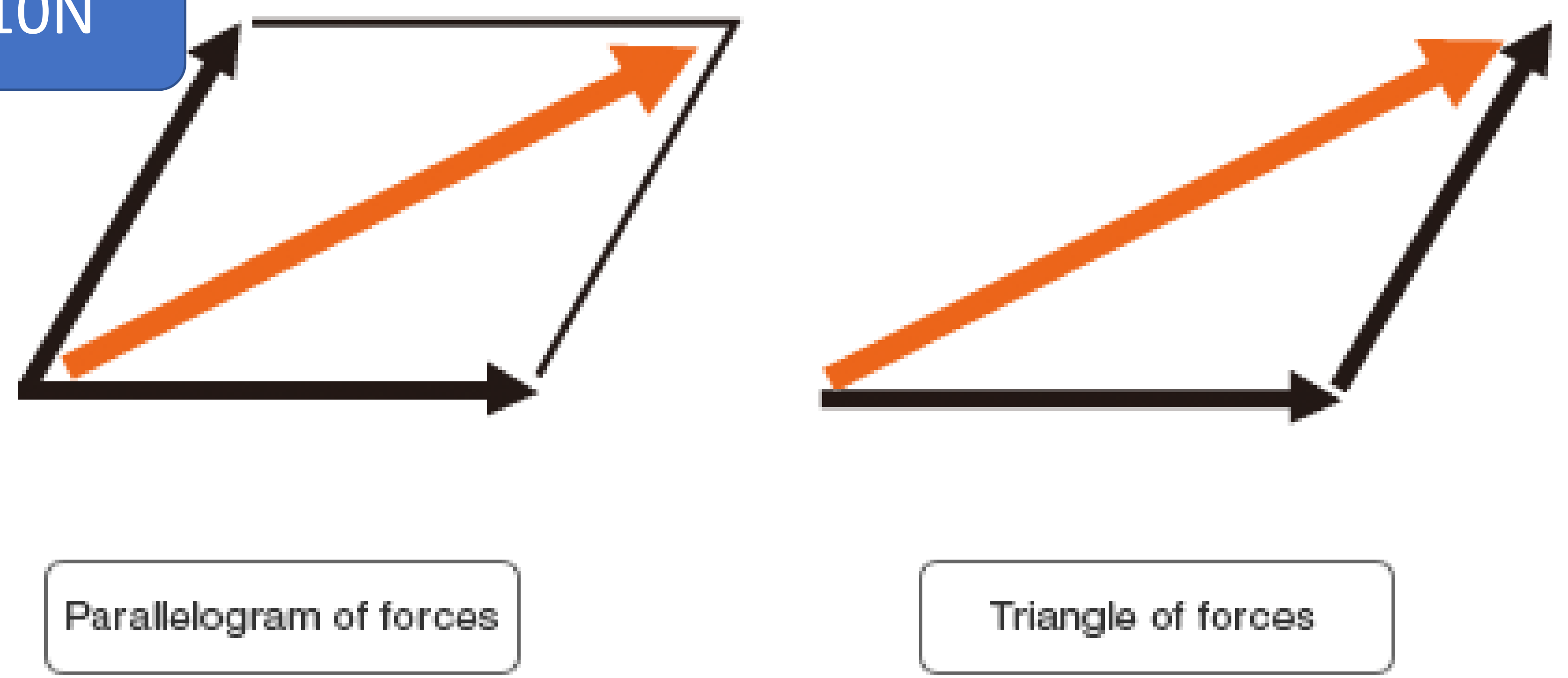
H Vectors can be added using scale diagrams

Scale 1cm : 10N



Use a pencil, ruler and protractor!

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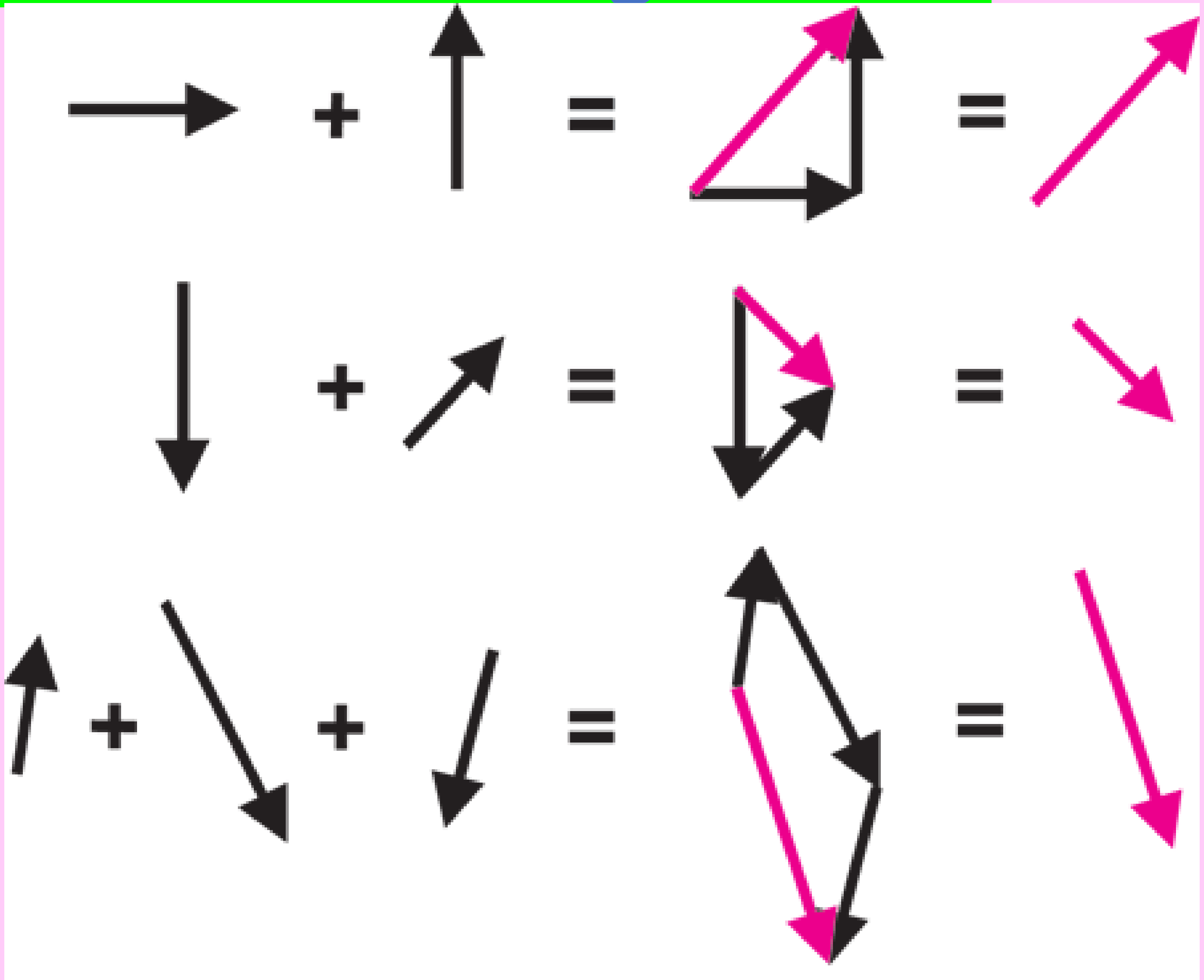
H Vectors can be added using scale diagrams

What would the diagram look like if the object was in equilibrium?



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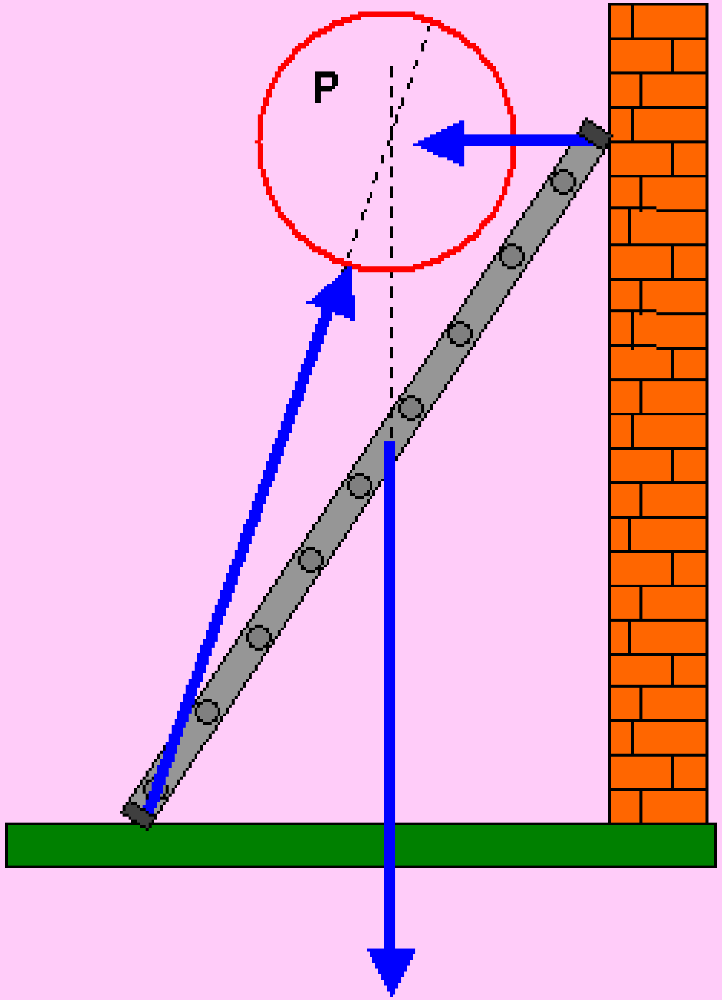

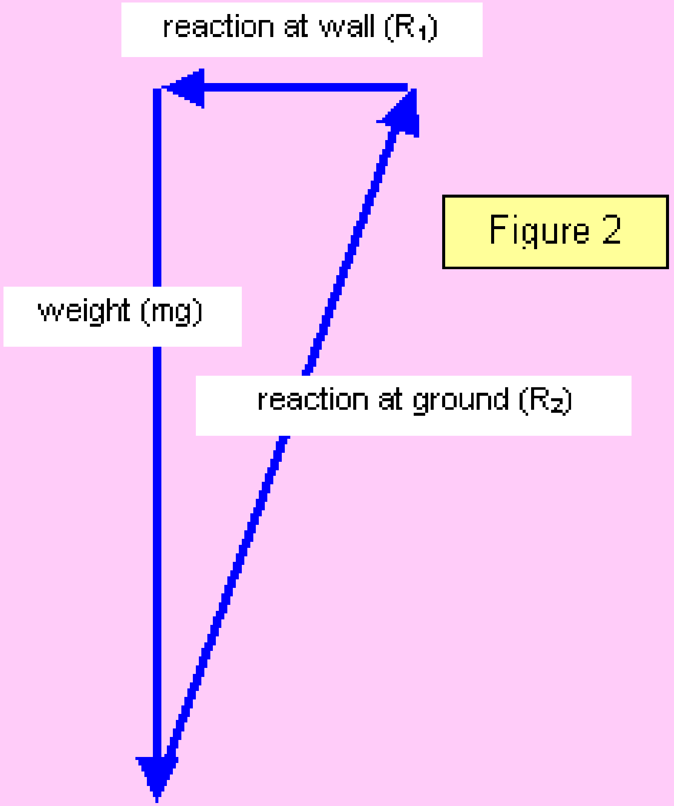

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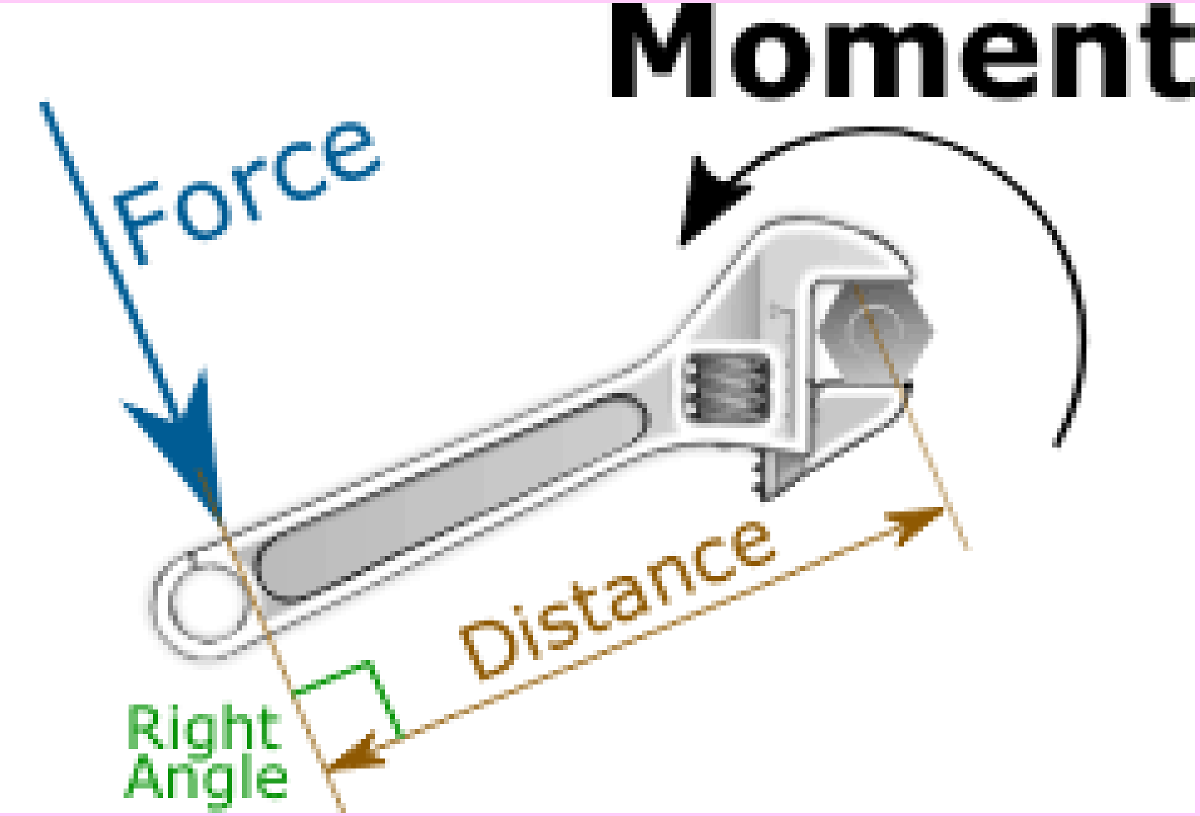
S Turning effect of a force



The "moment of a force" is the turning effect it has.

This is an anti-clockwise or negative moment.

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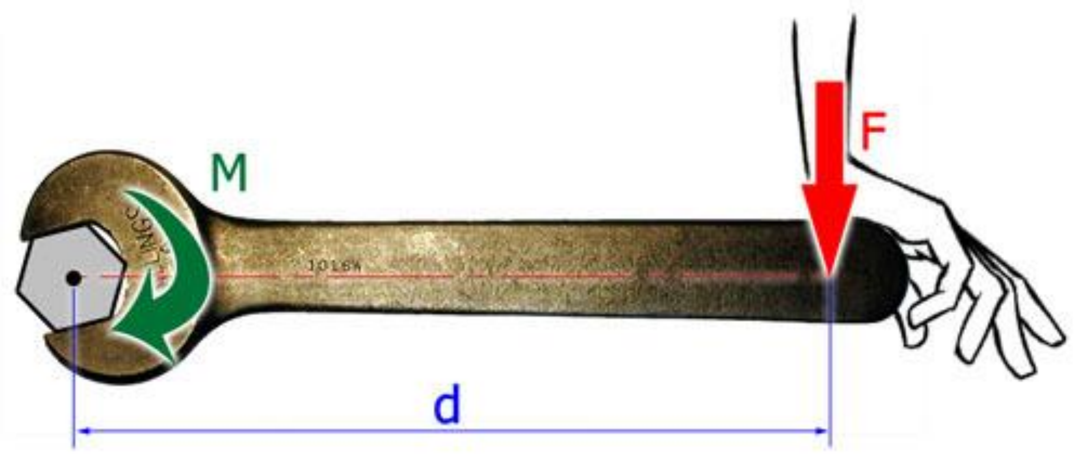
S Turning effect of a force



The "moment of a force" is the turning effect it has.

This is a clockwise or positive moment.

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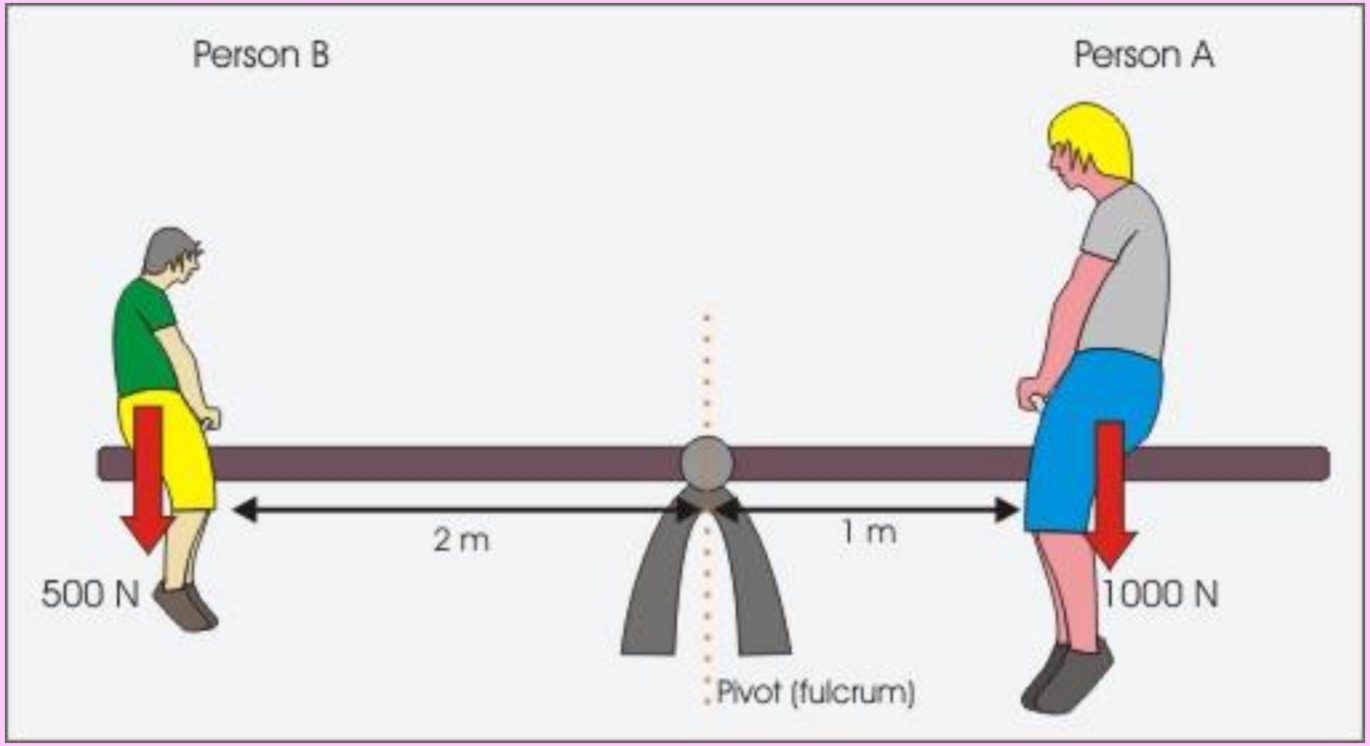
S Turning effect of a force



In equilibrium, the moments of all the forces add up to zero.

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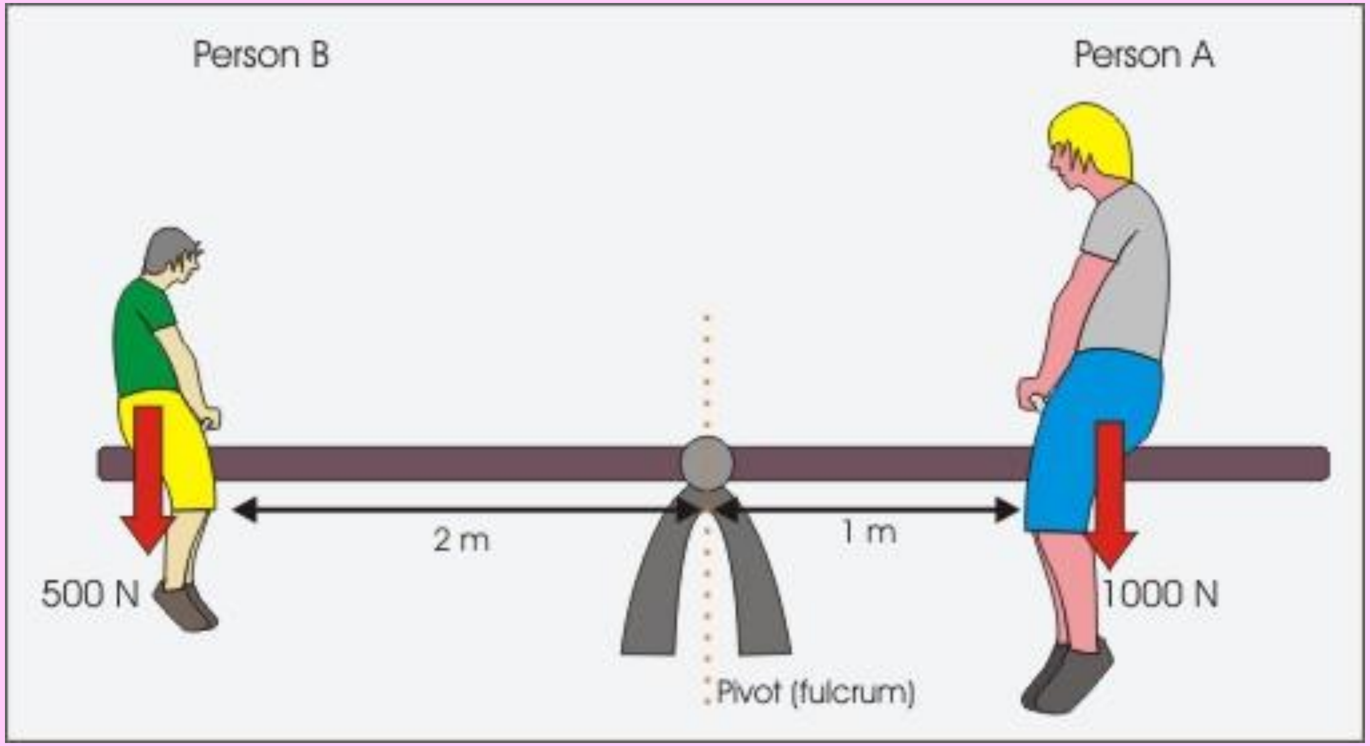
S Turning effect of a force

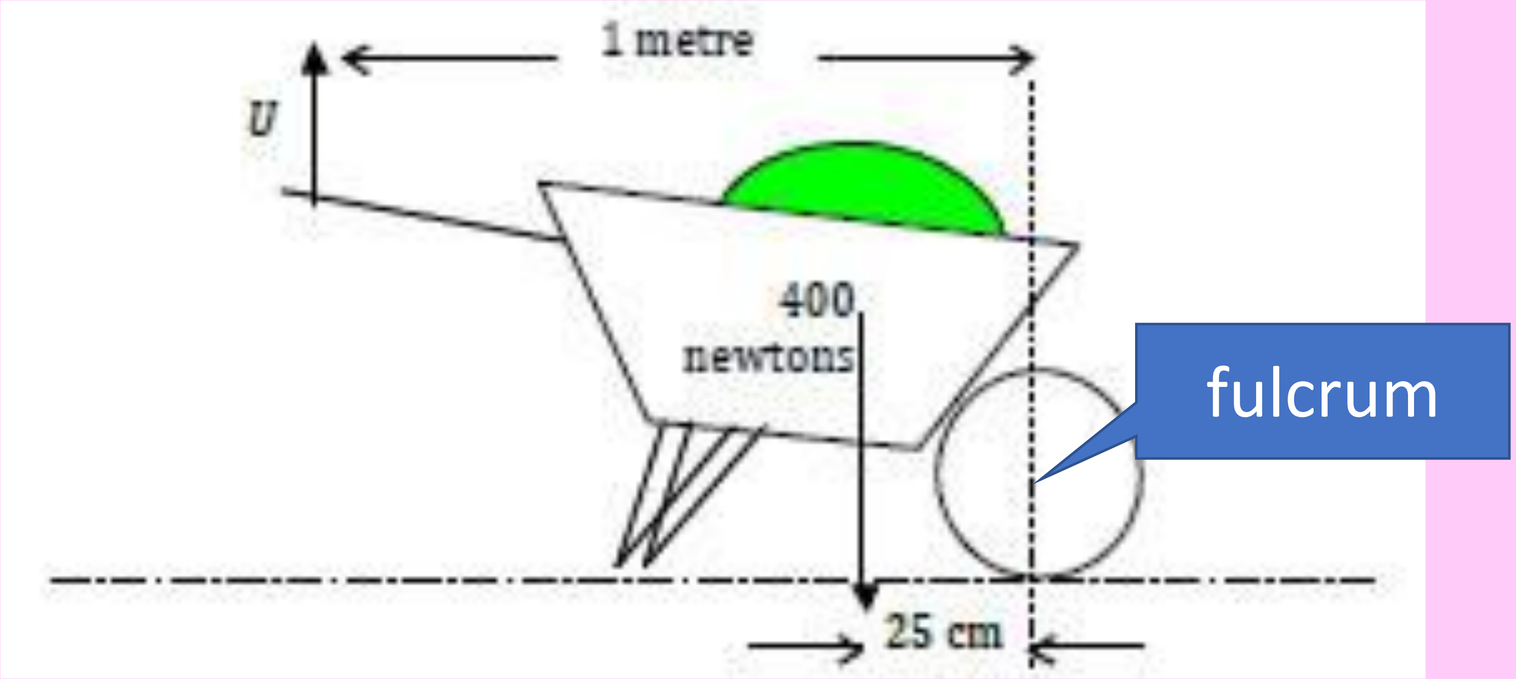


In equilibrium, the positive moments equal the negative moments in size.

S What is the unknown force U?

Think…

Positive moment = Negative moment



$U \times 1 = 400 \times 0.25$

$U = 100$ N

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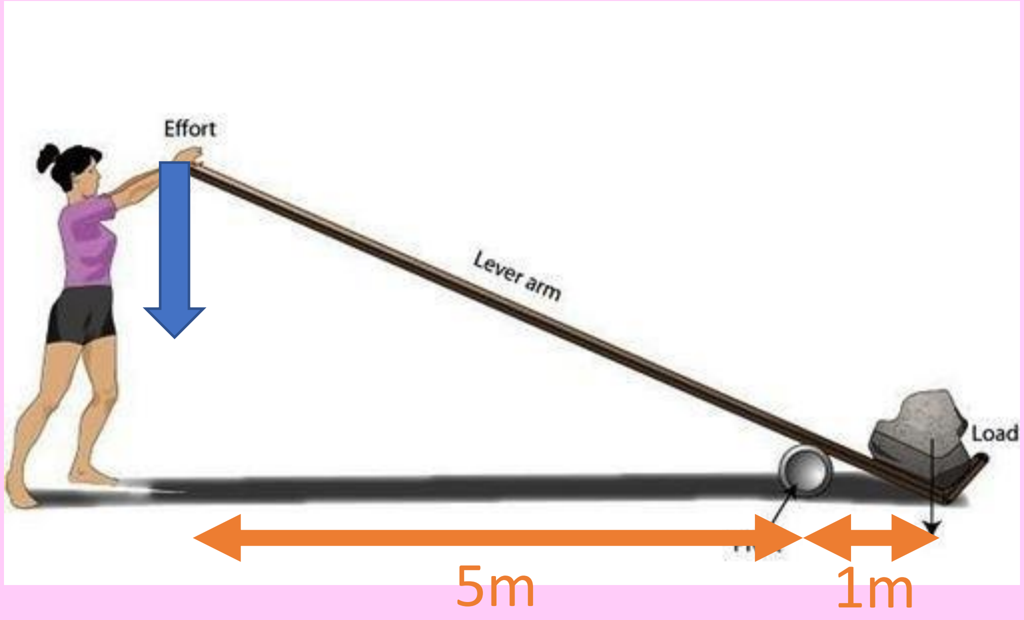
S How does a lever help?



Anne is able to pull down on the lever with a maximum force of 700N. What is the maximum mass she is able to lift with the lever shown?

700 x 5 = F x 1

3500 = F

But F = m x g and g is 10N/kg on Earth,

so mass, m = 3500 / 10 = 350 kg

EXTENSION - If Anne used a lever made from a heavy material like steel, why would this help her lift more mass?

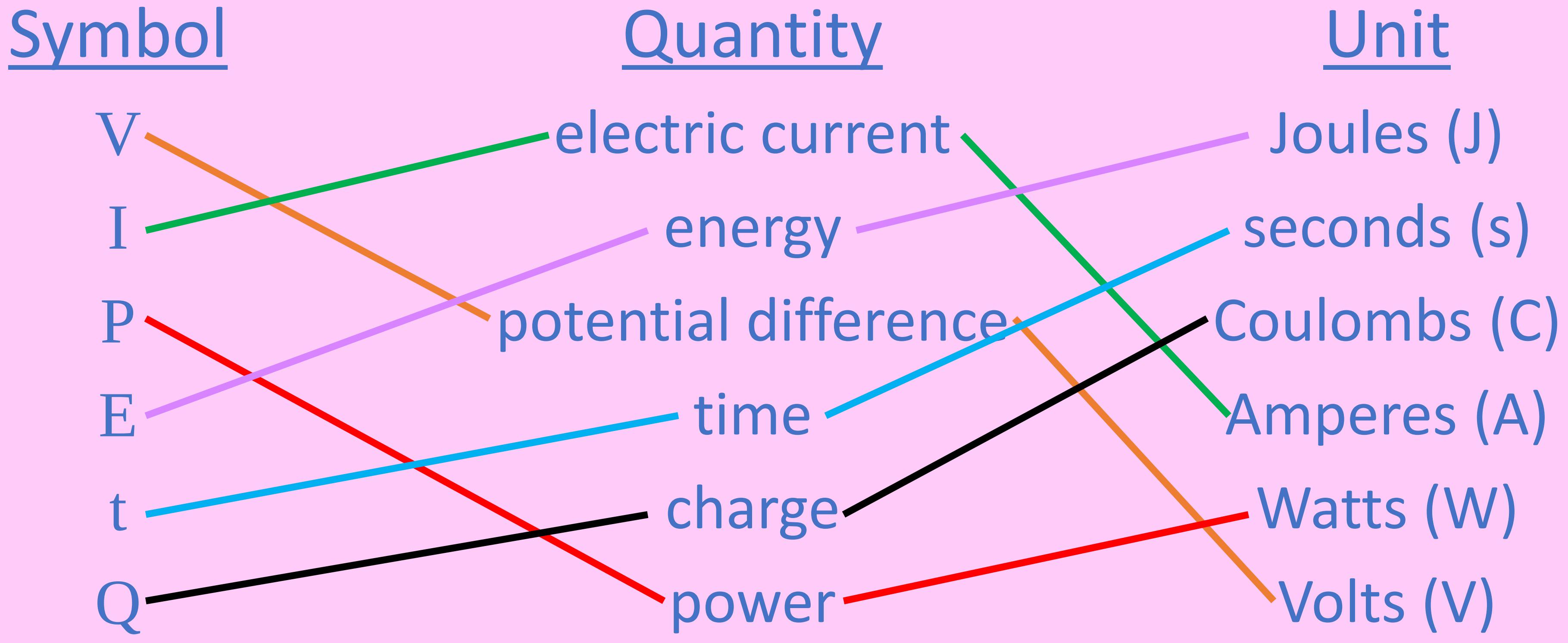
SP10/CP9
Electricity and circuits

The one that everyone needs to know everything for and therefore guaranteed to come up

Match the quantity with its symbol and unit

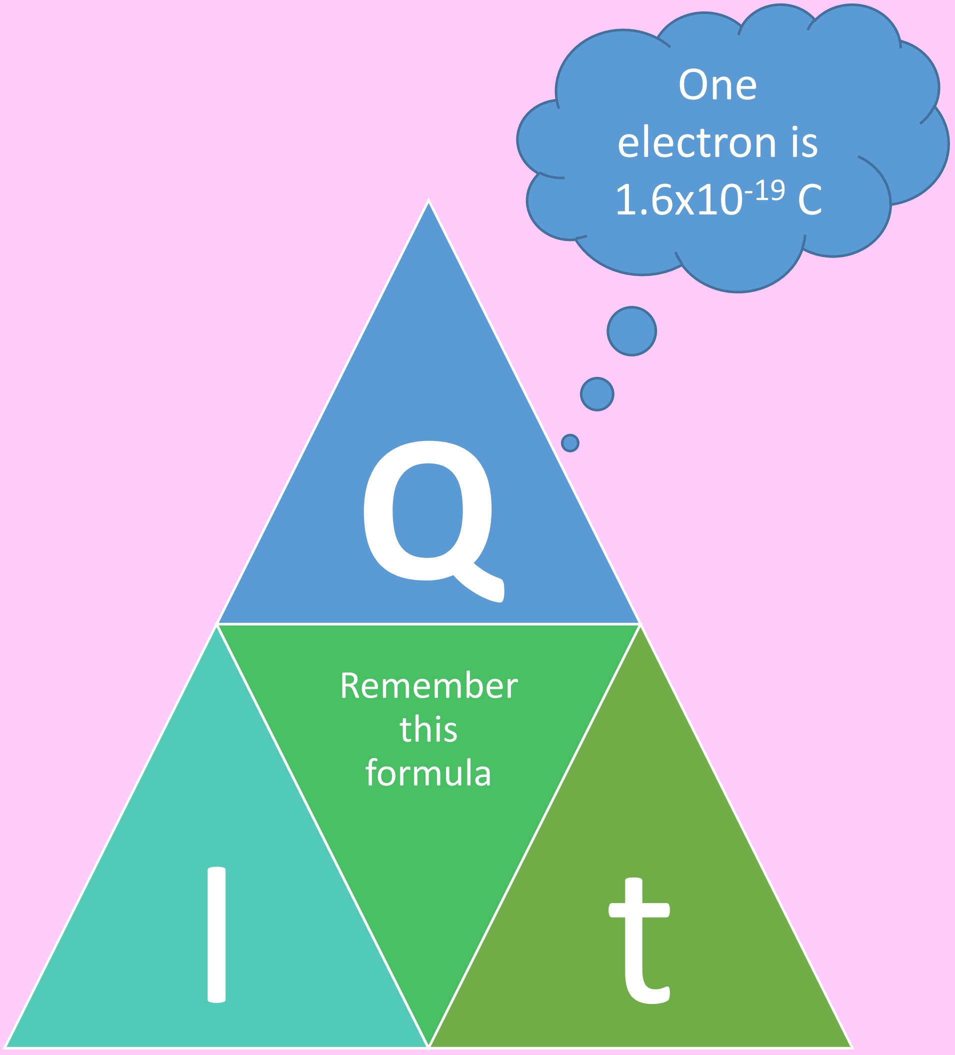
Symbol	Quantity	Unit
V	electric current	Joules (J)
I	energy	seconds (s)
P	potential difference	Coulombs (C)
E	time	Amperes (A)
t	charge	Watts (W)
Q	power	Volts (V)

Match the quantity with its symbol and unit

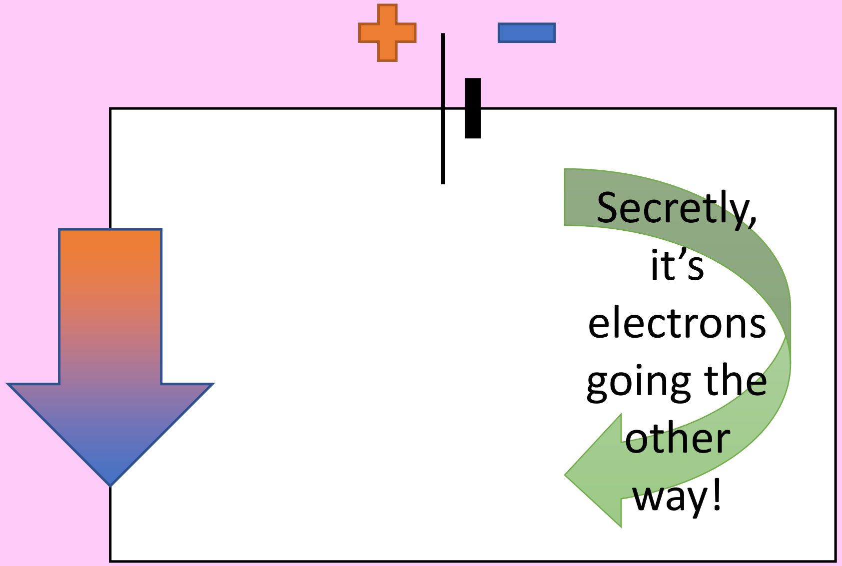


Electric current

- Charge, Q, is counted in Coulombs (C)
- Current, I, is measured in Amperes (A)
- 1 Amp is 1 Coulomb of charge flowing past a point in 1 second
- You can work out the charge transferred in a time, t, measured in seconds (s)



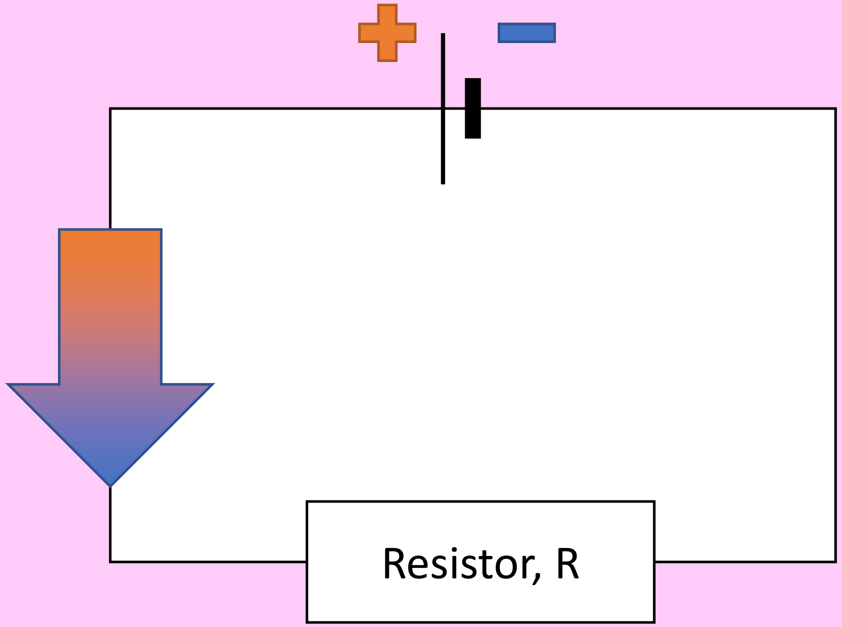
Simple electrical circuits



For electric charge to flow round a circuit, you need:

- A complete circuit
- A cell to provide the "push" and the energy, called the emf (electromotive force) or voltage
- The current would be huge, going from + to –
- It would heat and melt the wires (a short circuit)

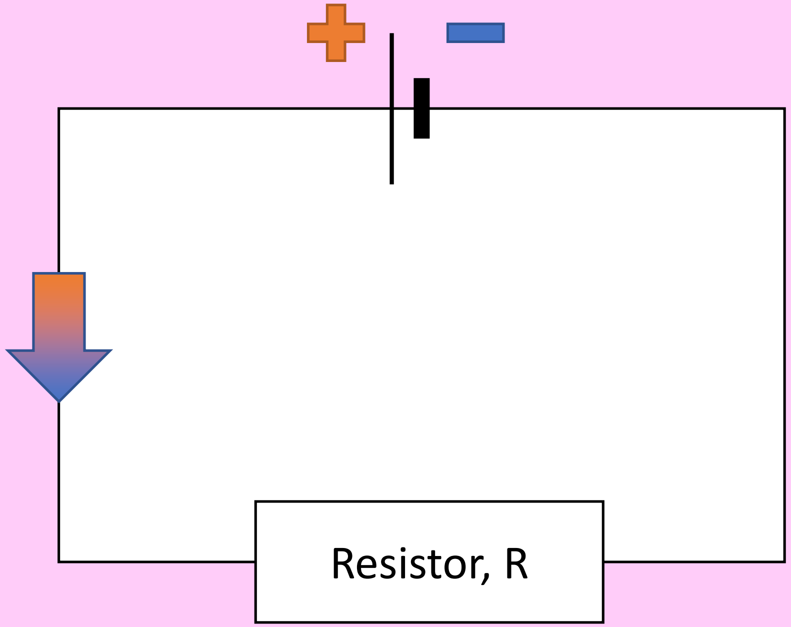
Simple electrical circuits



To stop the wires melting, we need:

- A resistance
- This "resists" the flow of current
- The current would decrease
- The energy is spent heating the resistor instead

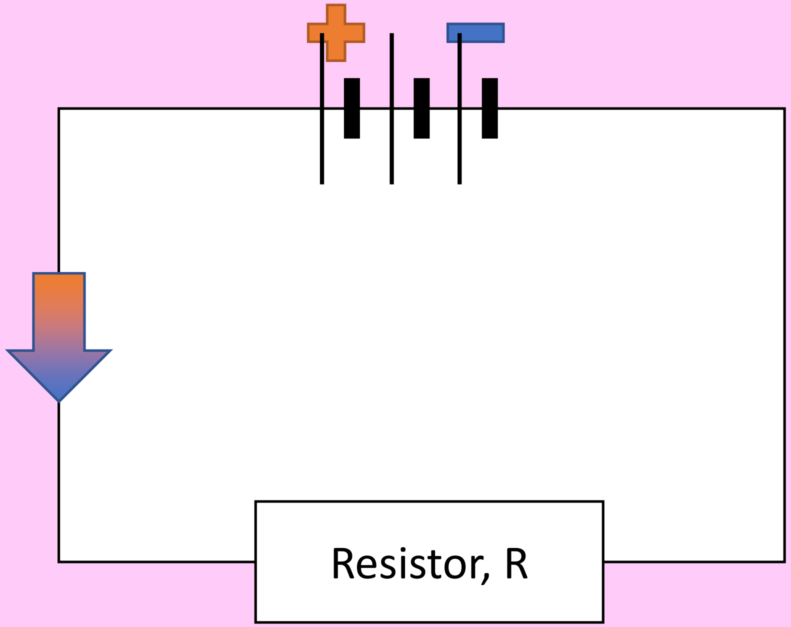
Simple electrical circuits



The size of the resistance affects the current:

- A smaller resistance
- Allows more current flow
- A bigger resistance
- Allows less current flow

Simple electrical circuits

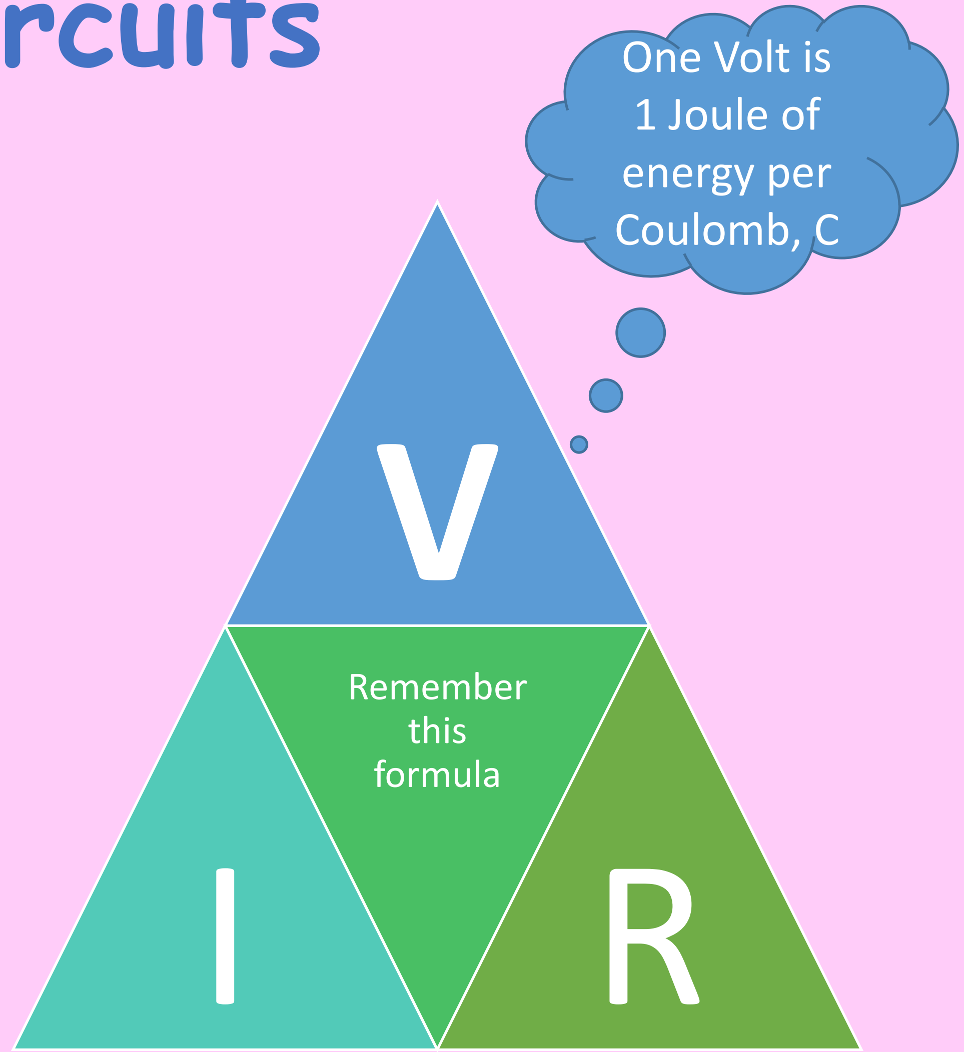


The size of the emf or voltage also affects the current:

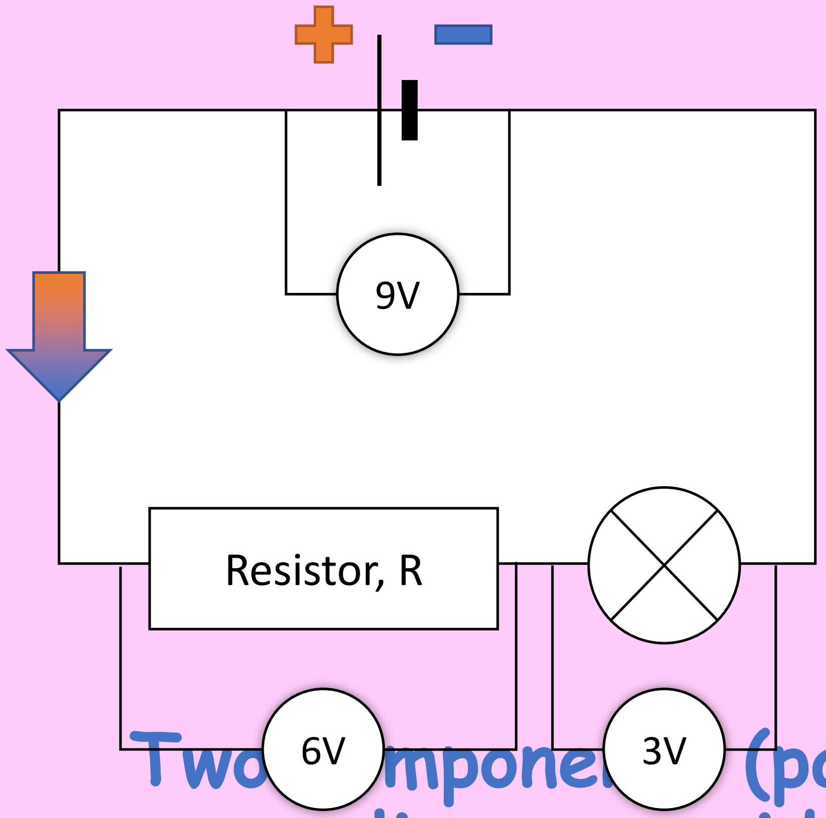
- A bigger voltage
- Allows more current flow
- A smaller voltage
- Allows less current flow

Simple electrical circuits

- Voltage, V, is counted in Volts (V)
- Current, I, is measured in Amperes (A)
- You can work out the Resistance, R, measured in Ohms (Ω)
- 1 Ohm is when 1 Volt can push a current of 1 Amp



Simple electrical circuits



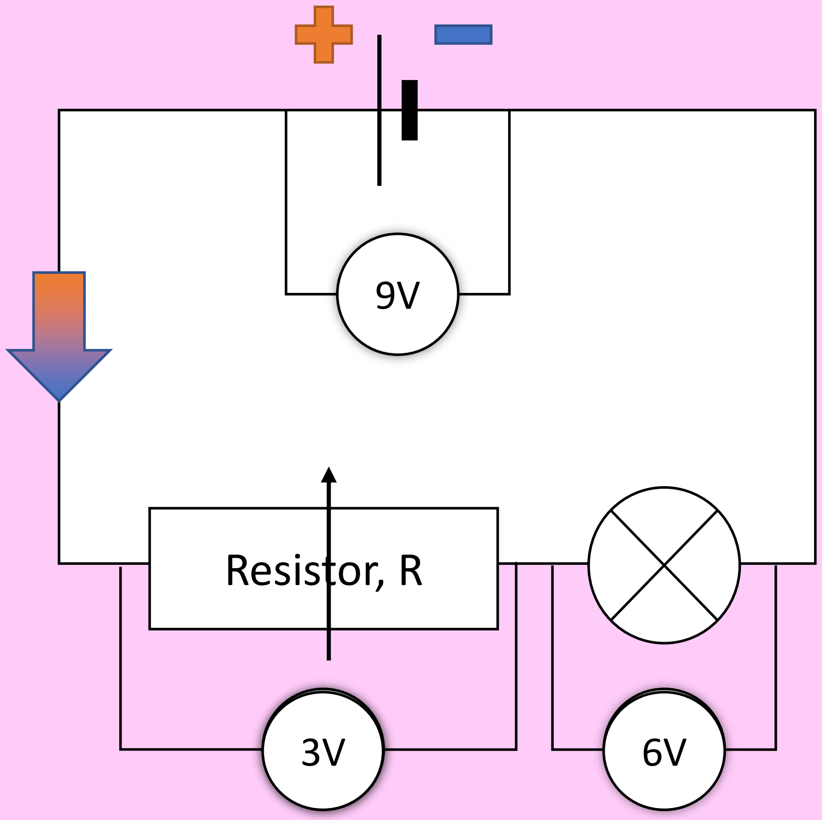
A voltmeter can measure the potential energy difference between two points in the circuit:

- This one measures the emf or voltage supplied, 9V
- This one measures the potential difference of the resistor, 6V
- This one measures the potential difference of the bulb, 3V

Two components (parts) placed on the same line are said to be "in series".

The voltages in the circuit add up to the total emf or voltage supplied

Simple electrical circuits



The voltages in the circuit add up to the total emf or voltage supplied

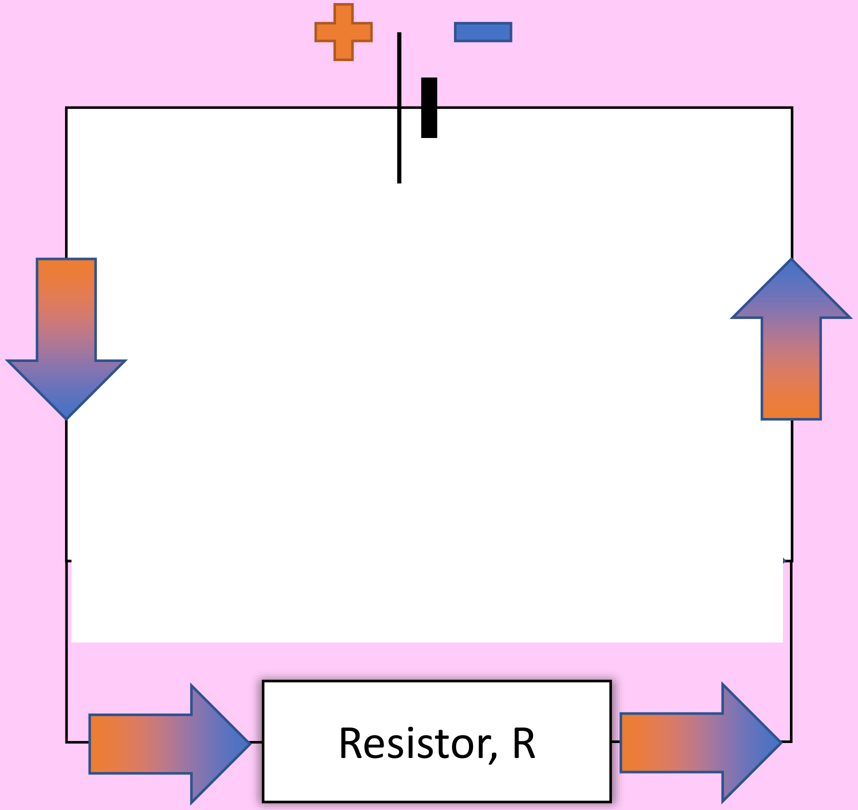
If the resistance is decreased…

- Less voltage is spent in the resistor
- More voltage is spent in the bulb
- The total resistance is less so more current flows

If the resistance is increased…

- The opposite effect happens

Simple electrical circuits



This is a **parallel** circuit. The new wire makes it easier for current to get round, so the **total resistance is less**

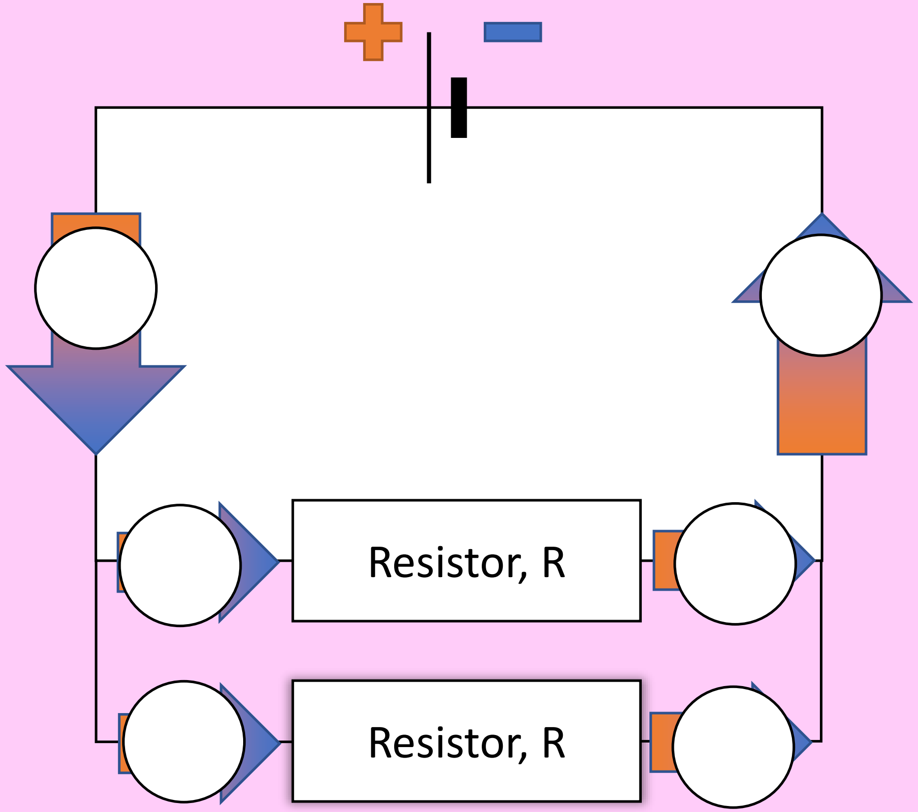
Electric current flow round a circuit is conserved:

- what goes in must come out ☺

When a new wire is added:

- It gets its own current
- This adds to the current in the original circuit

Simple electrical circuits

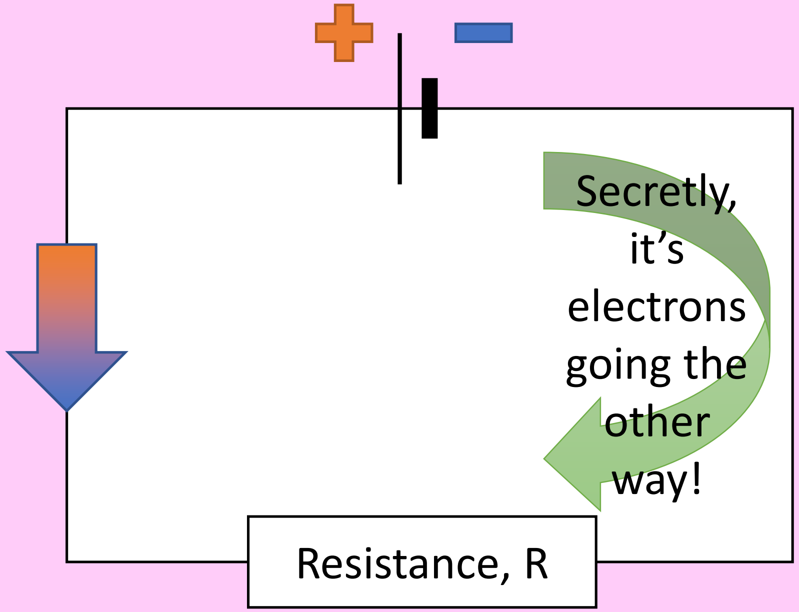


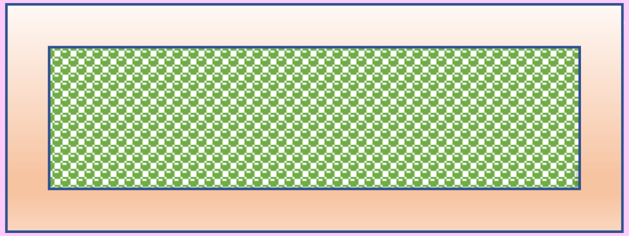
This is a **parallel** circuit. The new wire makes it easier for current to get round, so the **total resistance is less**

Current can be measured using ammeters:

- the current has to flow through the ammeter
- The current from the cell…
- …splits up through the two wires…
- …and rejoins to return to the cell

Resistance



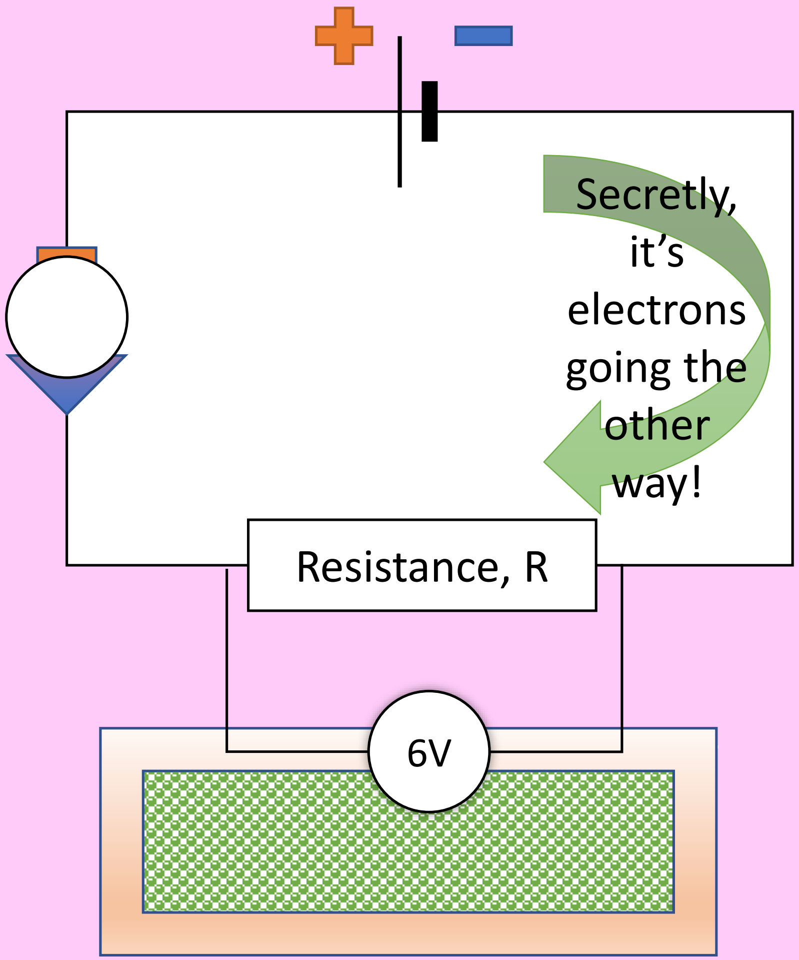


Remember this?

Resistance is caused by:

- Collisions between electrons and atoms in the conductor
- Collisions between electrons when there are too many

Resistance



We can measure:

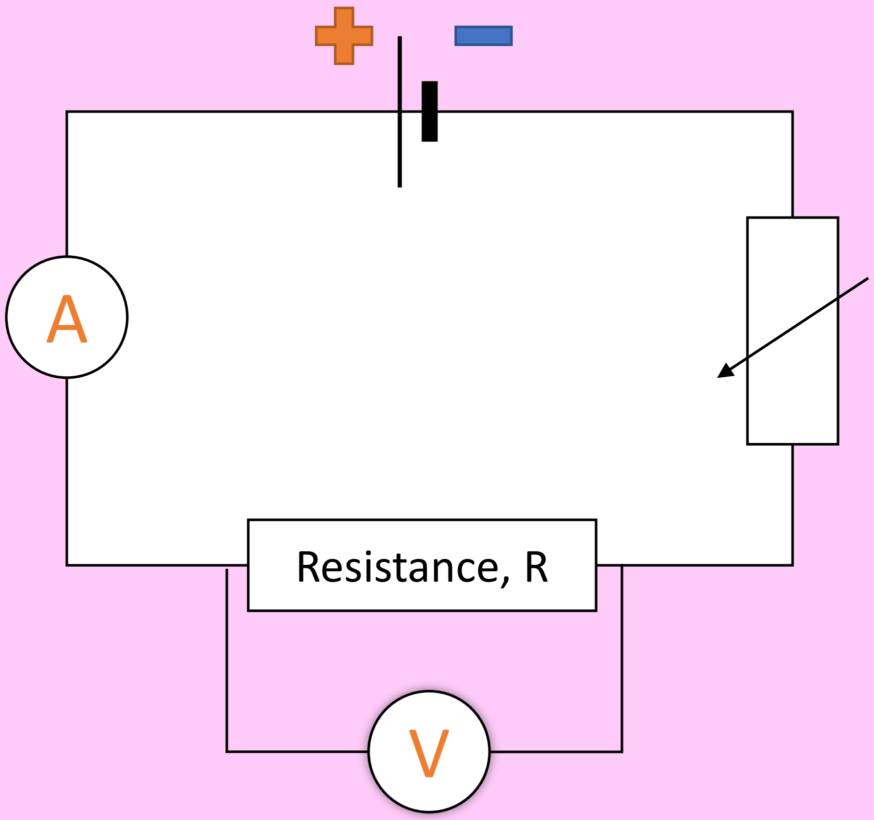
- Current with an ammeter
- Voltage (pd) with a voltmeter

We can calculate:

- Resistance
- Power
- Energy used

f_x sheet

Resistance

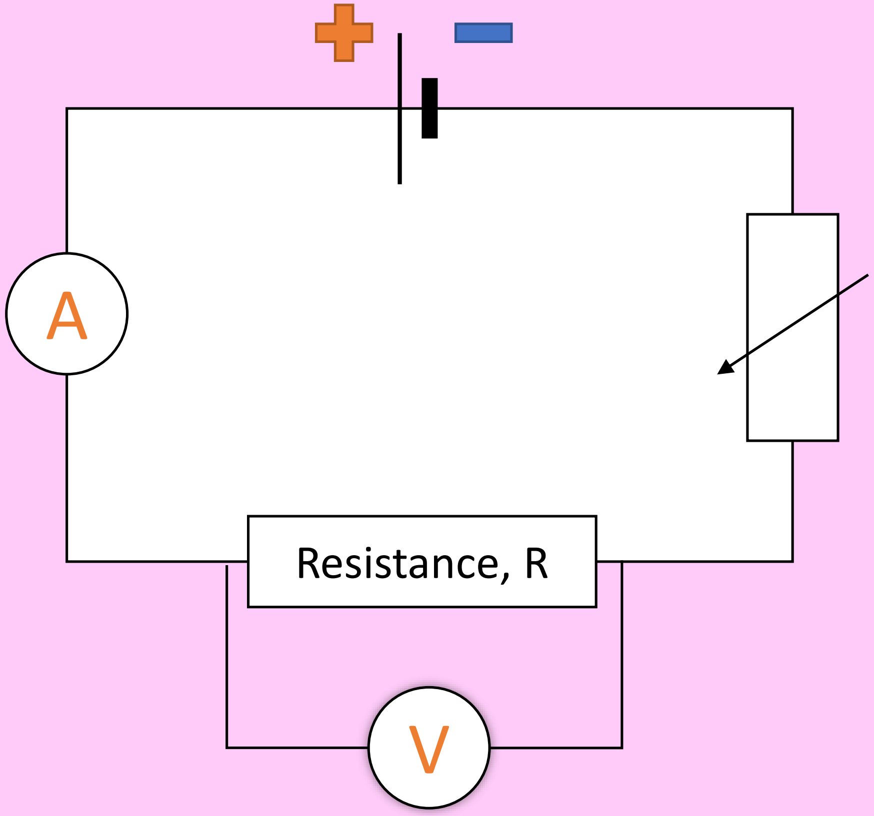


Standard Test Circuit

If we add a variable resistor:

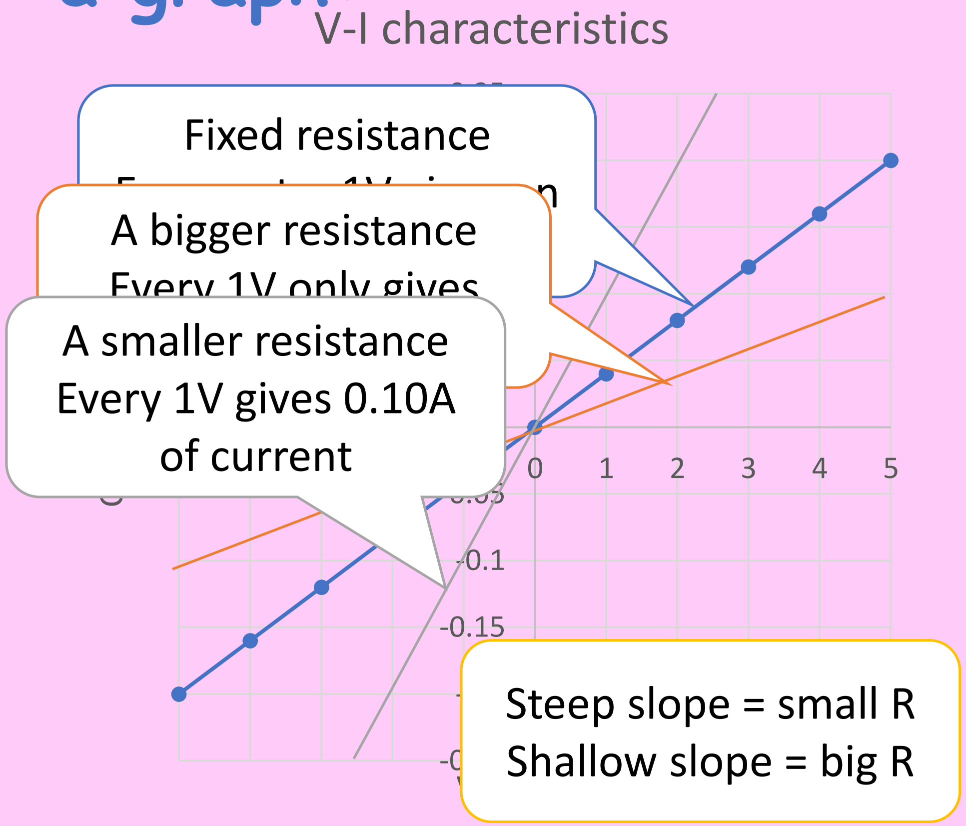
- We can adjust the resistance
- Which changes the voltage on the resistance
- And changes the current that will pass through

Resistance



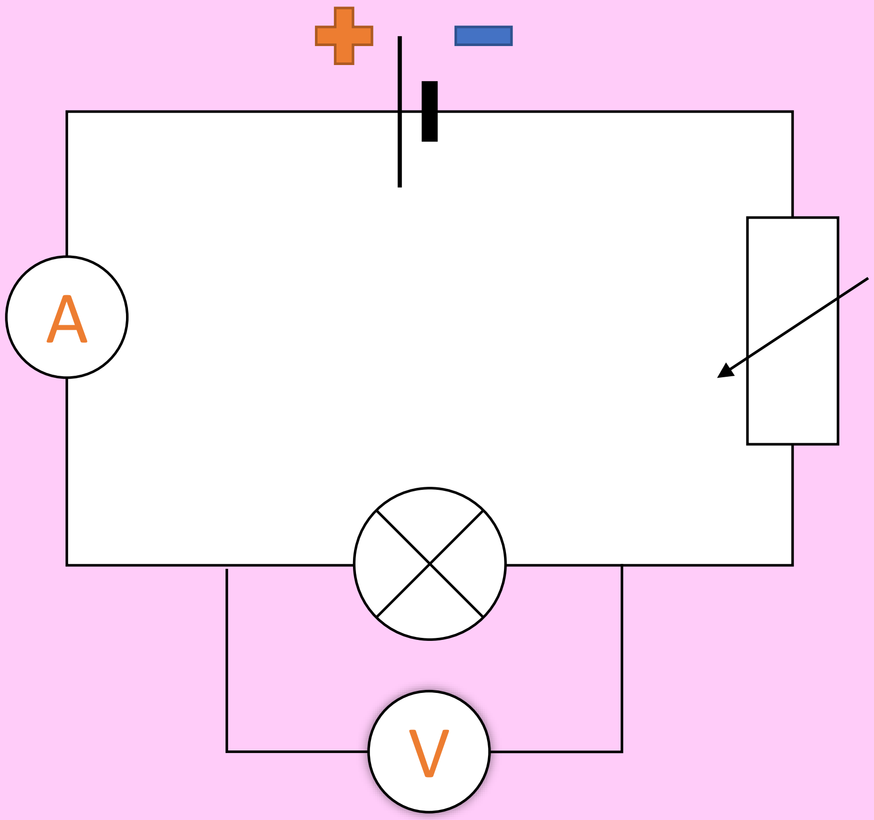
Standard Test Circuit

This allows us to plot a graph:



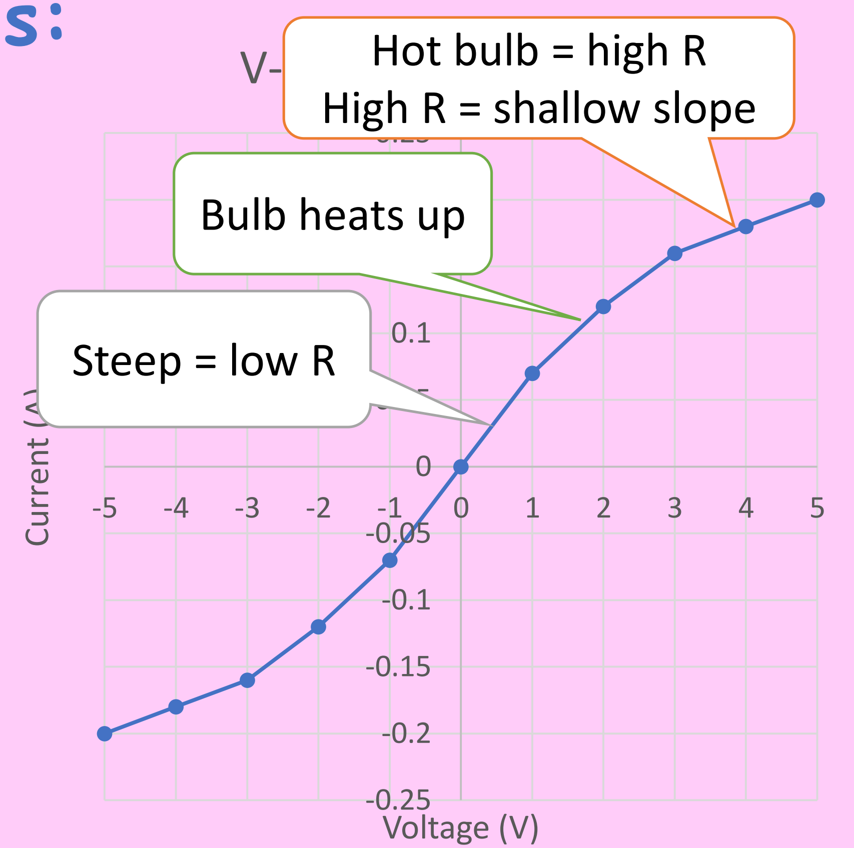
LO - GCSE Physics Revision

Resistance

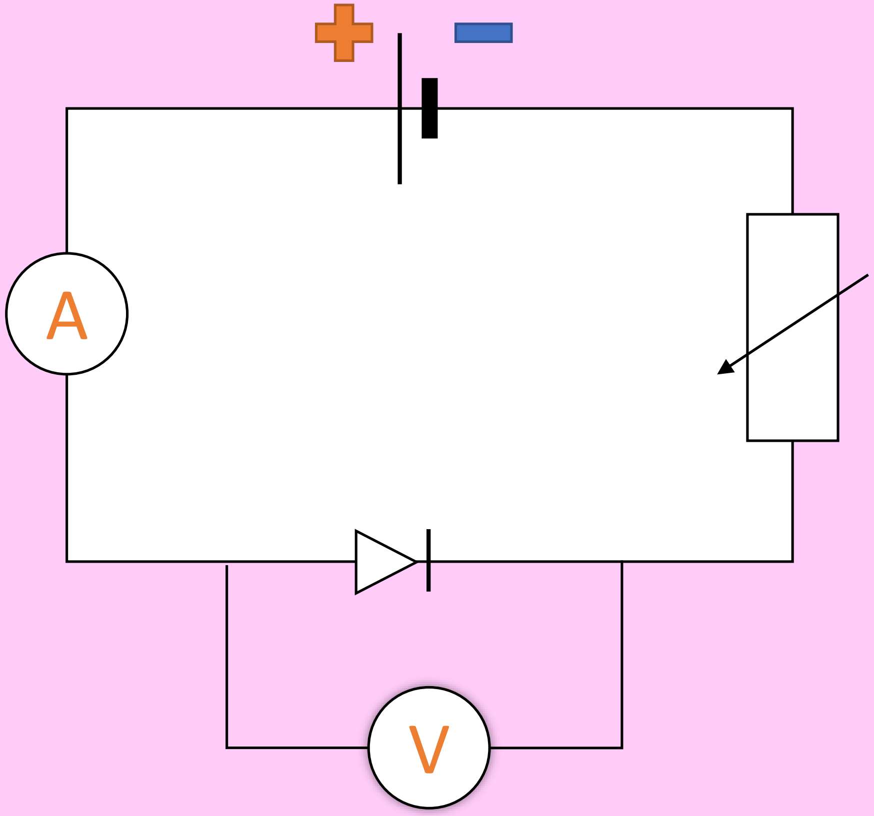


Standard Test Circuit

The graph for a bulb is:

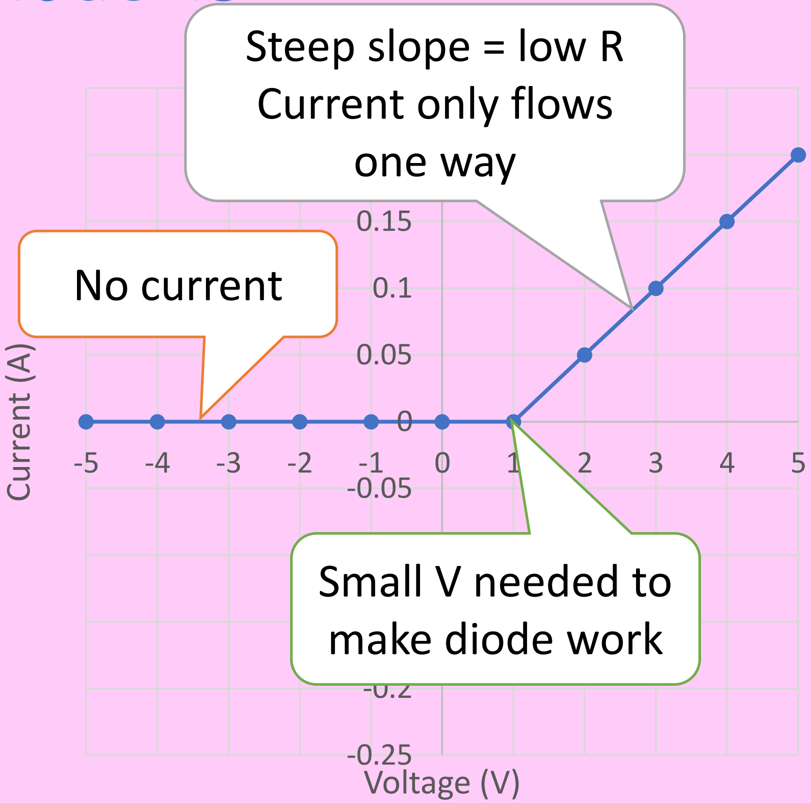


Resistance

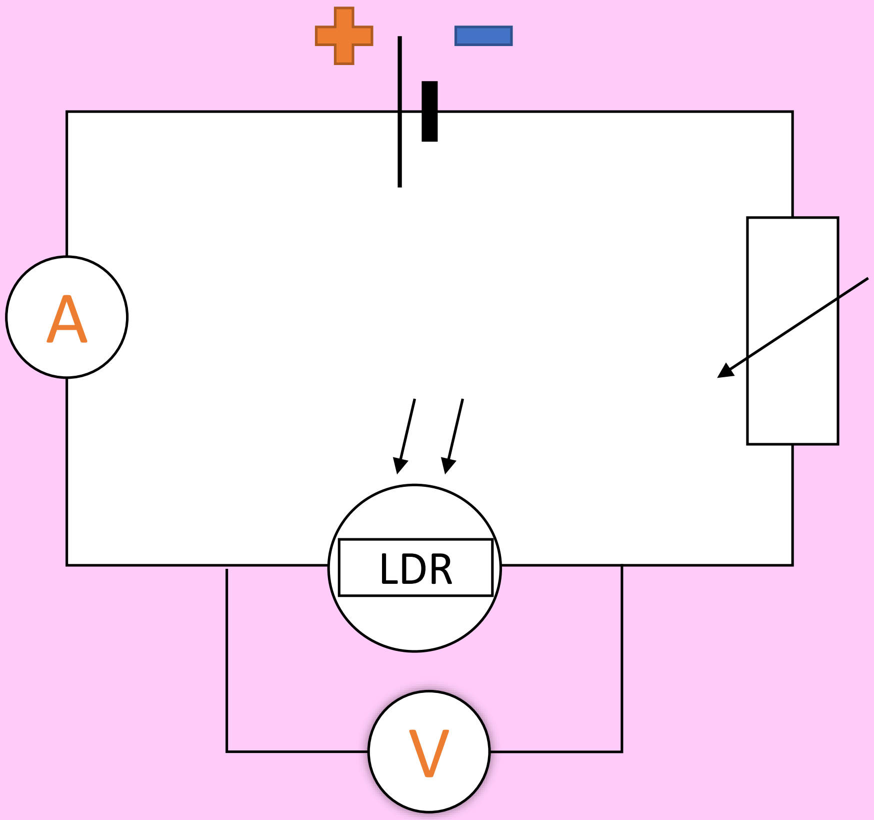


Standard Test Circuit

The graph for a diode is:



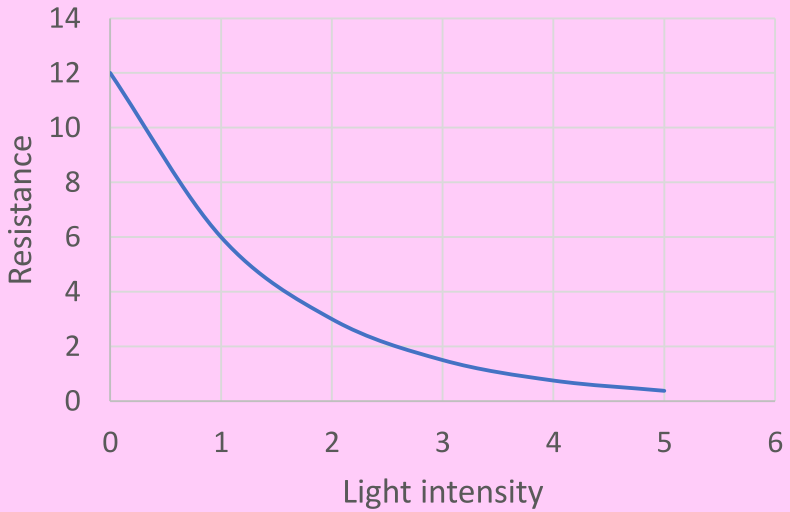
Resistance



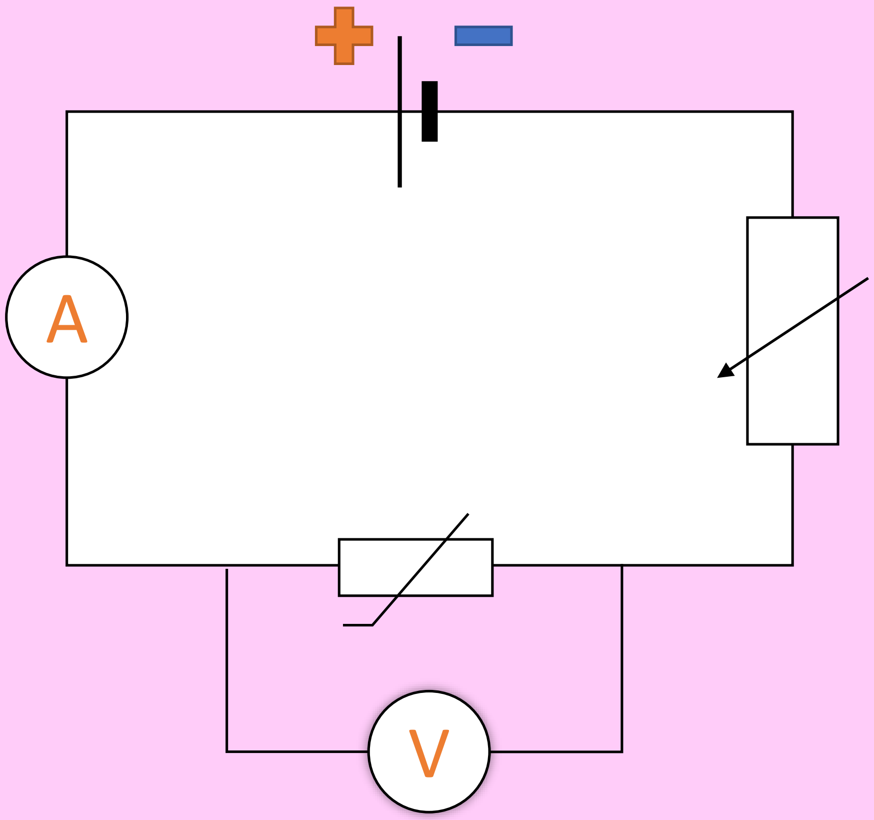
Standard Test Circuit

An LDR acts like a normal resistor except:

- When light hits it, R gets less



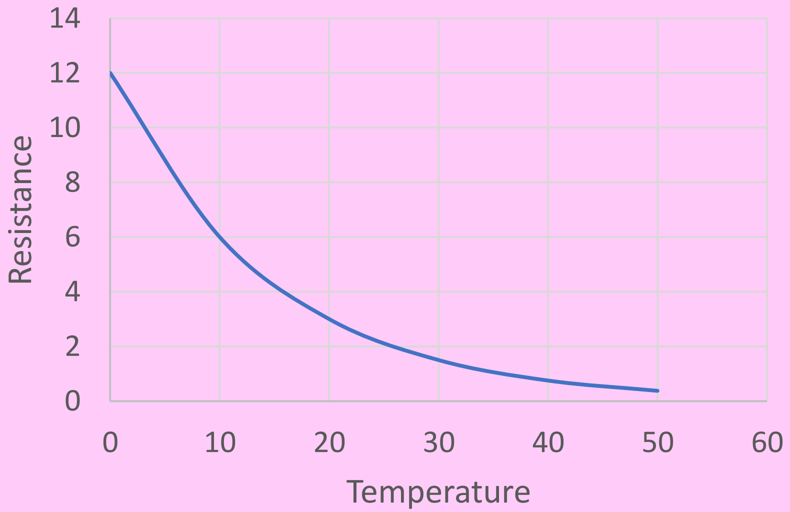
Resistance



Standard Test Circuit

A thermistor acts like a normal resistor except:

- When it gets hot, R gets less

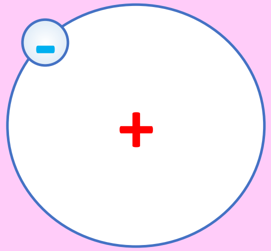


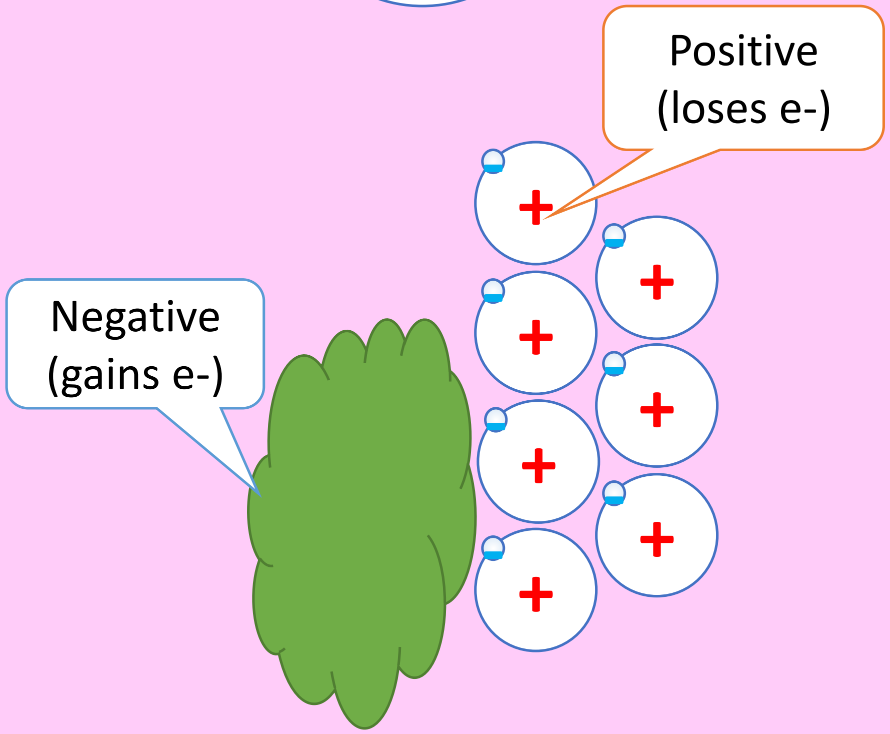
SP11
Static electricity and electric field

Separate science students only

S How is static charge created?

- An atom is **neutral**, with equal + and – charges
- A material made from atoms is **neutral** too
- But if two different materials are rubbed together…
- Negative electrons can be transferred





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S Electrostatic force

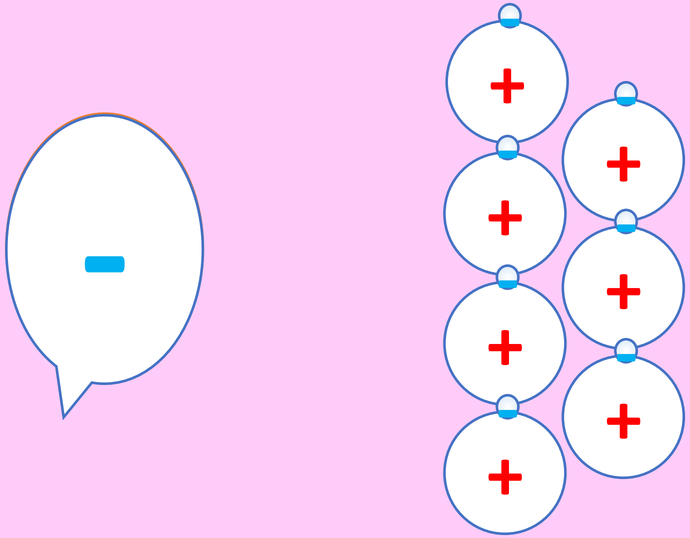
Forces between charges

- + and + repel
- + and - attract
- - and - repel

The force is bigger if:

- There are more - or more +
- The + and - are closer

Force on a neutral object



Electrons move away from balloon, then + and - attract

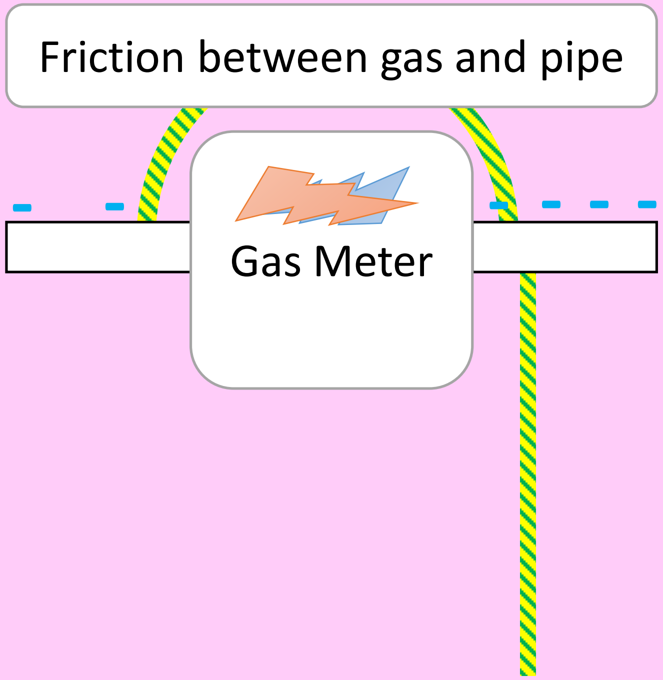
LO - GCSE Physics Revision

S Earthing and Cross-Bonding

To stop electric charge building up:

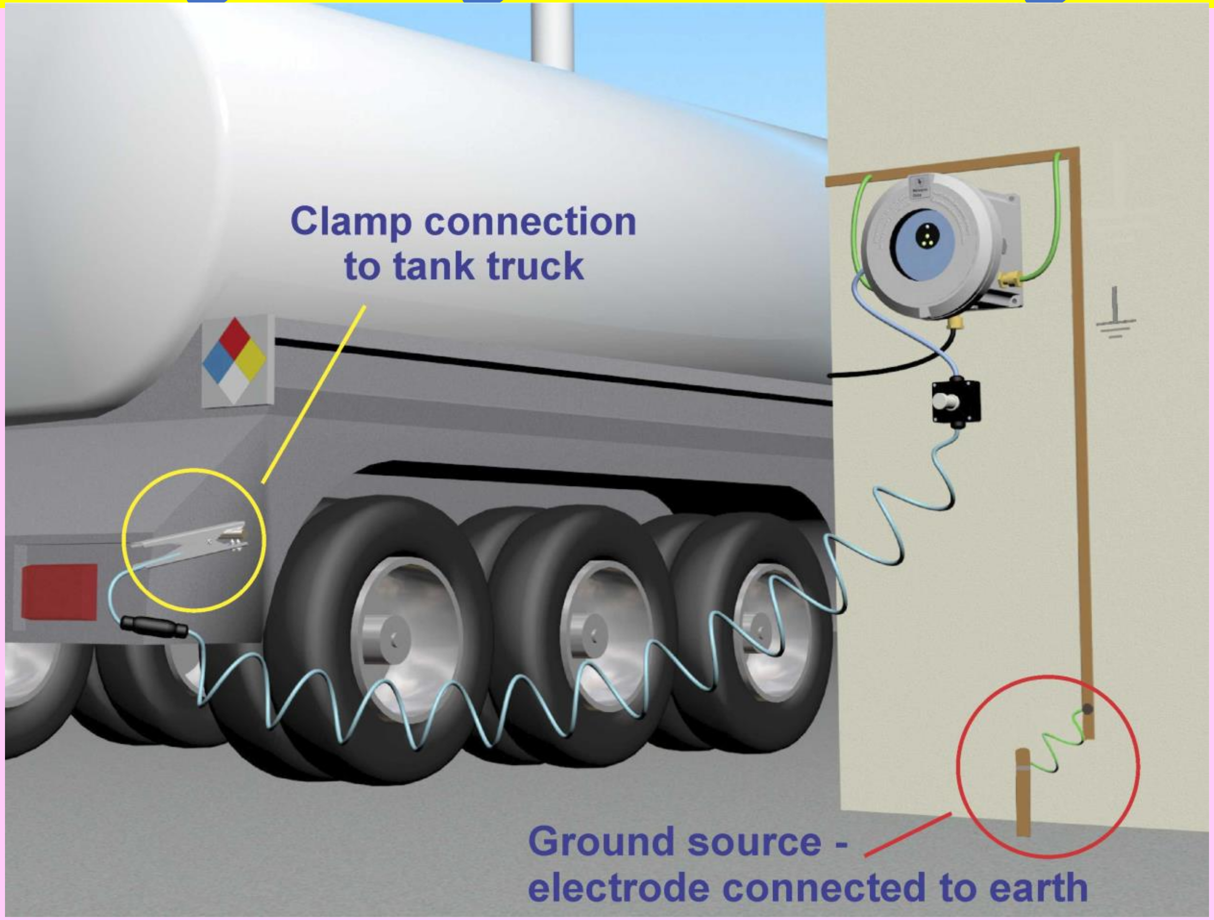
- Earth the object using a conductor
- Cross-bond all metallic parts

When you touch a charged object you act as an Earth wire and get a shock!



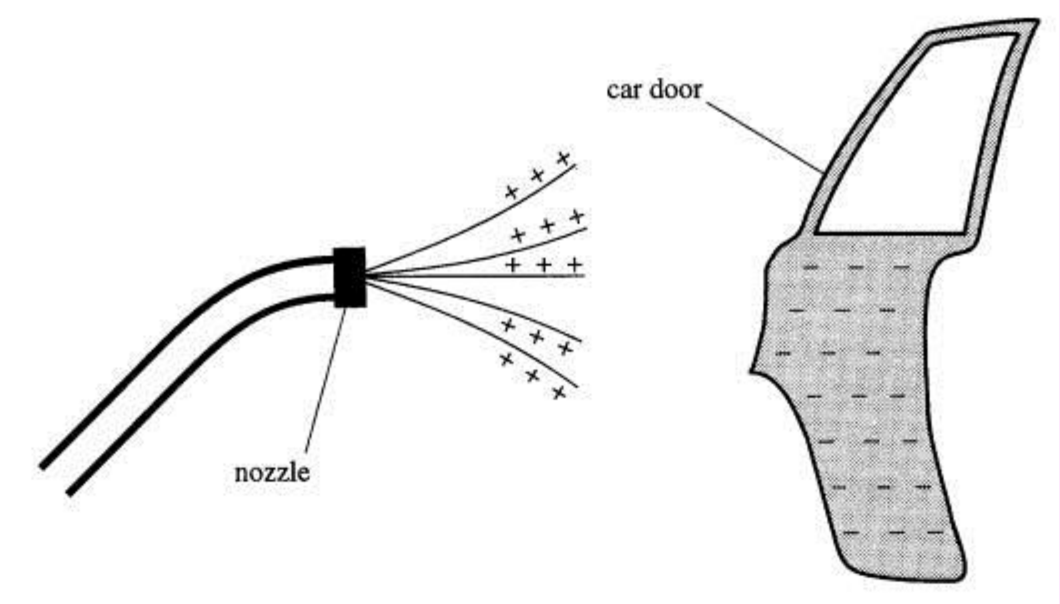
LO - GCSE Physics Revision

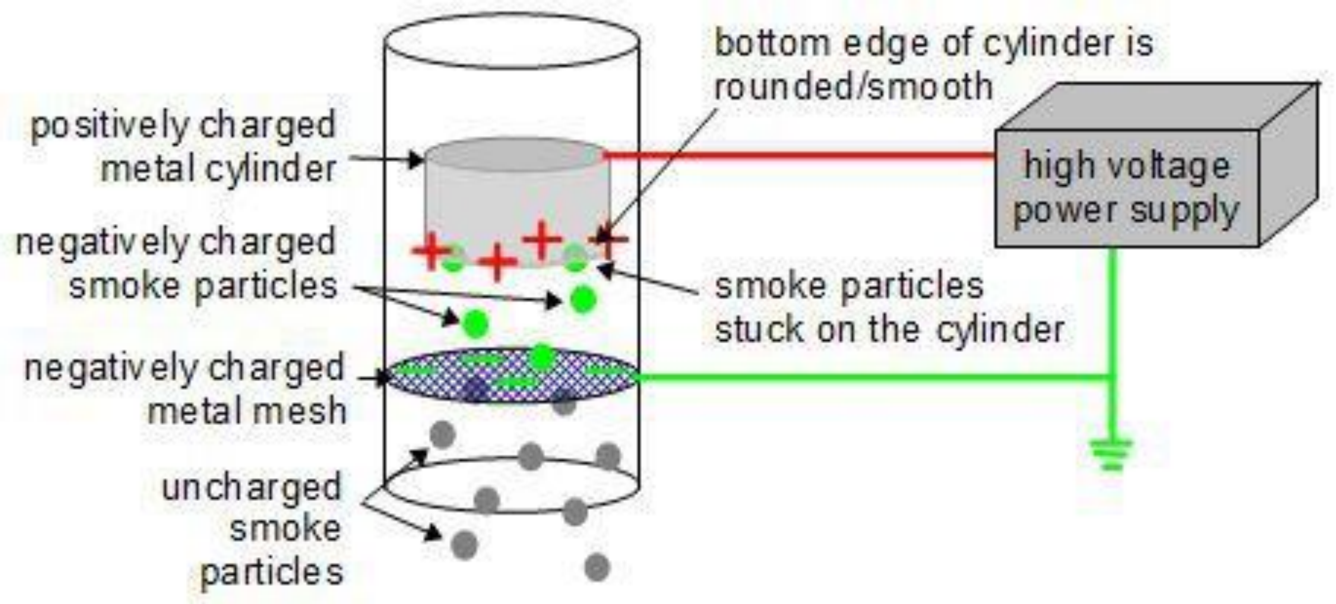
S Describe and explain a situation when electric charge might be dangerous.



LO - GCSE Physics Revision

S Describe and explain a situation when electric charge might be useful.





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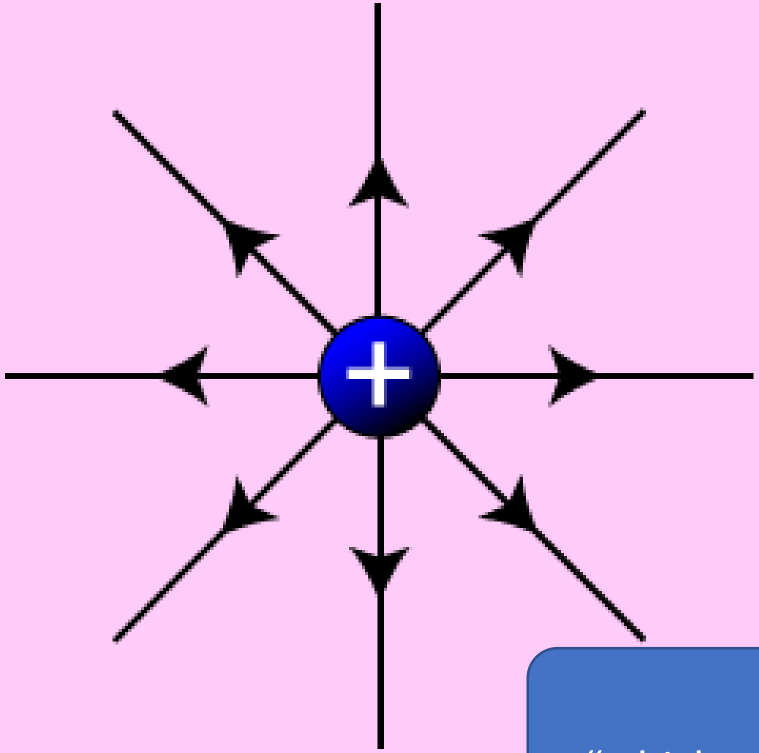
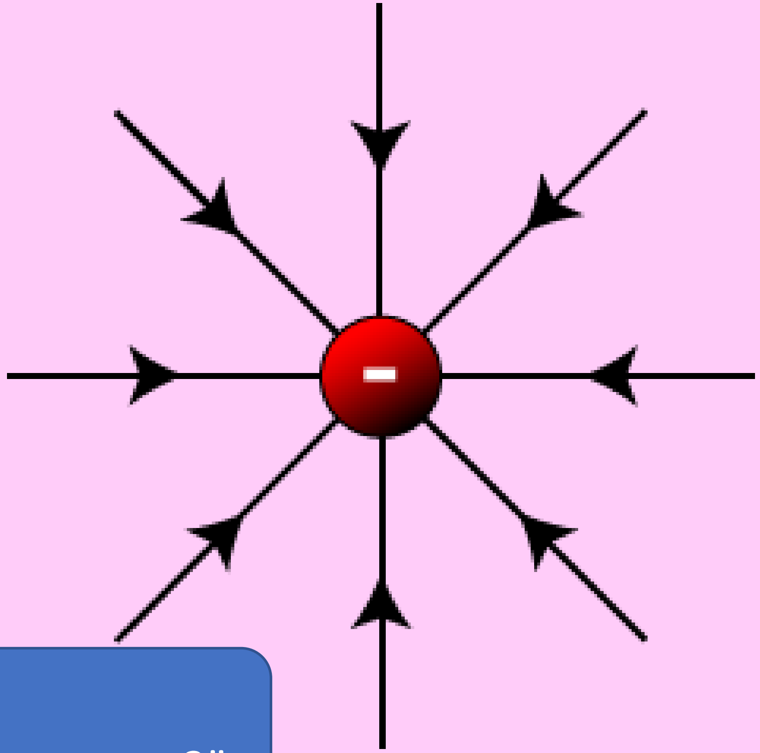
S Electric field

the area around a charge where the force can be felt is the force field.

Around a positive charge



Around a negative charge

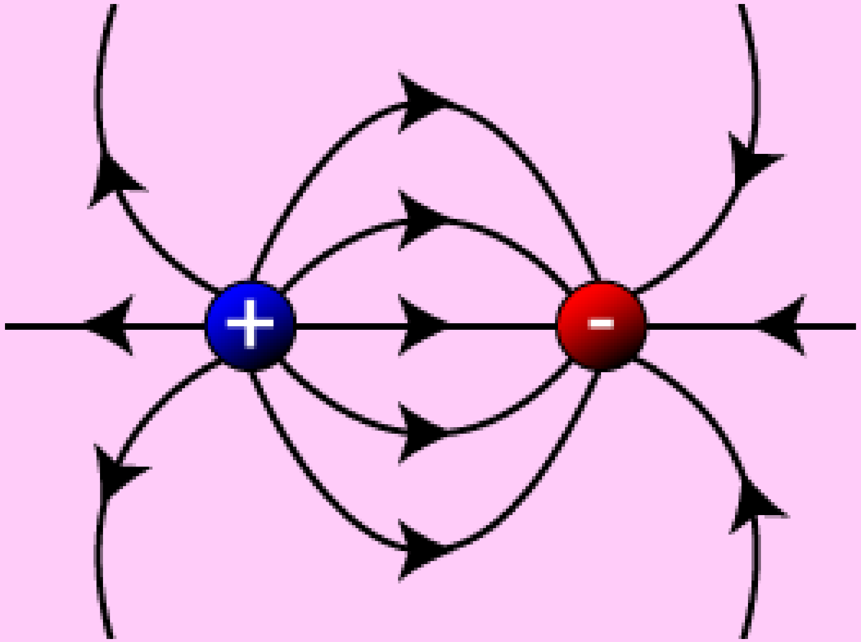


STRONG
If lines are close together

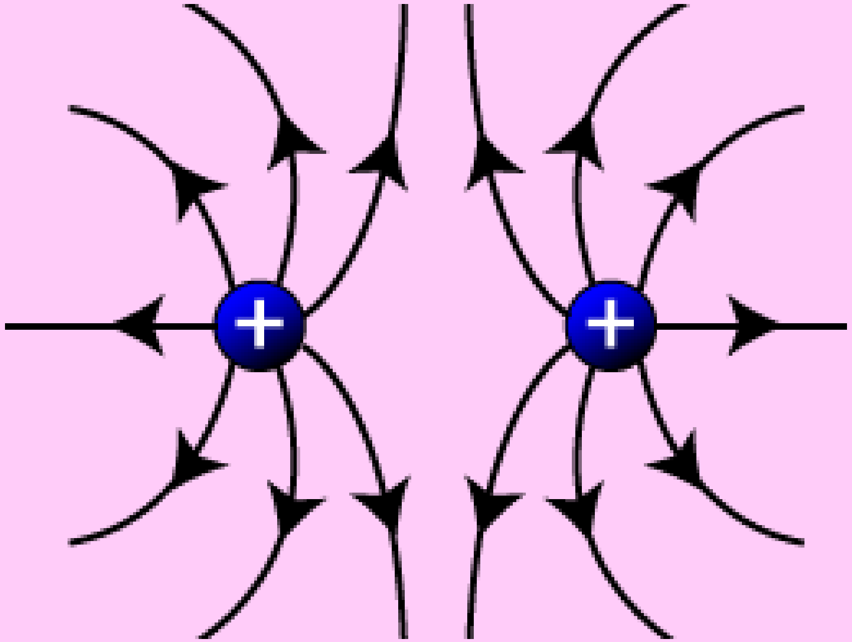
Ask yourself:
“which way will a positive proton move?”

S Electric field between particles

Attraction
or attracting



Repulsion
or repelling



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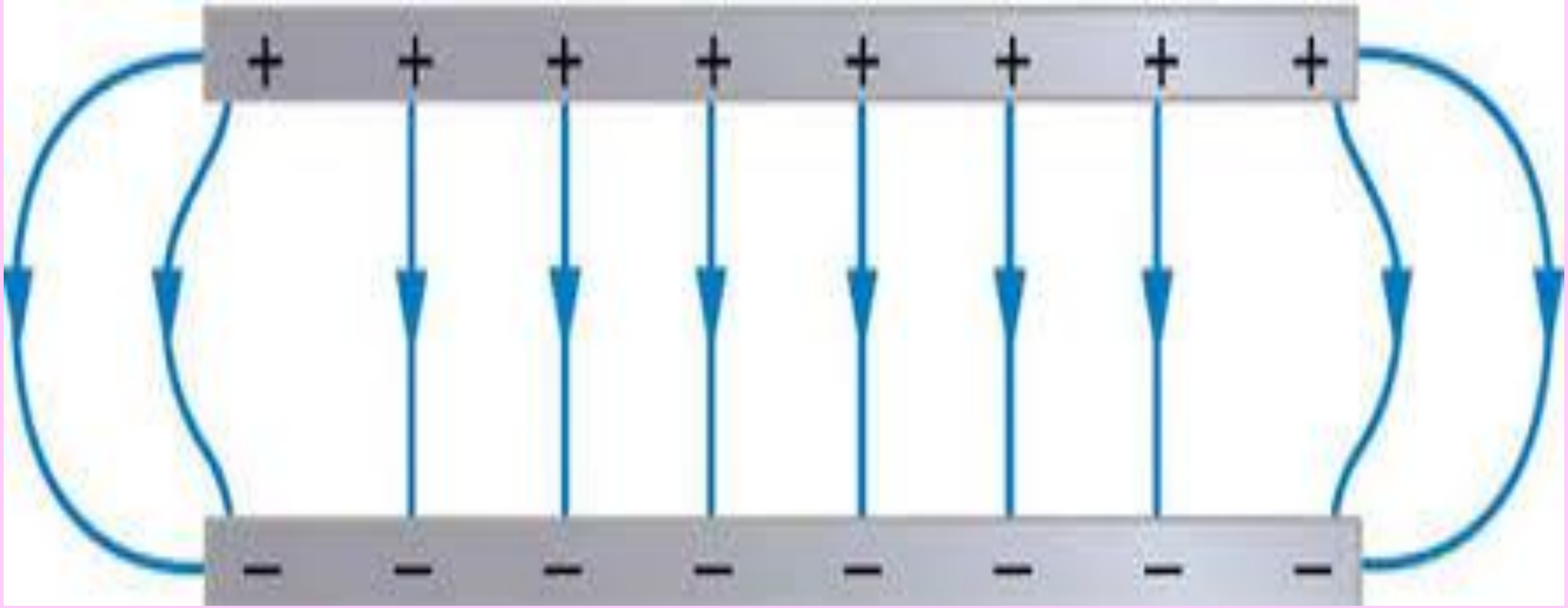
S Electric field between parallel plates



SP12/CP10
Magnets and magnetic materials

The one about magnets and stuff.

There is a bit of Higher work about motors too.

Match up the key words and definitions

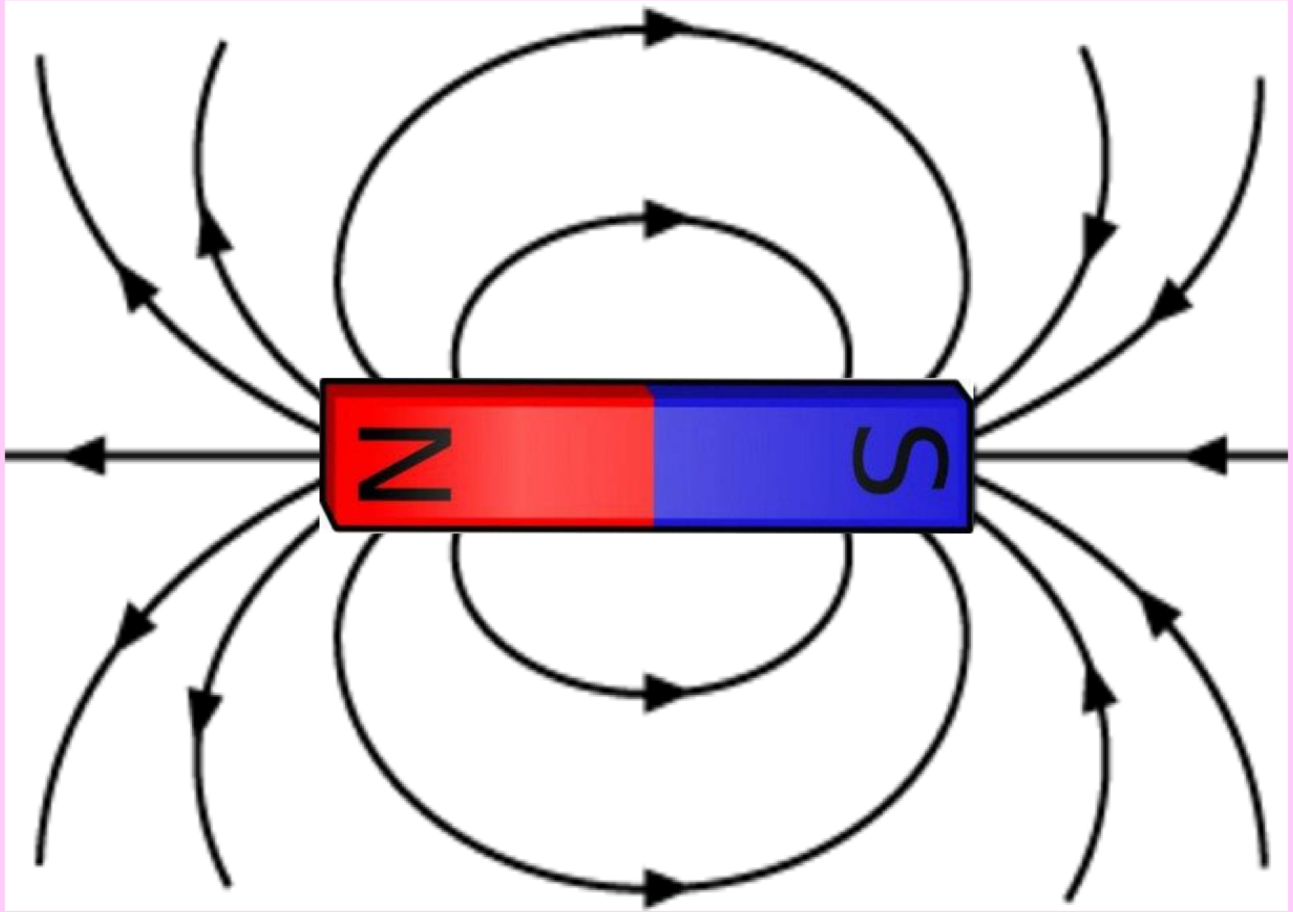
magnet	the area around a magnet where a magnetic force can be felt	when an object has both North and South poles
dipolar	**monopole**	**non-magnetic**
a single North or South pole	**magnetic**	a material that creates a magnetic field
a material that can feel the effect of a magnetic field	a material that can't feel the effect of a magnetic field	**magnetic field**

Match up the key words and definitions

magnet	the area around a magnet where a magnetic force can be felt	when an object has both North and South poles
dipolar	**monopole**	**non-magnetic**
a single North or South pole	**magnetic**	a material that creates a magnetic field
a material that can feel the effect of a magnetic field	a material that can't feel the effect of a magnetic field	**magnetic field**

LO - GCSE Physics Revision

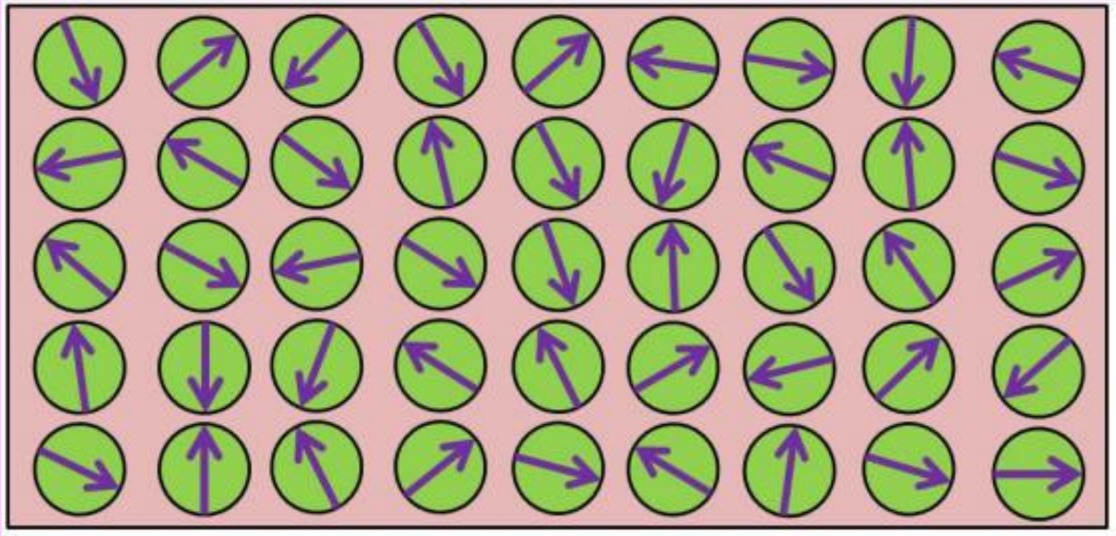
Use iron filings in a petri dish to show the magnetic field around a bar magnet:



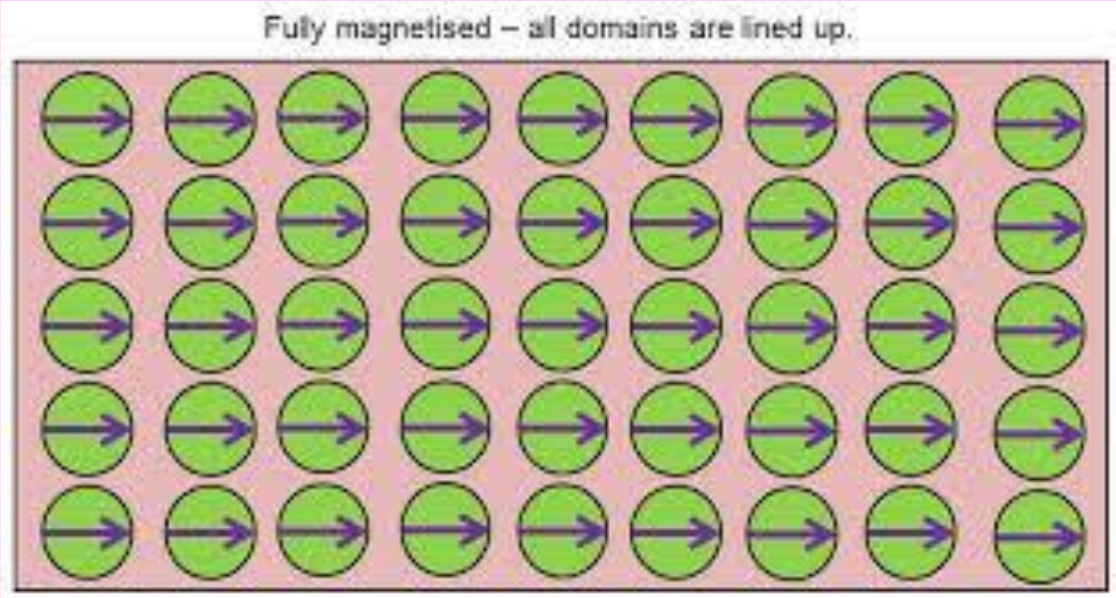
Where is the magnetic field the strongest?

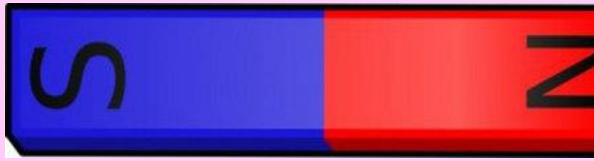
How do you know?

How is a piece of magnetic material magnetized?



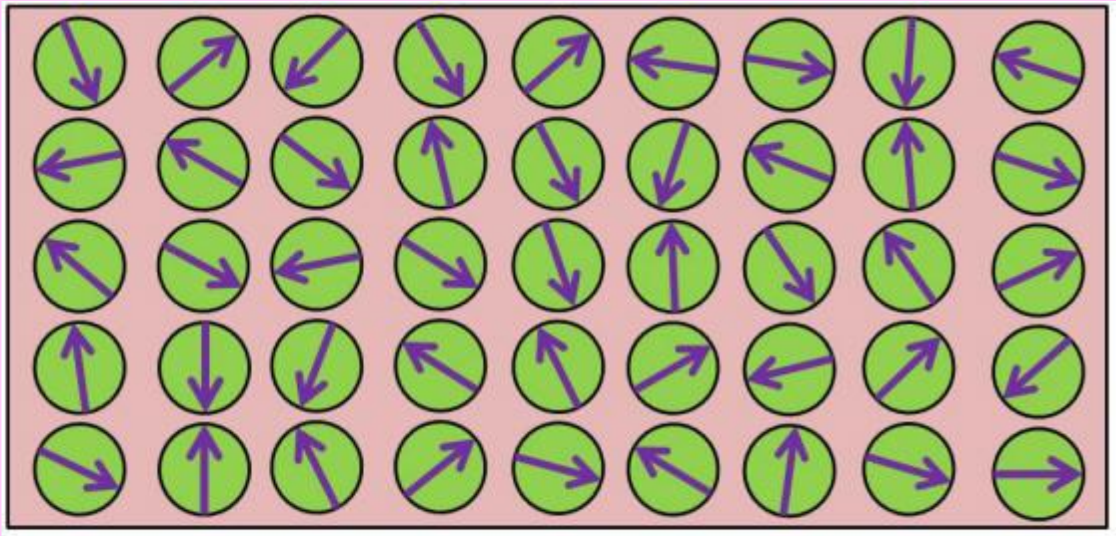
How is a piece of magnetic material magnetized?





This is induced magnetism

How is a piece of magnetic material magnetized?

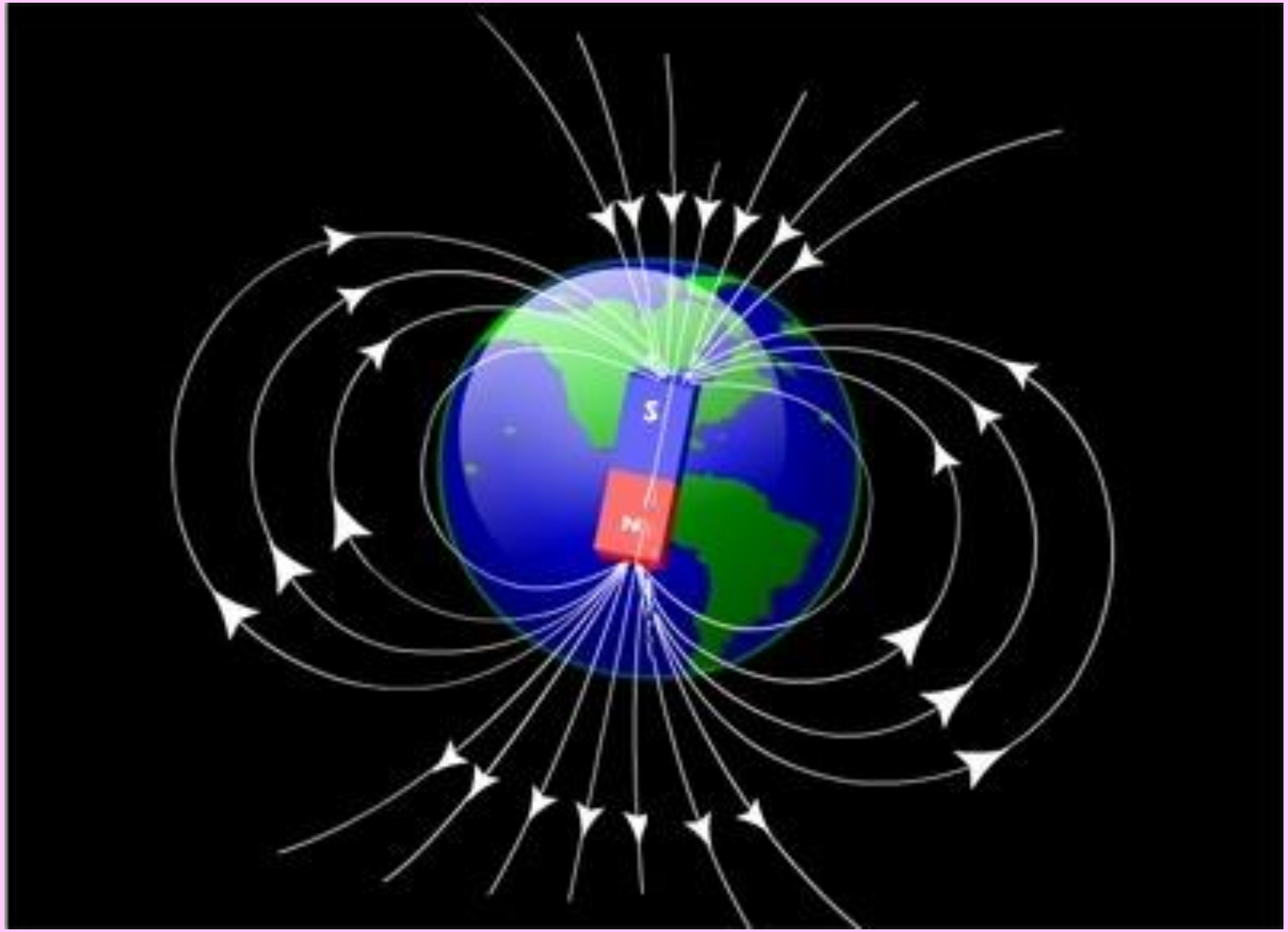


It is lost if the magnet is removed or the metal is heated or hit with a hammer!

What is the Earth's magnetic field?

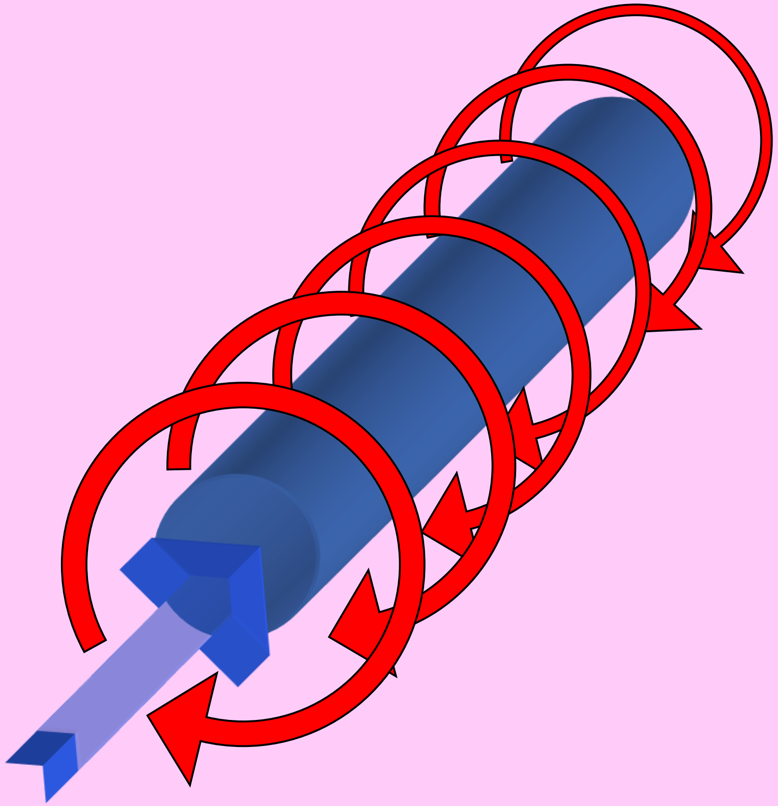
Where is the magnetic field the strongest?

How do we know there is a magnetic South Pole at what is called North Pole?



Remember electromagnetism?

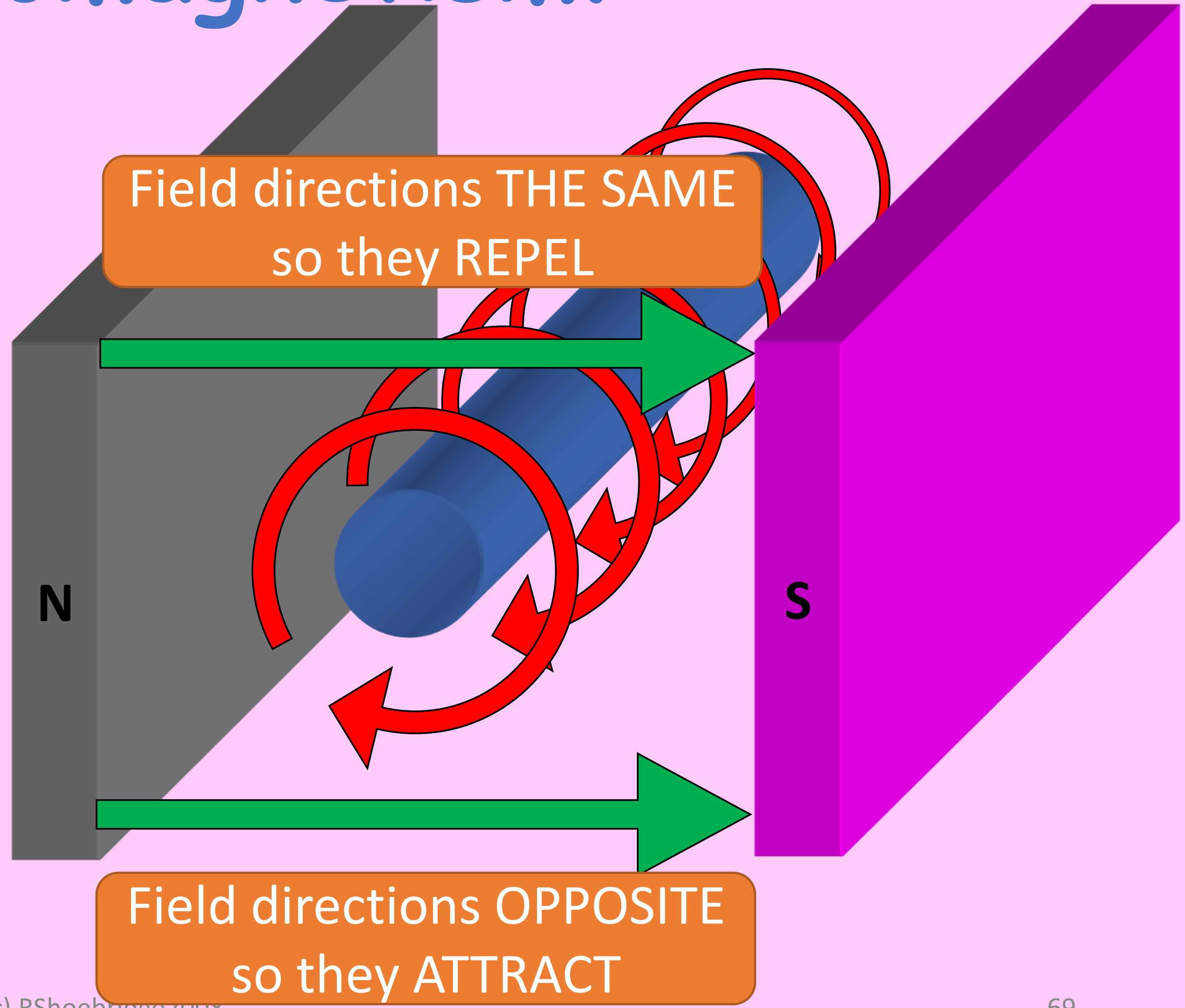
- When an electric current passes through a wire it creates a magnetic field
- This is called an induced magnetic field



Remember electromagnetism?

The Motor Effect

- What will happen?
- Wire gets pushed down



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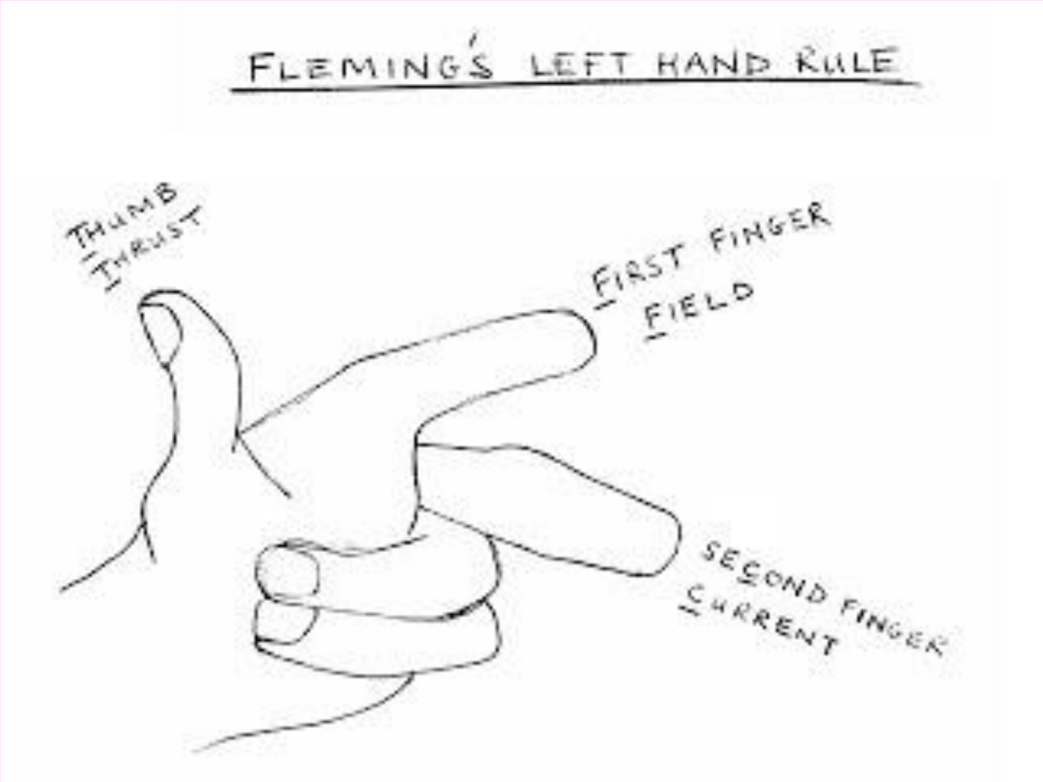
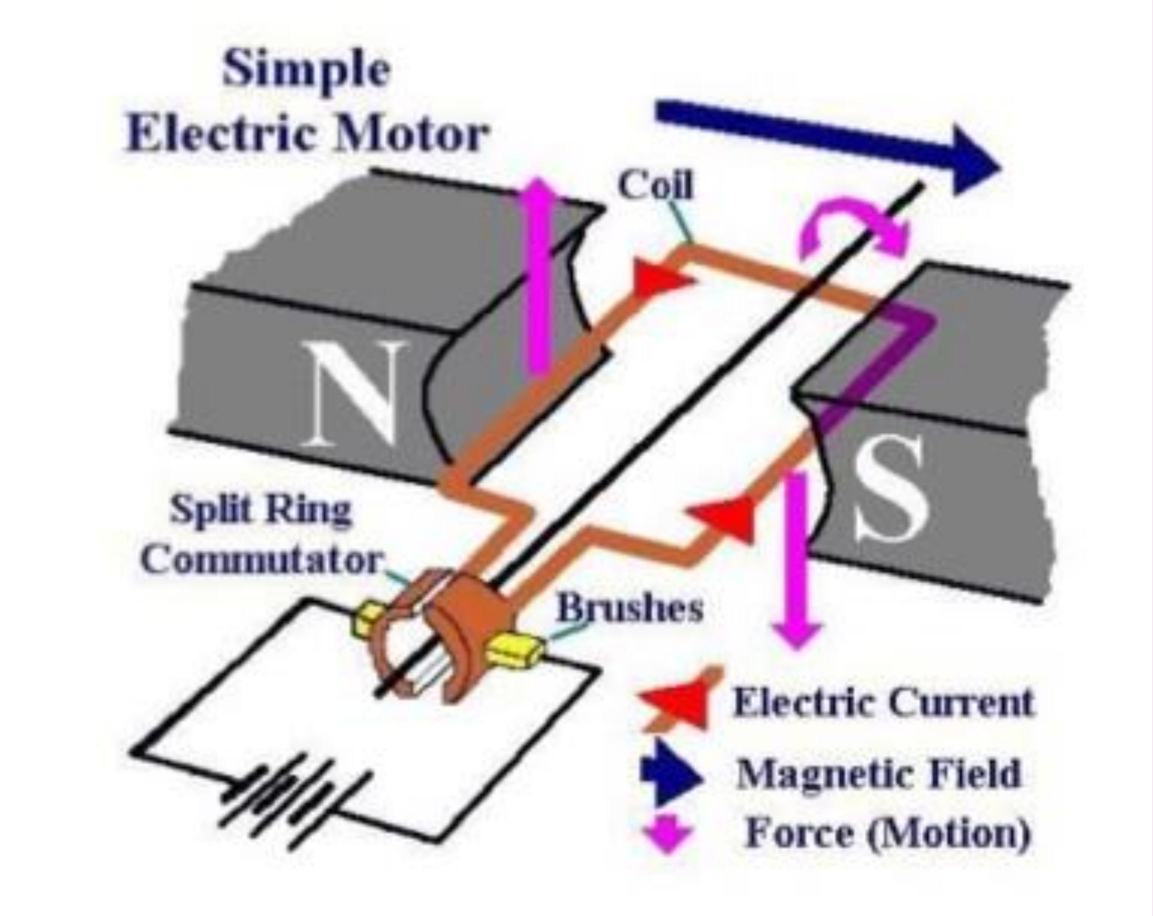
H Fleming's Left Hand Rule





H How to calculate the force on a wire carrying current while its in a magnetic field

- This is an equation on the paper:

$$F = B \times I \times L$$

Where:

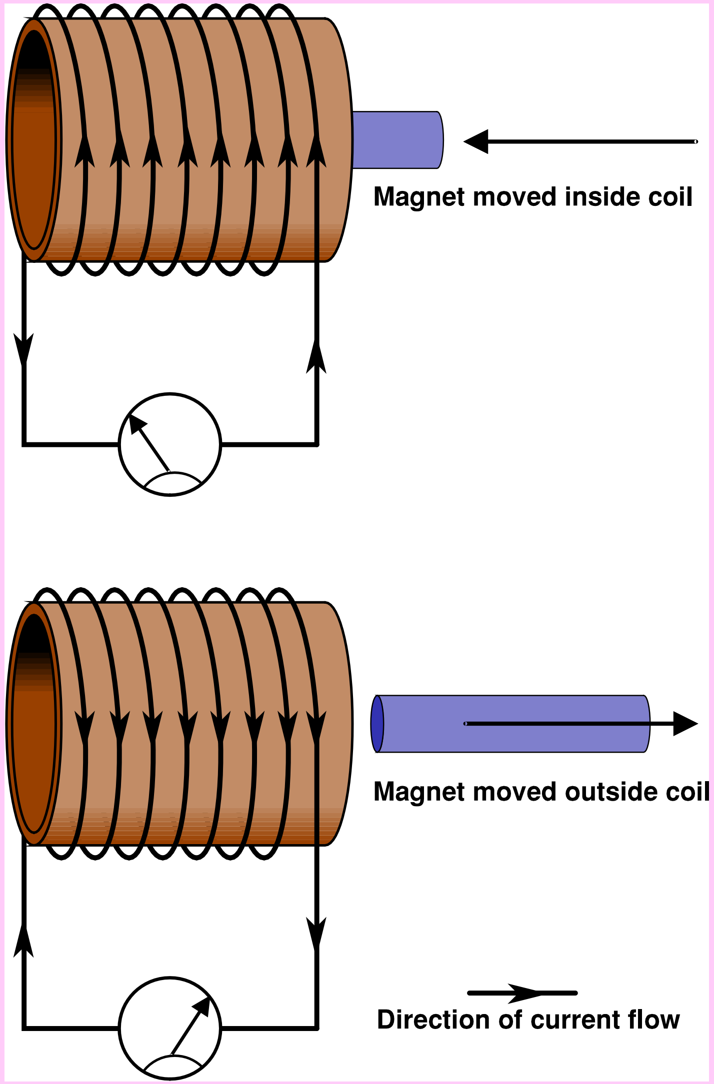
B = the magnetic field strength in Tesla
I = the current in the wire in Amps
L = the length of the wire in metres

SP13/CP11 Electromagnetic induction

The one about generating electricity and transformers

mainly for Higher level students with some extra bits for Separate science but be warned – some of it might come up on Foundation!

The induction coil generator



A coil of wire is attached to an **ammeter** that **measures electric current in Amps (A).**

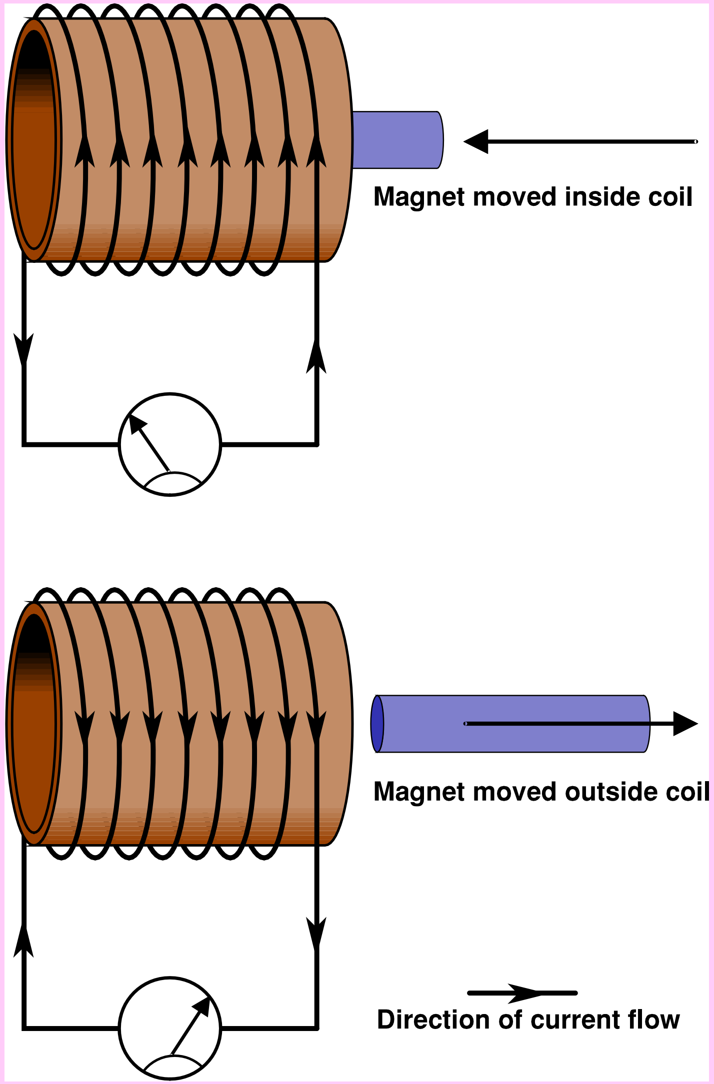
When a magnet is pushed into the coil the ammeter shows a current (anti-clockwise).

When the magnet is pulled out of the coil the ammeter shows a current (clockwise).

An electric current is a flow of electrons or charge.

This is called an **Induction Coil.**

The induction coil generator



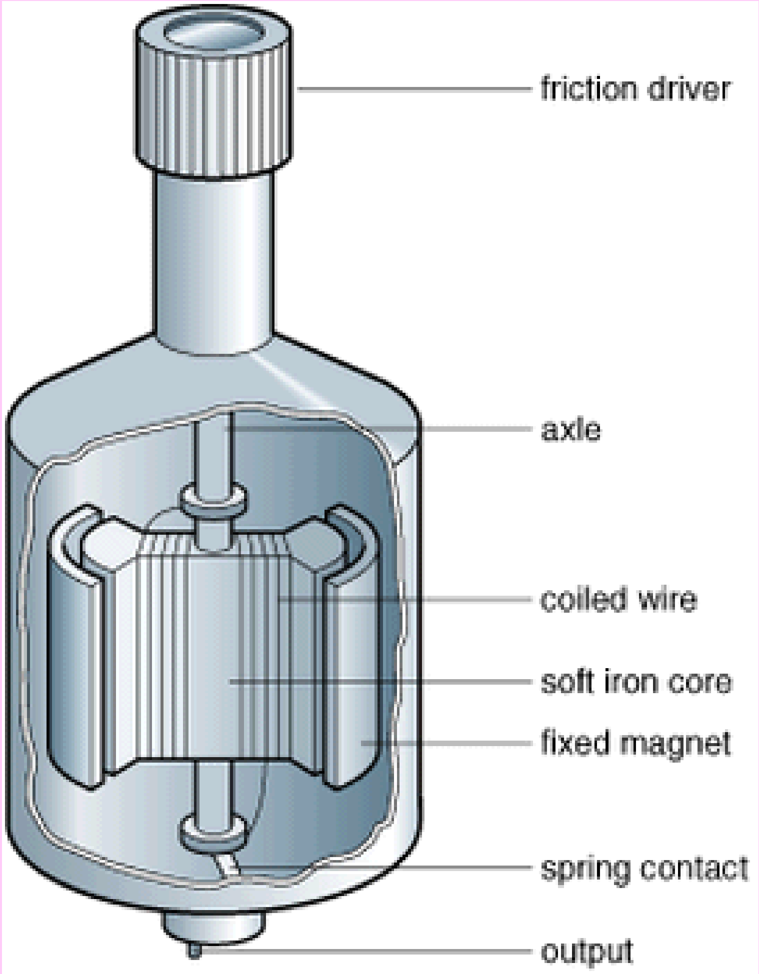
The induced electric current changes direction if:

- The magnet is pulled out
- The other end of the magnet is pushed in

The induced electric current is bigger if:

- More coils are used
- The magnet is stronger
- The magnet is moved faster

The generator (dynamo)

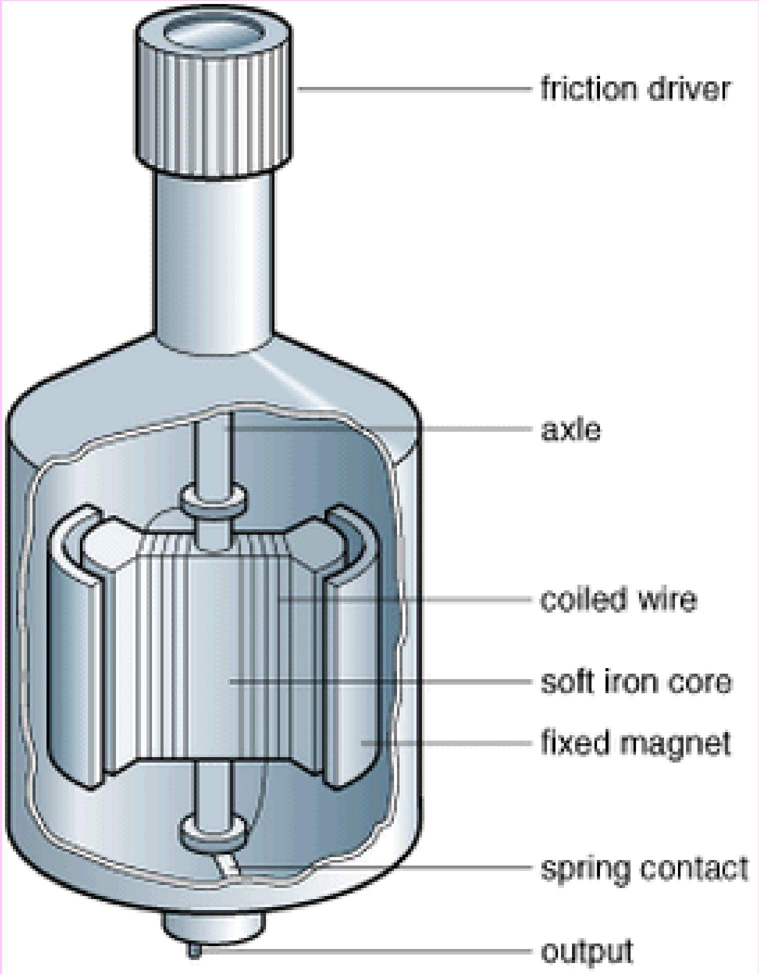


The generator spins a coil inside a magnet.

As the coil rotates past the magnet it induces an electric current that goes backwards and forwards in the wire.

This is alternating current.

The generator (dynamo)



To increase the size of the alternating current:

- Use more coils
- Use a stronger magnet
- Rotate the coil faster
- Use a larger area coil

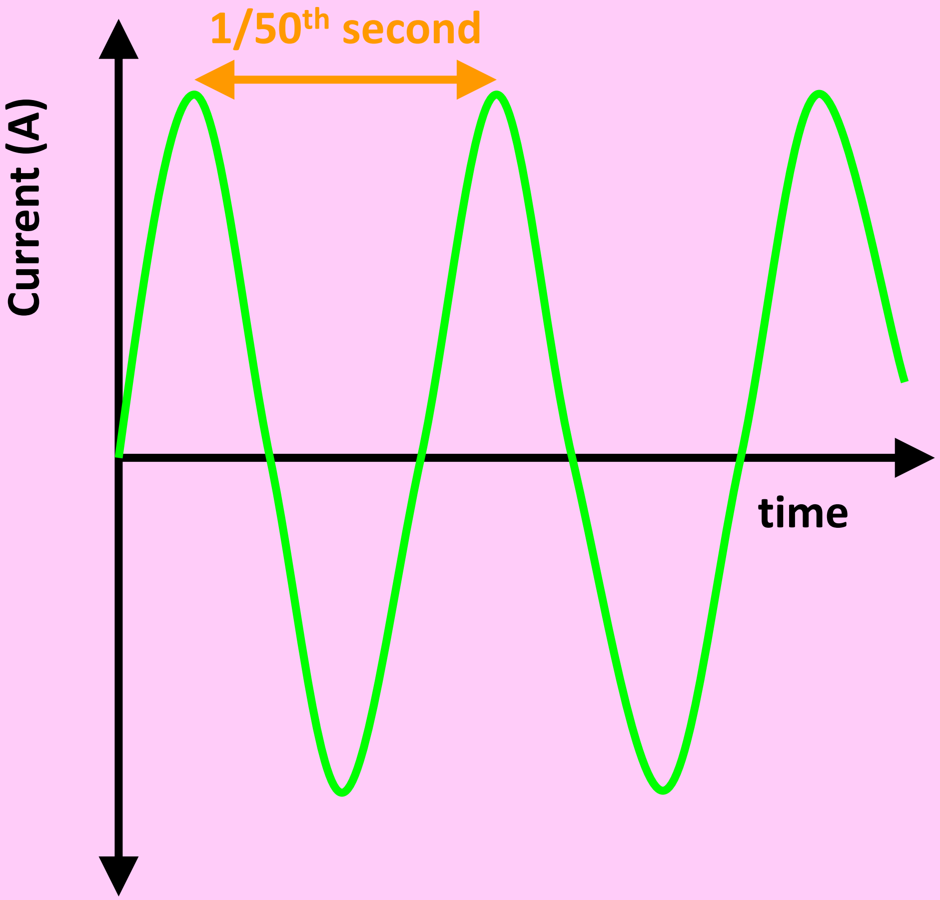
Power stations use very large versions of dynamos that are attached to big fans called turbines.

Alternating current

Generators produce **alternating current** which **changes direction** in the wire.

Mains electricity changes direction fifty times in one second.

This is **50Hz a.c.**



Heating effect of a current

- Power stations produce large currents that can heat up wires
- The power lost in a wire due to heating can be calculated using:
  - $P \propto I^2 \times R$
  - Notice that if the current doubles, the power lost is 4x bigger!
- To stop this happening we need to use the lowest currents possible
- We use transformers to change the size of the current

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Safety with electricity

- compare the current into the circuit with the current out of the circuit
- if they are not equal it switches off
- protects against faults and electrocution
- Unplug everything, switch on RCD, plug back in one-by-one

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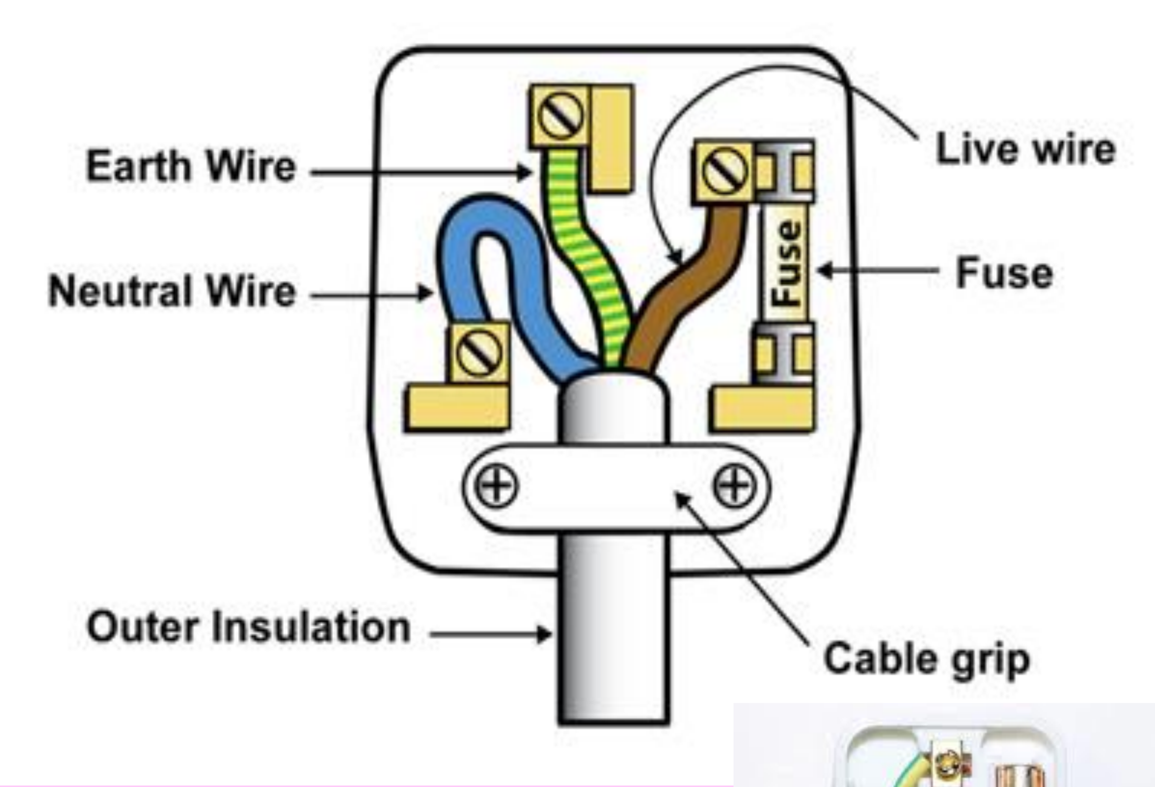
Safety with electricity

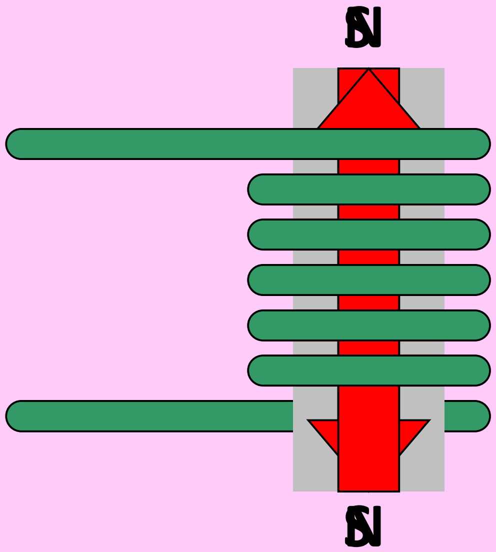


Fuse protects the cable from carrying too much current and catching fire.

A fuse will not protect you from electrocution UNLESS more than the correct amount of current flows through you!

The step-up transformer

The electric current made in power stations is too big to send down cables, it heats them up and loses all its energy. To avoid this we use a step-up transformer…



Take an iron core

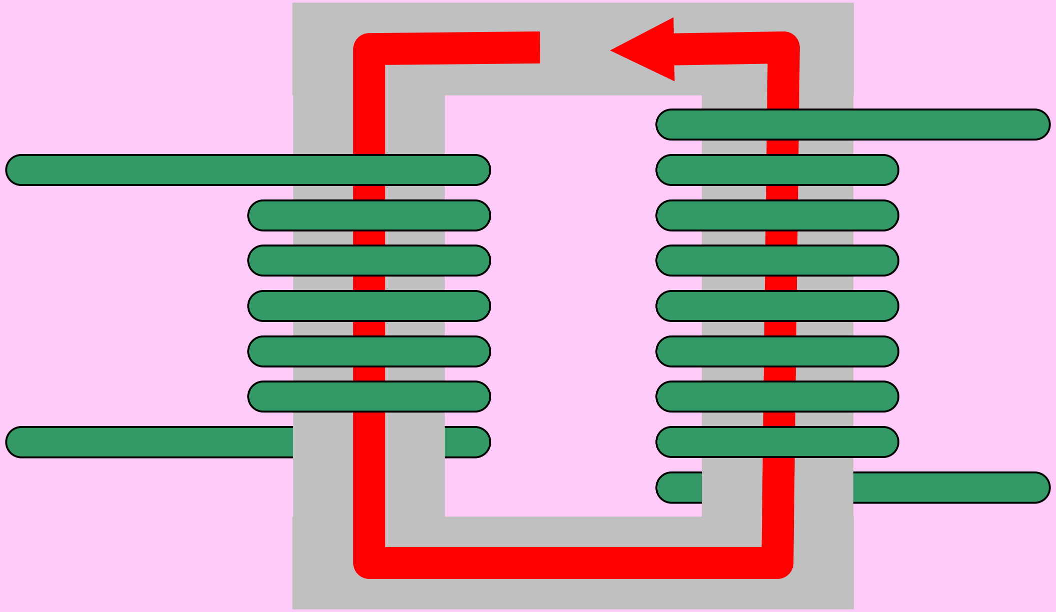
Reverse the current

A magnetic field is induced

The magnetic field direction reverses

The step-up transformer

The electric current made in power stations is too big to send down cables, it heats them up and loses all its energy. To avoid this we use a step-up transformer…



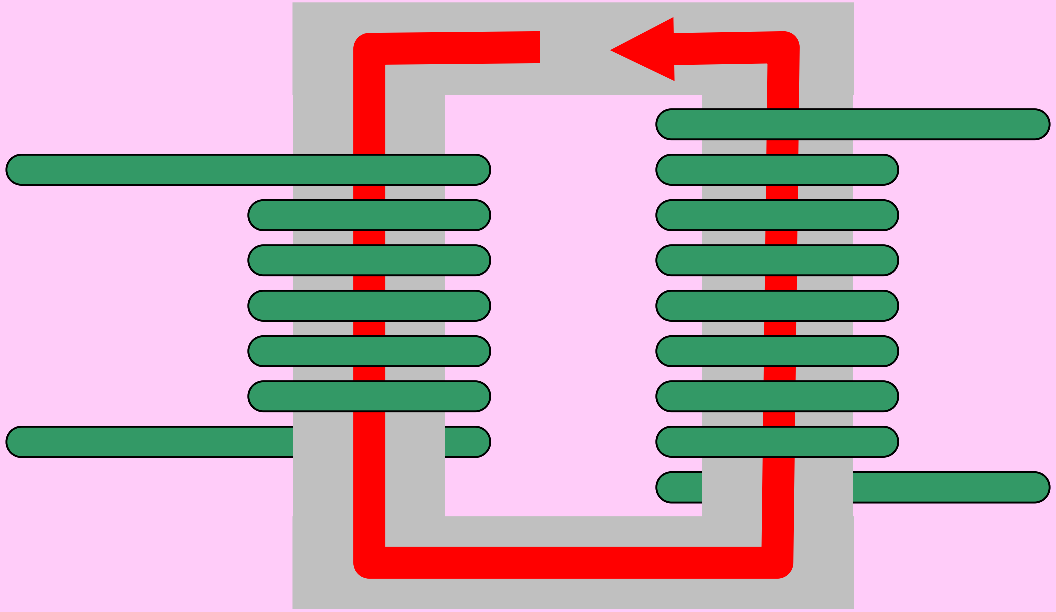
Extend the core

Add a second coil

The induced magnetic field links both coils

The step-up transformer

The electric current made in power stations is too big to send down cables, it heats them up and loses all its energy. To avoid this we use a step-up transformer…



More coils means more voltage

240V on 6 coils steps up to 320V on 8 coils

1A on 6 coils steps down to 0.75A on 8 coils

The voltage increases

The current decreases and this stops it heating the wire

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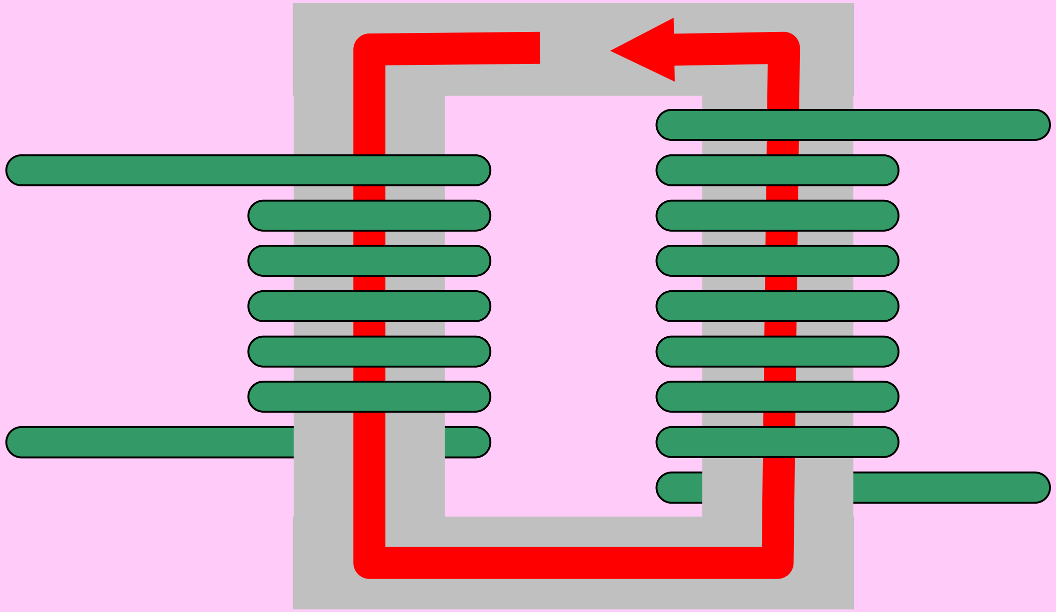
S Transformer calculations

The number of coils on the transformer effects the voltage.

6 coils → 9 coils is x1.5
So 240 Volts x1.5 → 360 Volts

But to conserve energy this means…
3 Amps ÷ 1.5 → 2 Amps

This is so that V x I always gives the same answer…
240 x 3 = 720 = 360 x 2



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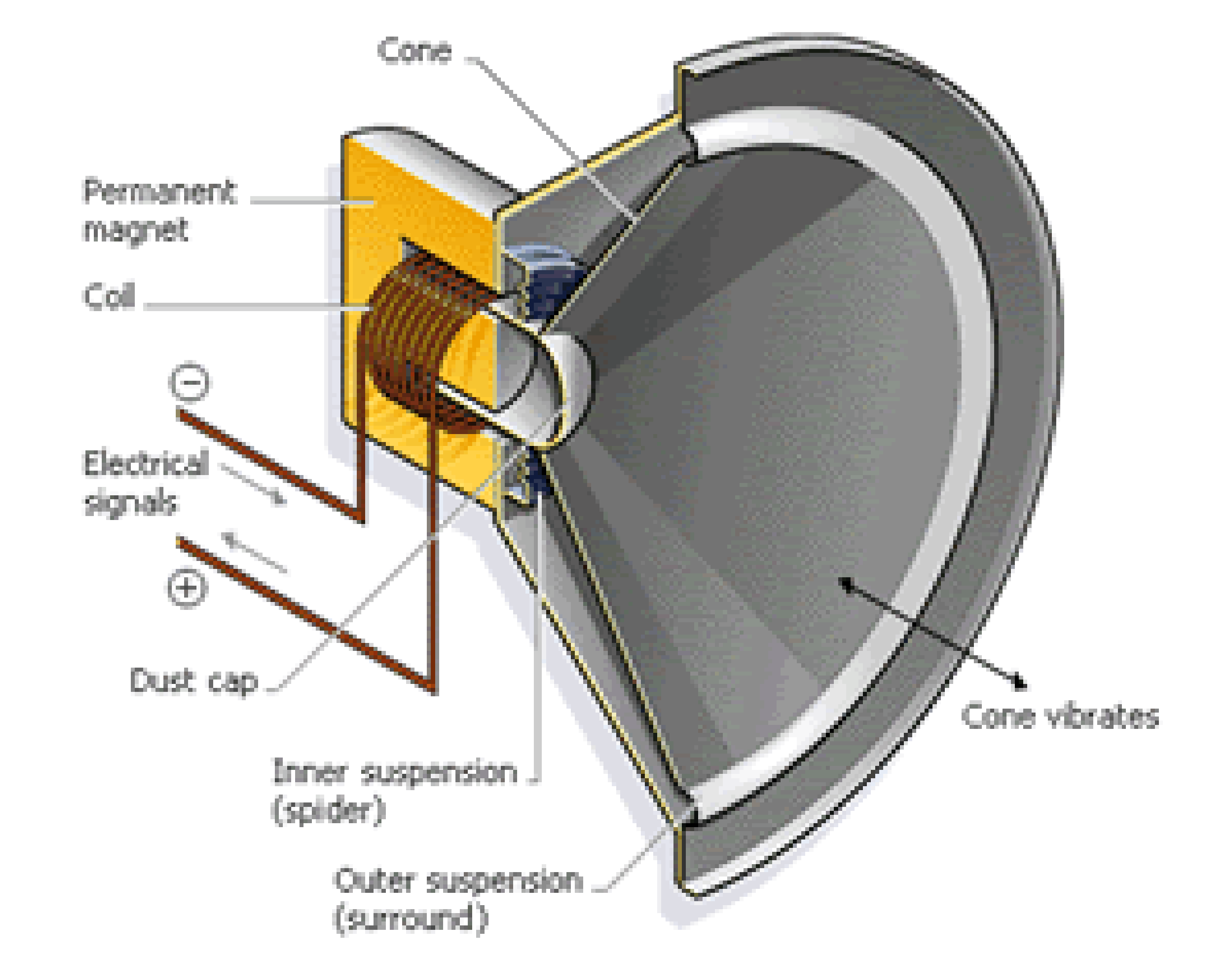
S Loudspeakers and microphones



Microphone

Alternating current in coil induces

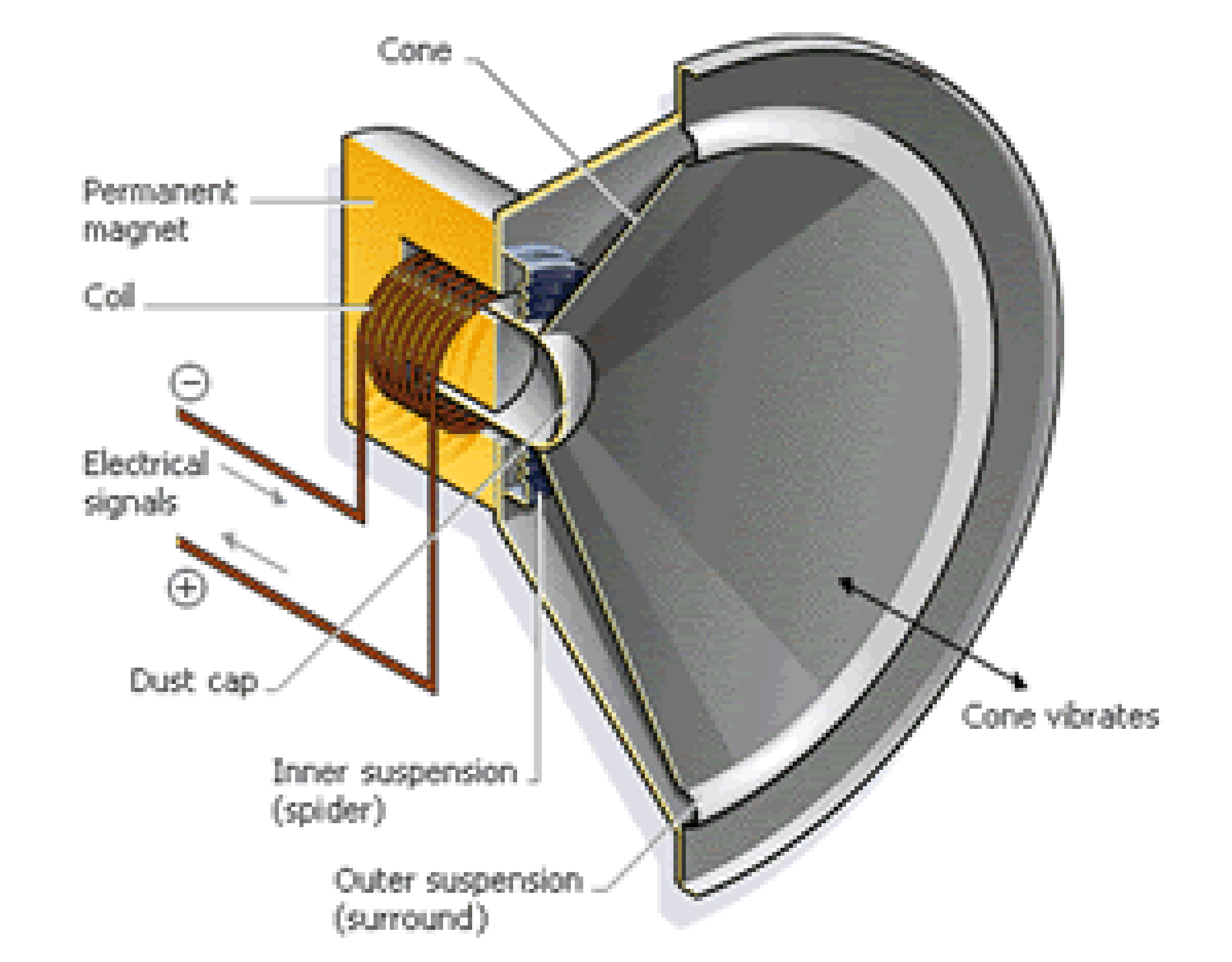
Alternating magnetic field in coil

Motor effect causes coil to move past magnet

Paper cone moves

Sound vibrations made

S Loudspeakers and microphones



Loudspeaker

Sound **vibrations** made

Paper cone **moves**

Dynamo effect caused by coil moving past magnet

Alternating magnetic field in coil

induces

Alternating current in coil

SP14/CP12
The particle theory

The one about solids, liquids and gases

With some extra equations for the Separate scientists

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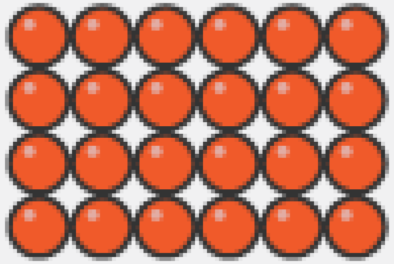
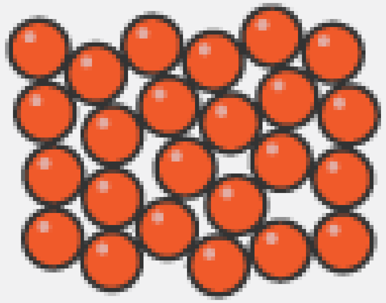
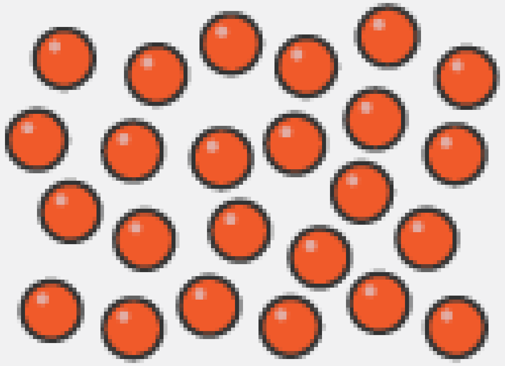
State	Solid	Liquid	Gas
Diagram			
Arrangement of particles			
Movement of particles			
Closeness of particles			

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<u>Interconversions</u> - the names for how they change state from to another

Start from:	Change to:	Name
solid	liquid	
liquid	solid	
liquid	gas	
gas	liquid	
solid	gas (skipping liquid phase)	
gas	solid (skipping liquid phase)	

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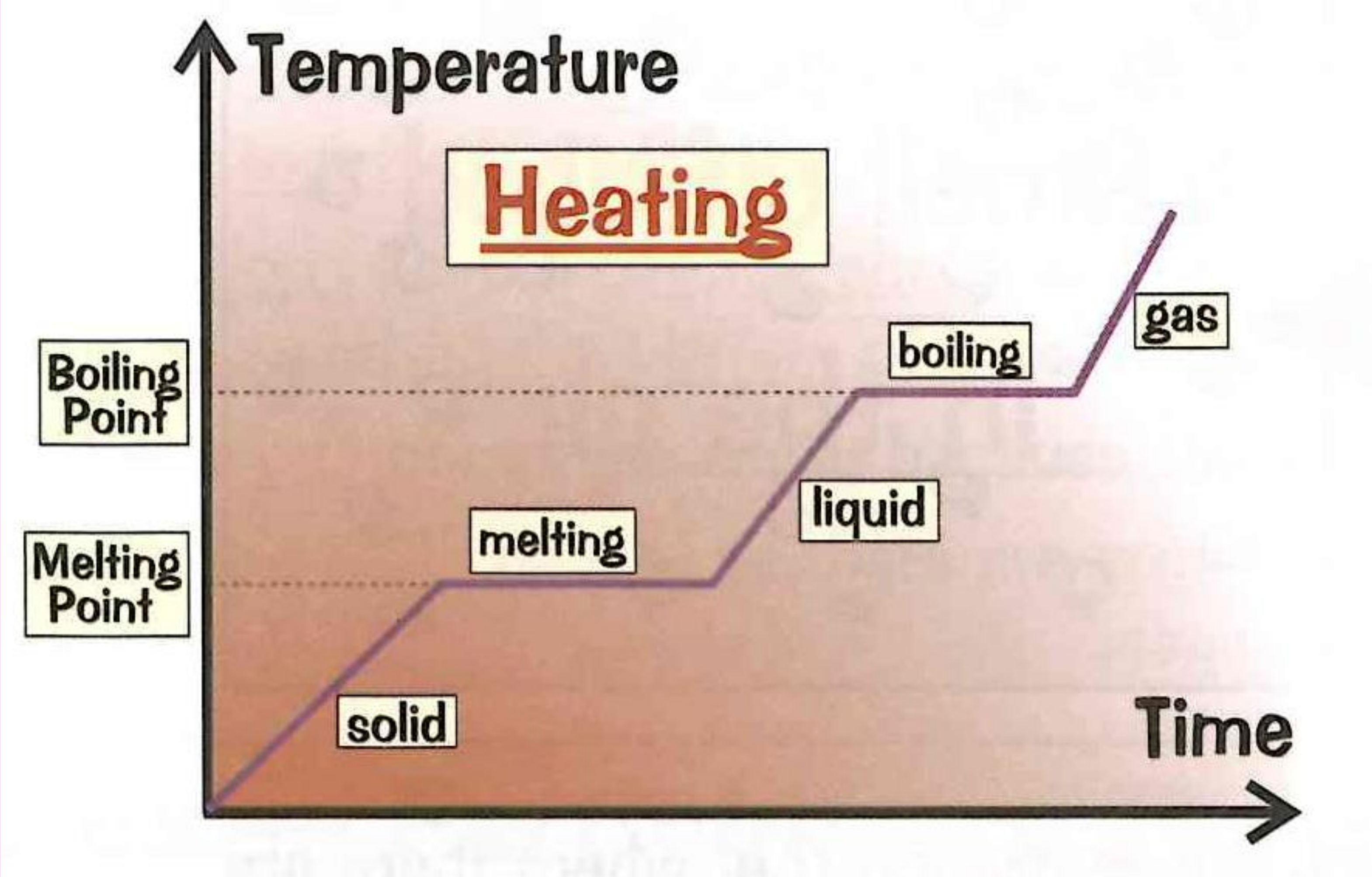
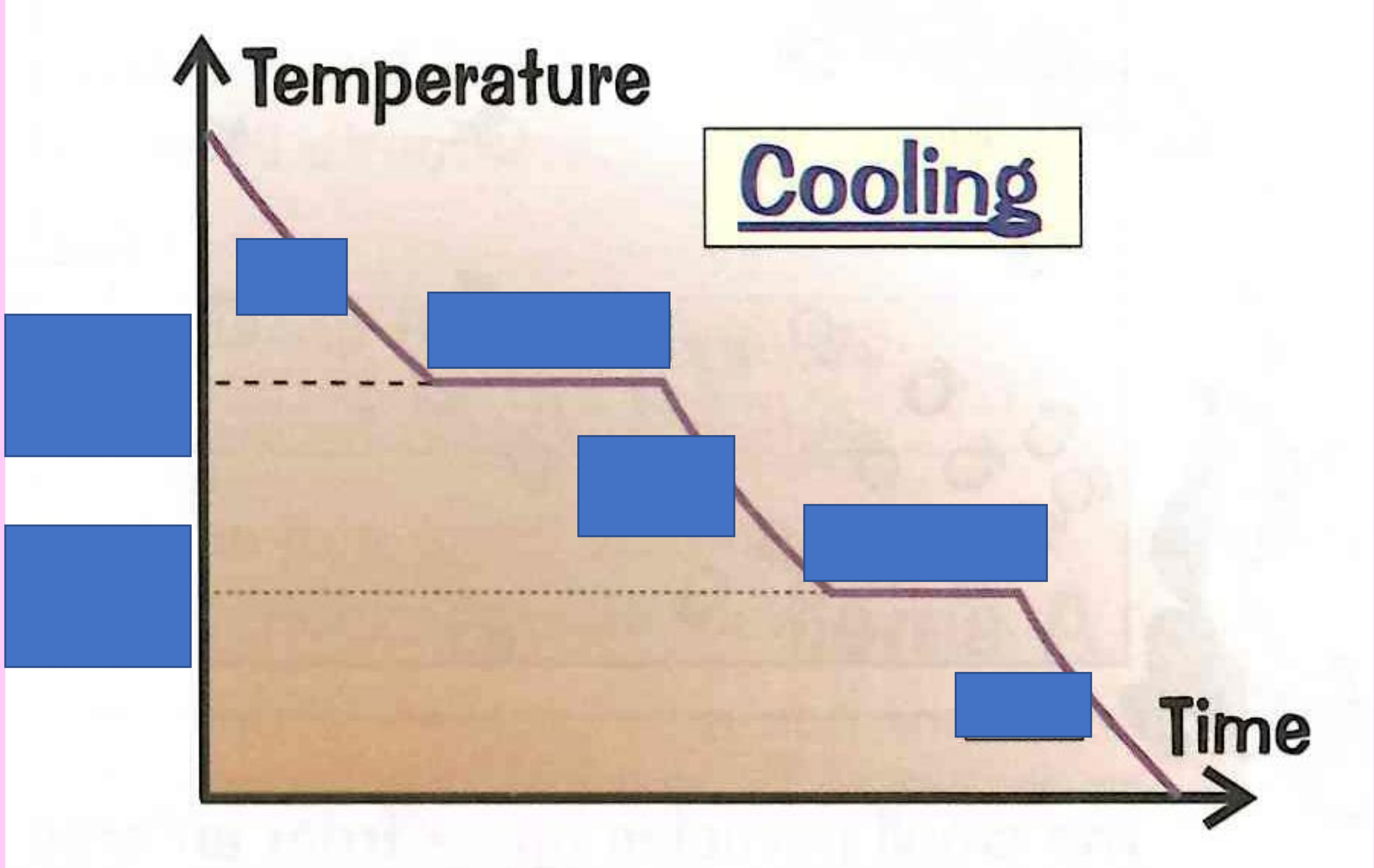
Heating/Cooling Curves



Heating/Cooling Curves



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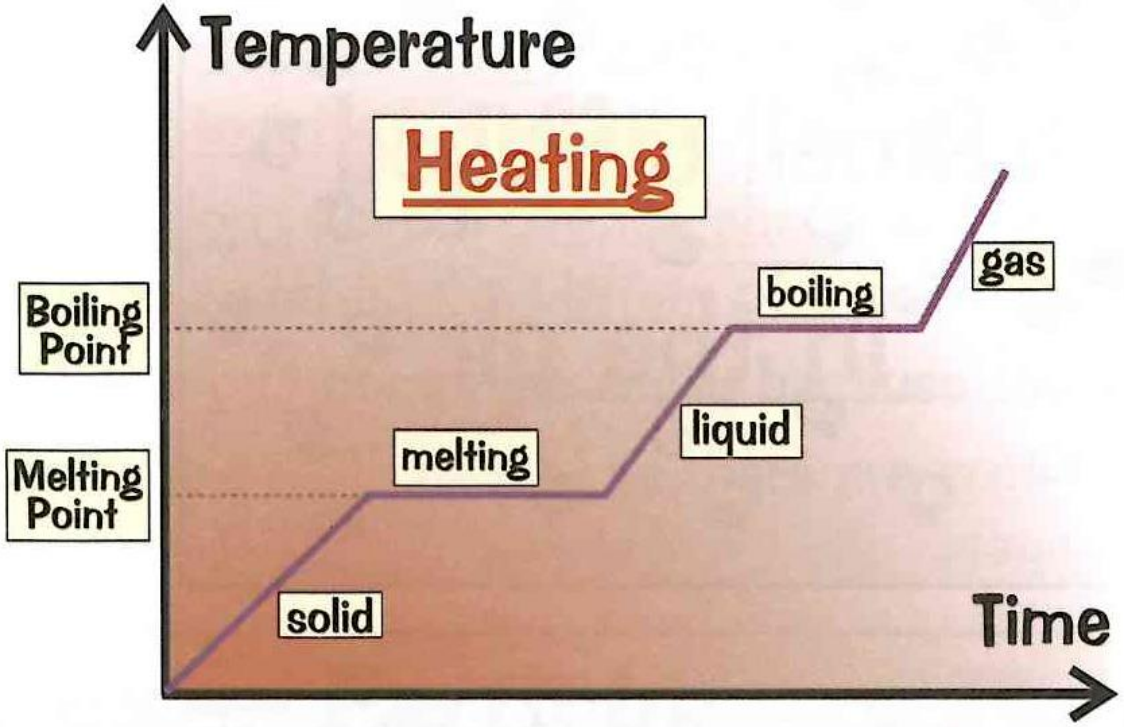

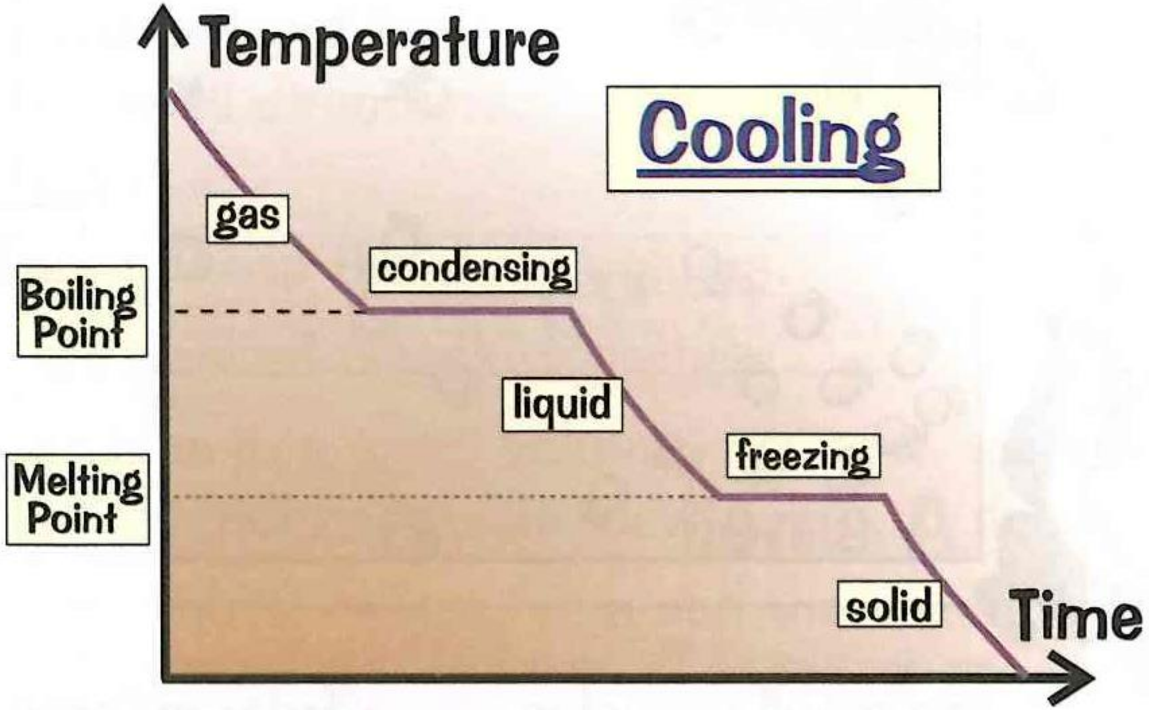

Explain what the flat lines on the graph mean in terms of energy and particles in matter

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Temperature is a measure of hot hot something is (ºC)

Heat is a measure of the thermal energy contained in an object (J)

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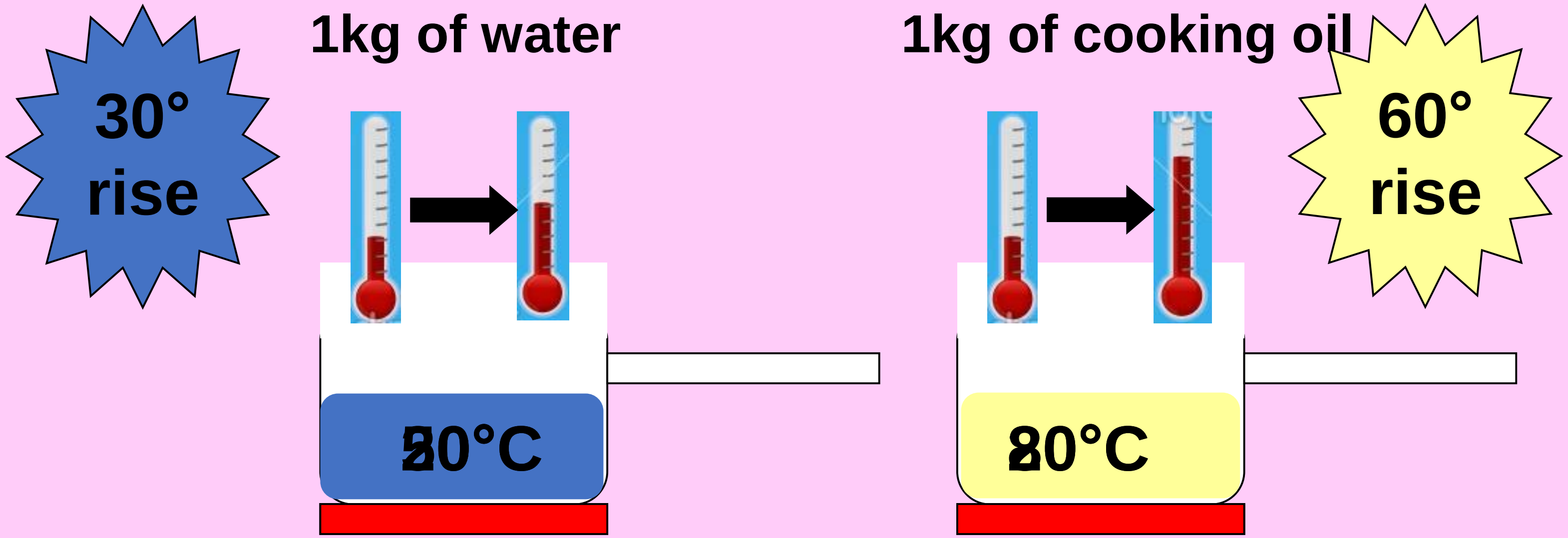

....heating

Identical rings turned on for 1 minute

The water heats up less than the oil.

The SAME AMOUNT OF HEAT produces HALF the TEMPERATURE RISE in the water as in the oil

Specific heat capacity

The Specific Heat Capacity of an object, is the amount of energy needed to change the temperature of 1 kg of the substance by 1°C

Substance	Specific heat capacity in J / kg °C
water	4181
oxygen	918
lead	128

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Calculating Specific heat capacity

$$\Delta Q = m\ c\ \ \Delta\theta$$

Q = energy transferred in Joules (J)

m = mass of substance in kg

c = specific heat capacity in J / kg/^{o}C

θ = (theta) is the temperature change in degrees Celcius (^{o}C)

How much energy must be transferred to raise the temperature of 2kg of water from 20^{o}C to 30^{o}C? [Specific heat capacity of water = 4200J/kg/^{o}C]

Specific Latent Heat

Changing from one state to another requires heat energy. The heat energy is being **used to change state**, rather than raise or lower the temperature of the substance.

The amount of energy required depends on the mass of the substance and the material.

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Specific Latent Heat

The amount of energy required to change the state of 1kg of a substance at its melting point is called the specific latent heat of the substance

$$Q = m L$$

Q = the energy required to change the state

m = is the mass of the substance (kg)

L = the specific latent heat of the substance (obtained from the given data)

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Calculate the energy required to change a mass of 0.65kg of ice at 0^oC into water at 0^oC where $L = 3.34 \times 10^5$ J/kg

$$Q = m\,L$$

$Q = (0.65kg) \times (3.34 \times 10^5\ J/kg)$

$Q = 217100\ J$

Heat energy required to melt 0.65kg water is 217100J

The Gas Laws

Yes, everyone has to know this one!

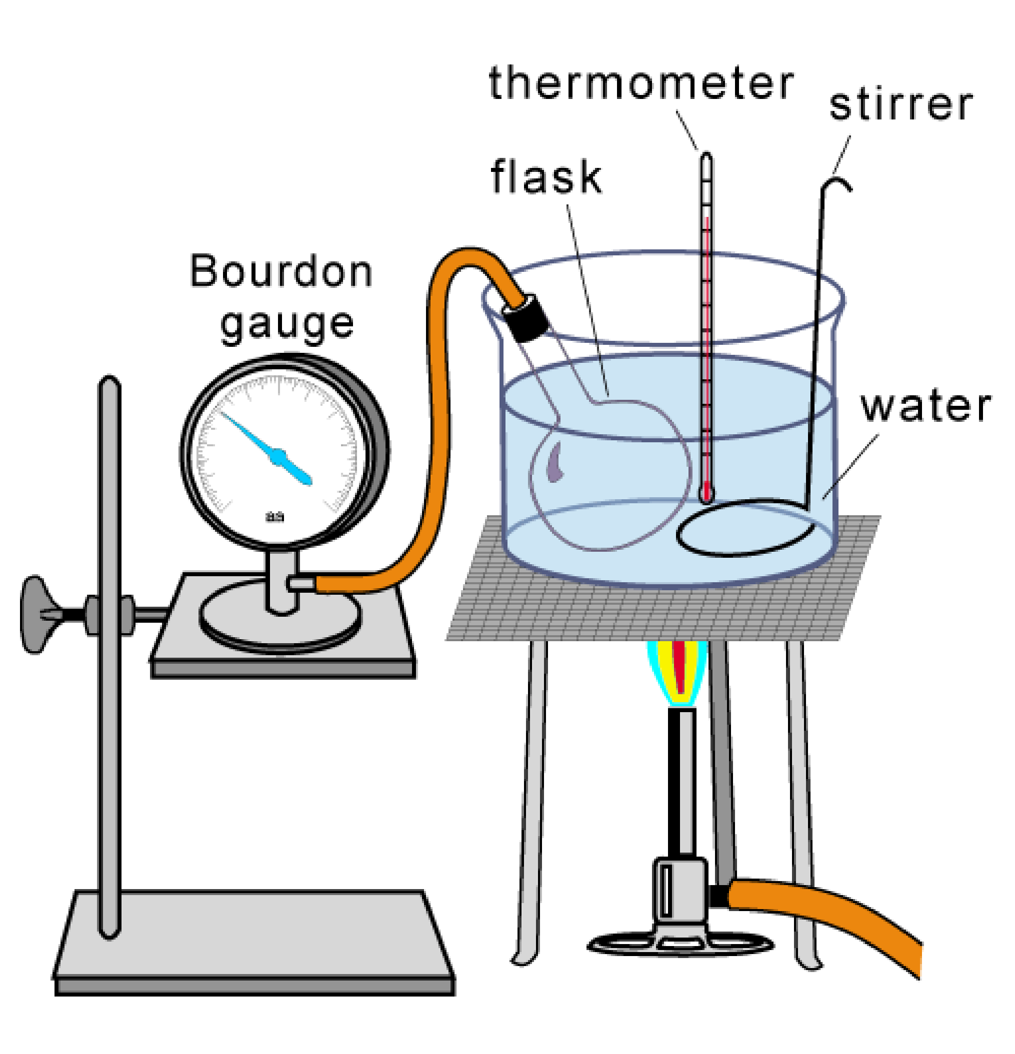
Three Laws that explain the relationship between:

Pressure & temperature of a gas - The Pressure Law

Volume & temperature of a gas - Charles' Law

Pressure & volume of a gas - Boyle's Law

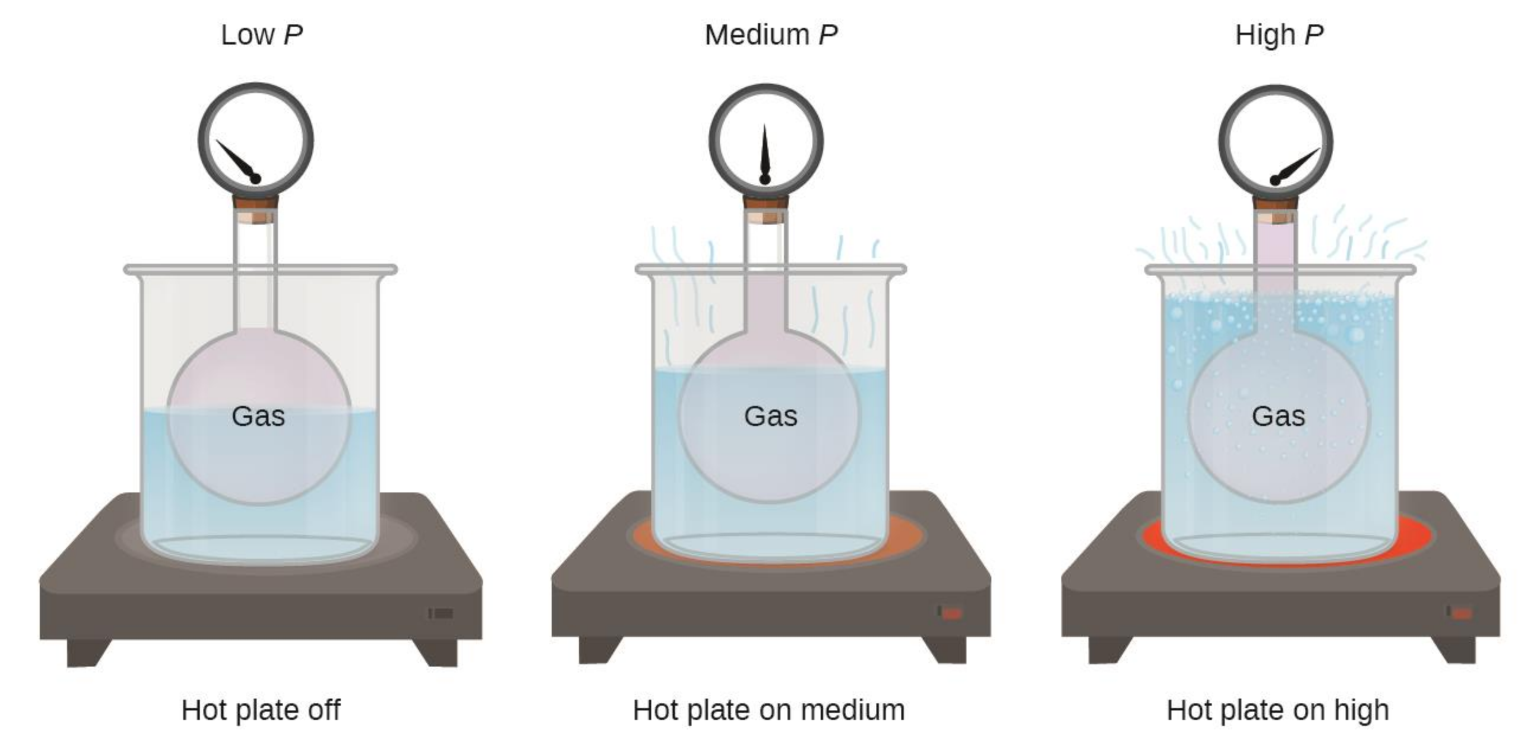
The Pressure Law



This is how the practical is done:

- The hot water bath heats the gas up.
- The thermometer measures the temperature of gas and water.
- The Bourdon gauge measures the pressure of the gas

The Pressure Law

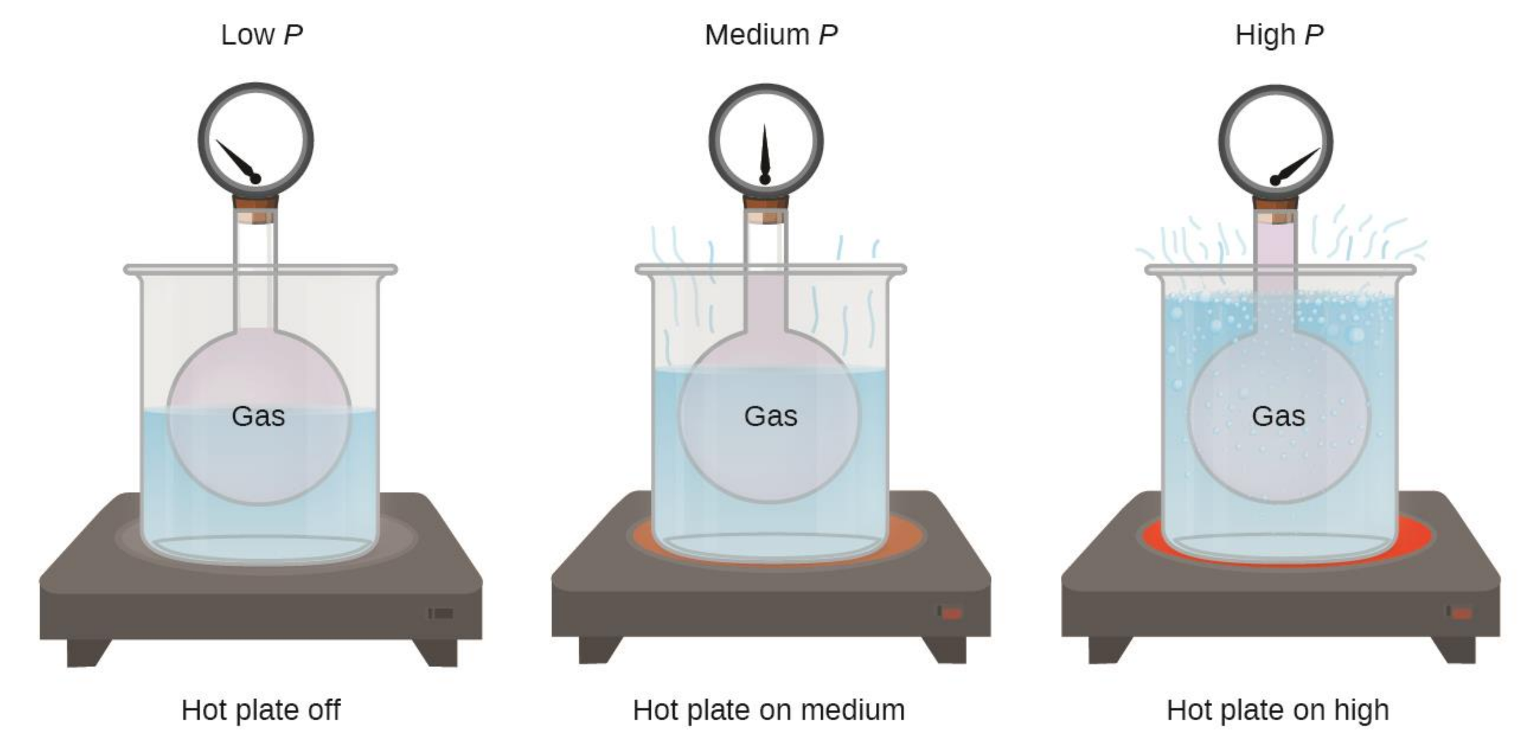


These are the results:

- At high temperature the pressure increases.
- At low temperature the pressure decreases.

Why?

The Pressure Law



Because:

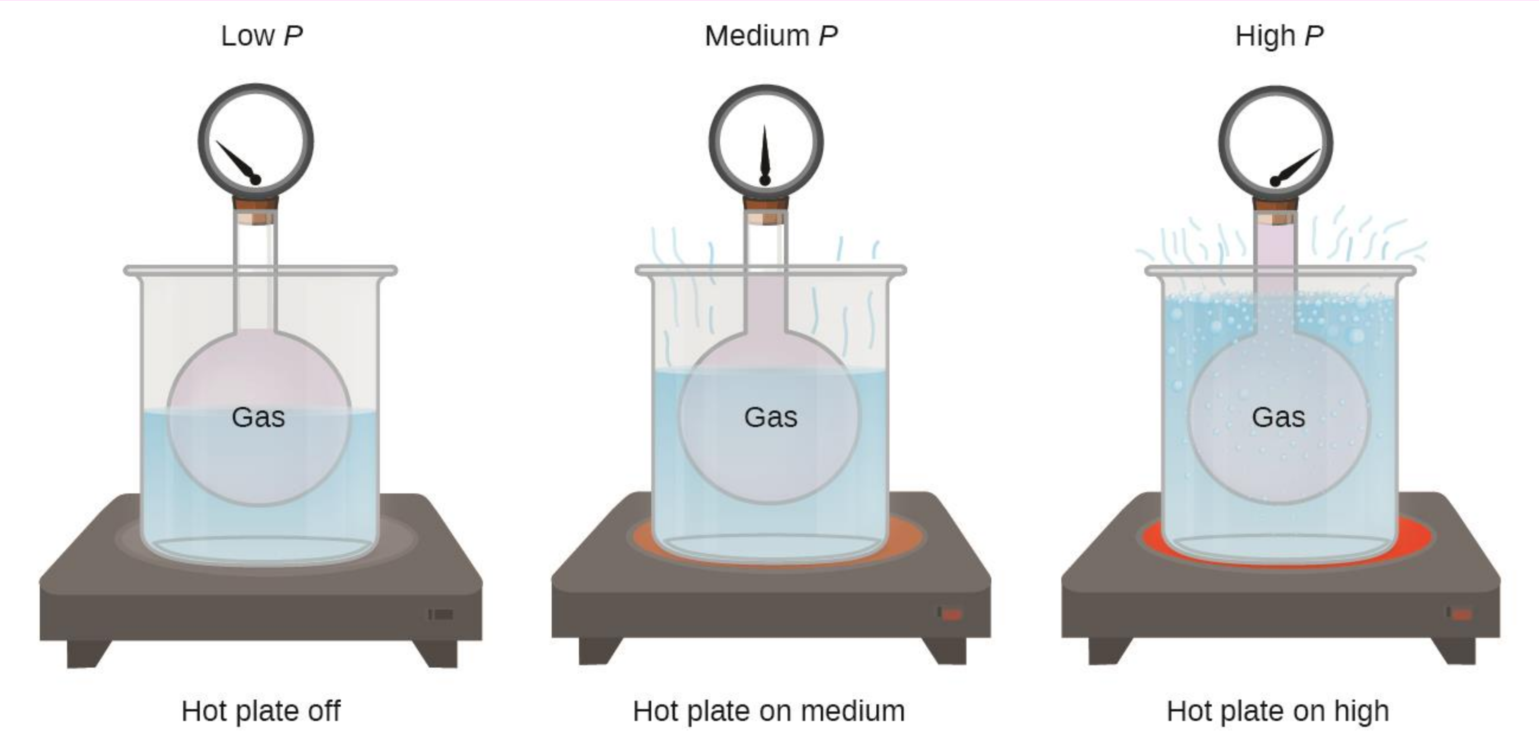
At high temperatures the gas particles move faster

They collide with the walls more often

They collide with the walls with more force

This increases the pressure.

The Pressure Law



Because:

At low temperatures the gas particles move slower

They collide with the walls less often

They collide with the walls with less force

This decreases the pressure.

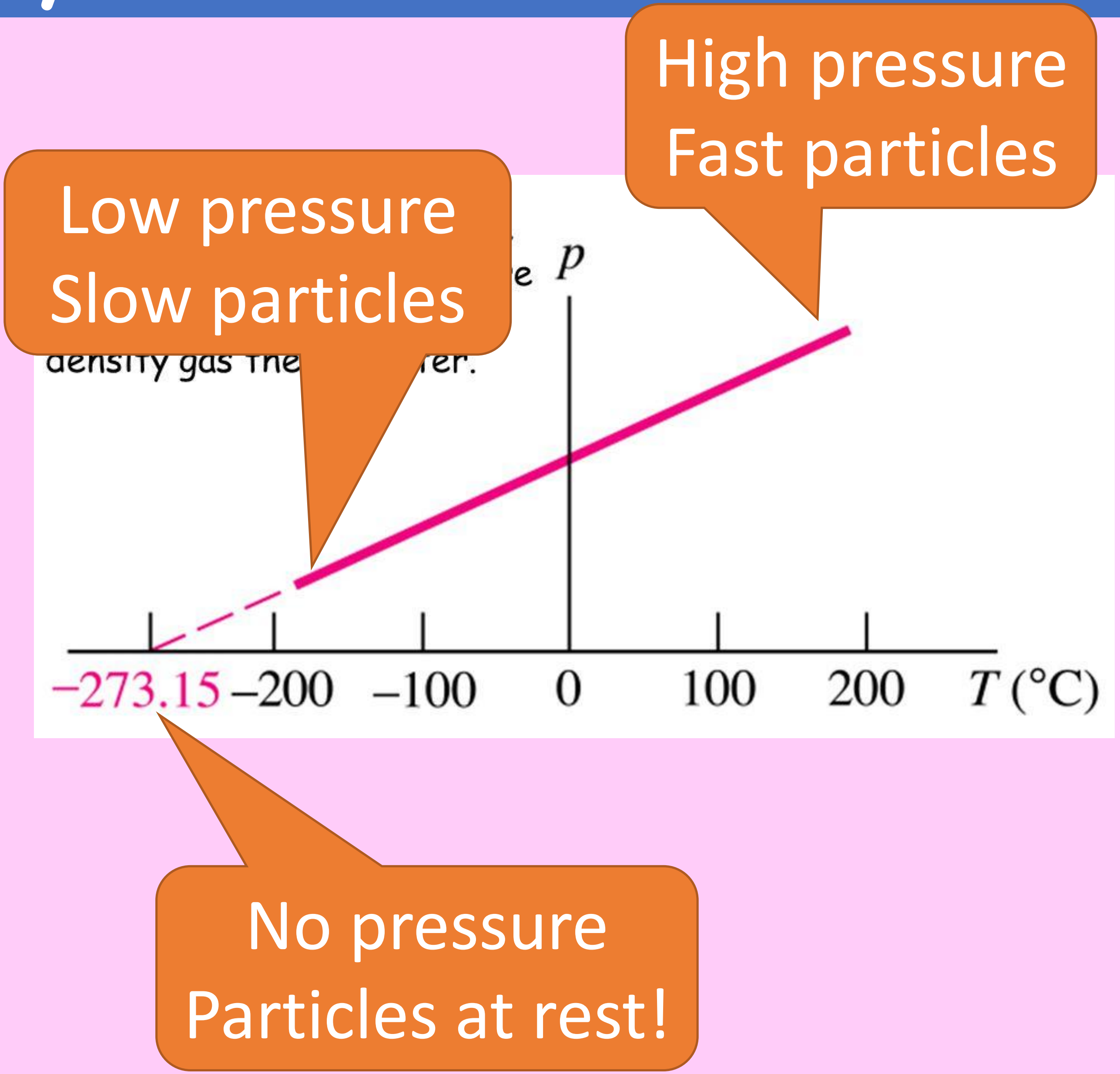
The Pressure Law

Scientists drew a graph of their results…

They found that particles stopped moving at

-273.15°C

You can't go colder than this because you can't move any slower!!!



The Pressure Law

WHAT A RUBBISH TEMPERATURE SCALE!!!

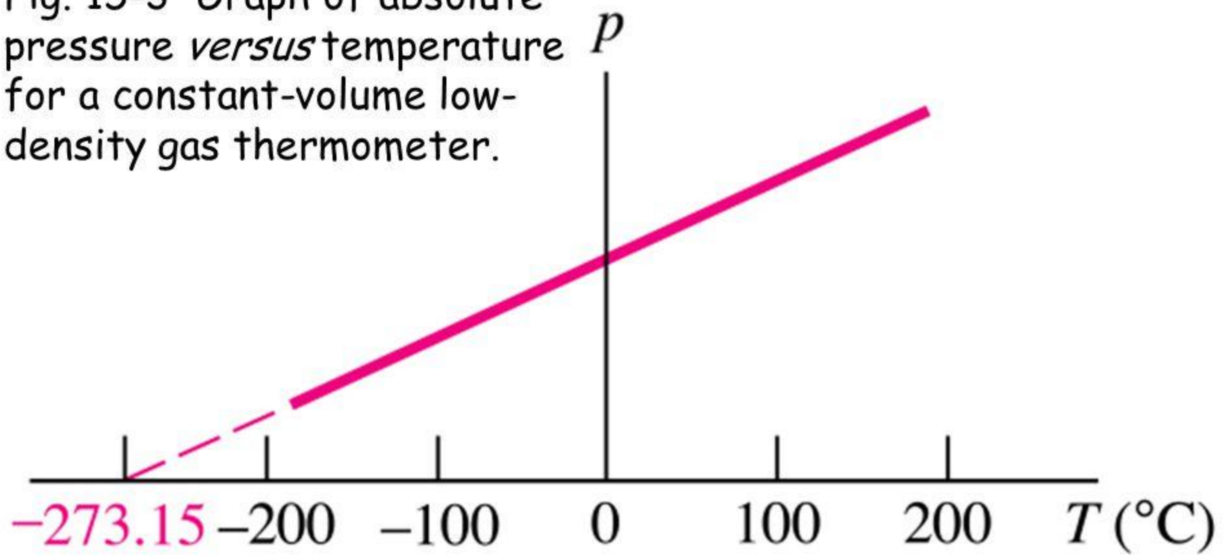
They invented a new temperature scale so that:

- At zero the particles had no energy
- As it got hotter the particles moved faster

They called it the…

THERMODYNAMIC temperature scale (Kelvin)

Fig. 15-3 Graph of absolute pressure *versus* temperature for a constant-volume low-density gas thermometer.



Kelvin = Celsius + 273

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S Charles' Law

If a gas is heated and is able to expand it will increase its volume

Why?

LO – GCSE Physics Revision

S Charles' Law

If a gas is heated and is able to expand it will increase its volume

Because:

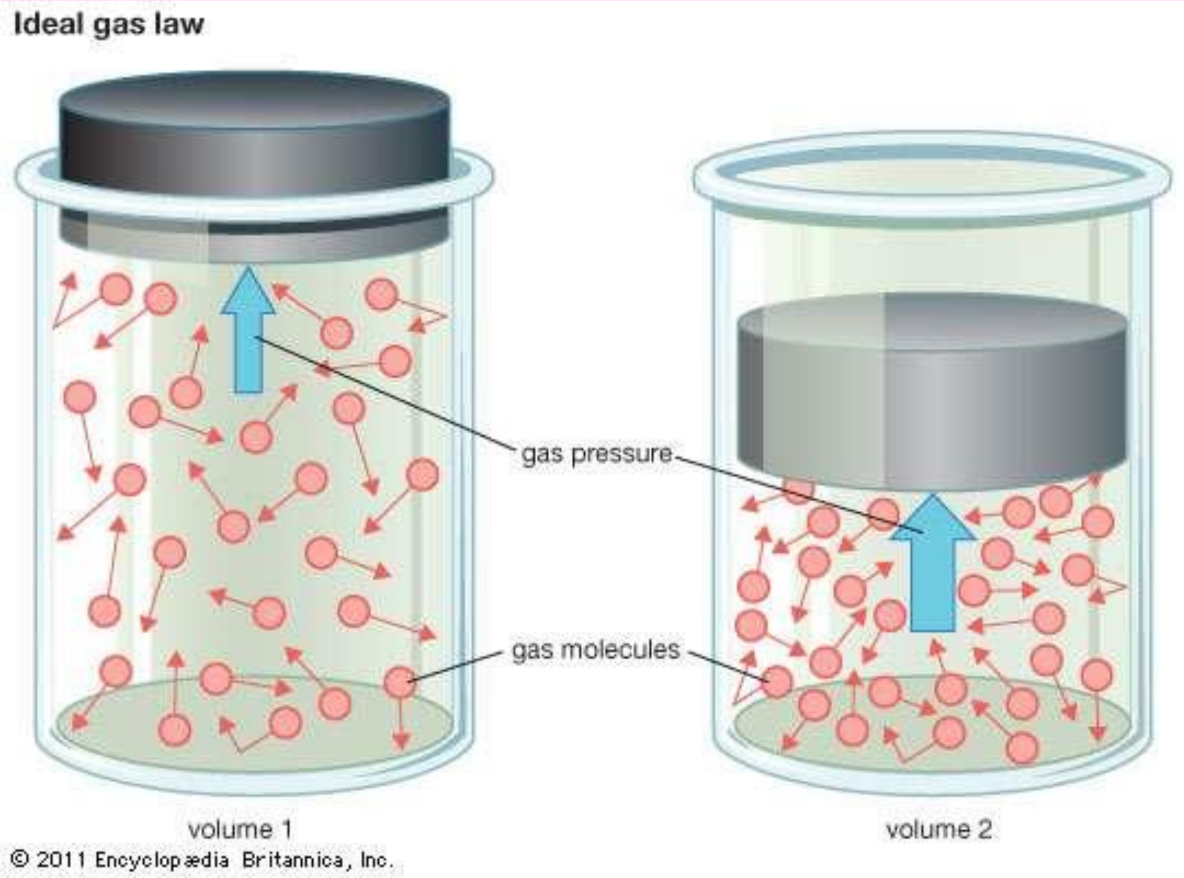
- The air on the outside is at a constant pressure
- The pressure inside the balloon is equal to this
- As the gas on the inside gets hot, the particles move faster, collide more often and with more force
- The pressure inside increases and this pushes the balloon outwards
- As the particles spread out, the pressure falls until it equals the outside pressure and the balloon stops expanding

LO - GCSE Physics Revision

S Boyle's Law

When you squash a gas into a smaller volume (very slowly) the pressure goes up

Why?



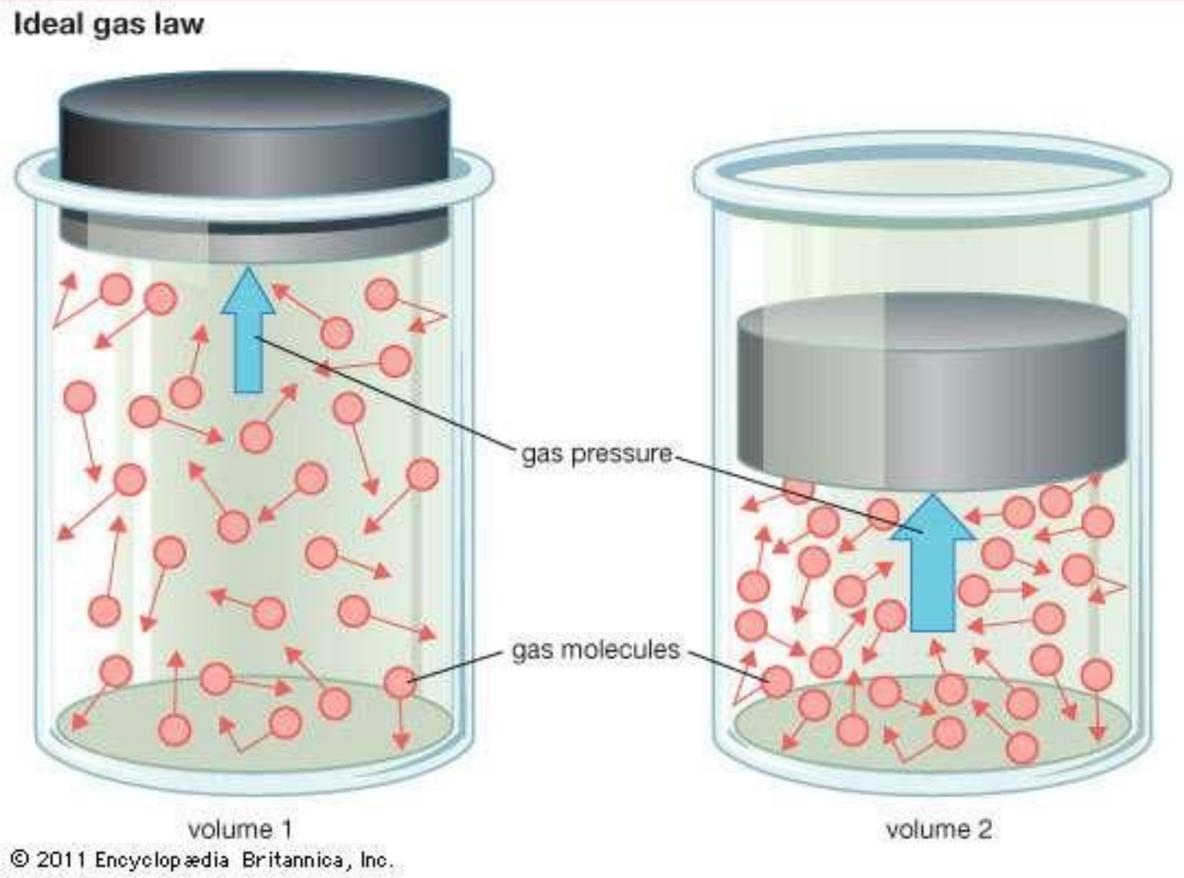
LO – GCSE Physics Revision

S Boyle's Law

When you squash a gas into a smaller volume (very slowly) the pressure goes up

Because:

- The particles move closer together (more dense)
- They collide with each other more often
- They collide with the walls more often
- This increases the pressure



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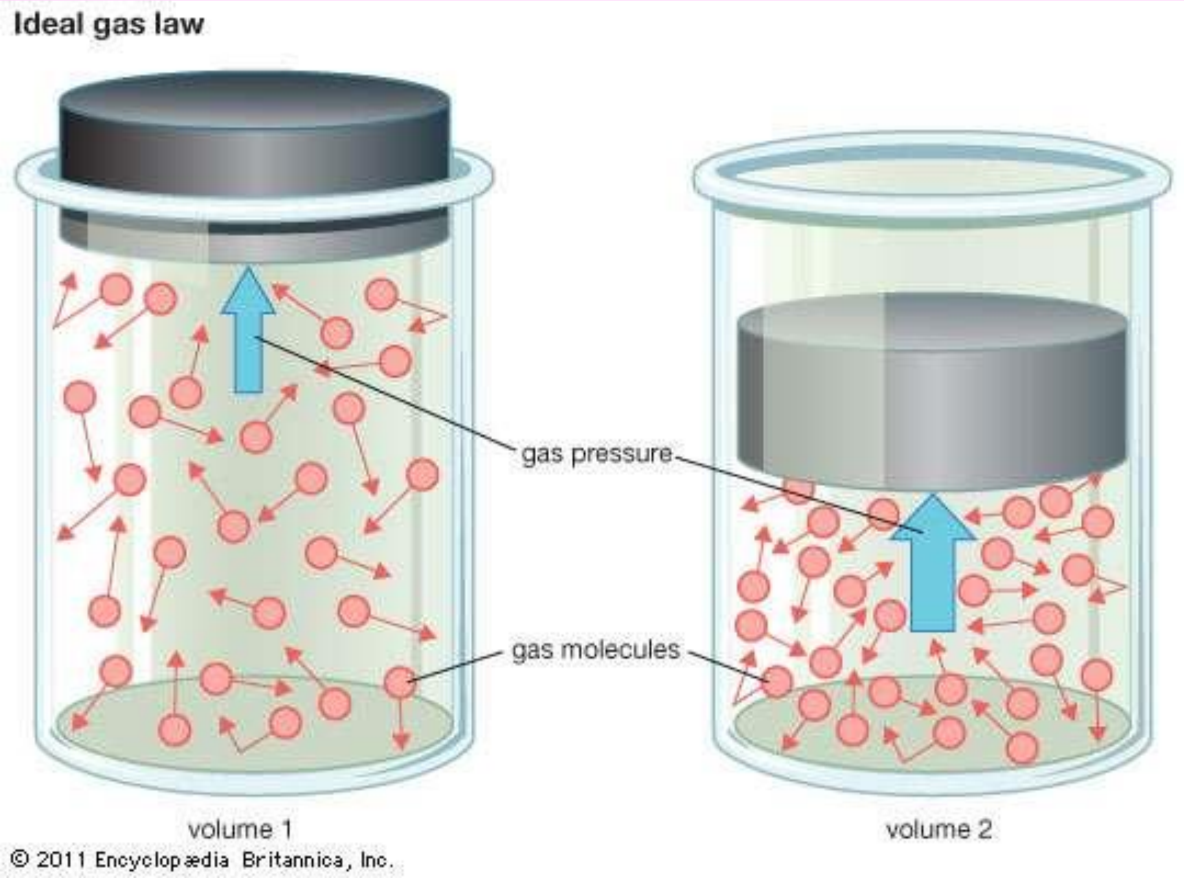
S Boyle's Law

NOTE: if you try to do Boyle's Law experiments too fast, the gas heats up and loses energy to the surroundings

There is a formula for Boyle's Law:

$$p_1V_1 = p_2V_2$$

p_1 is the start pressure
V_1 is the start volume
p_2 is the end pressure
V_2 is the end volume



SP15/CP13 Properties of matter under stress

The one about stretching and squashing things

and for Separate students it also includes some stuff about liquid pressure (trying to squash water)

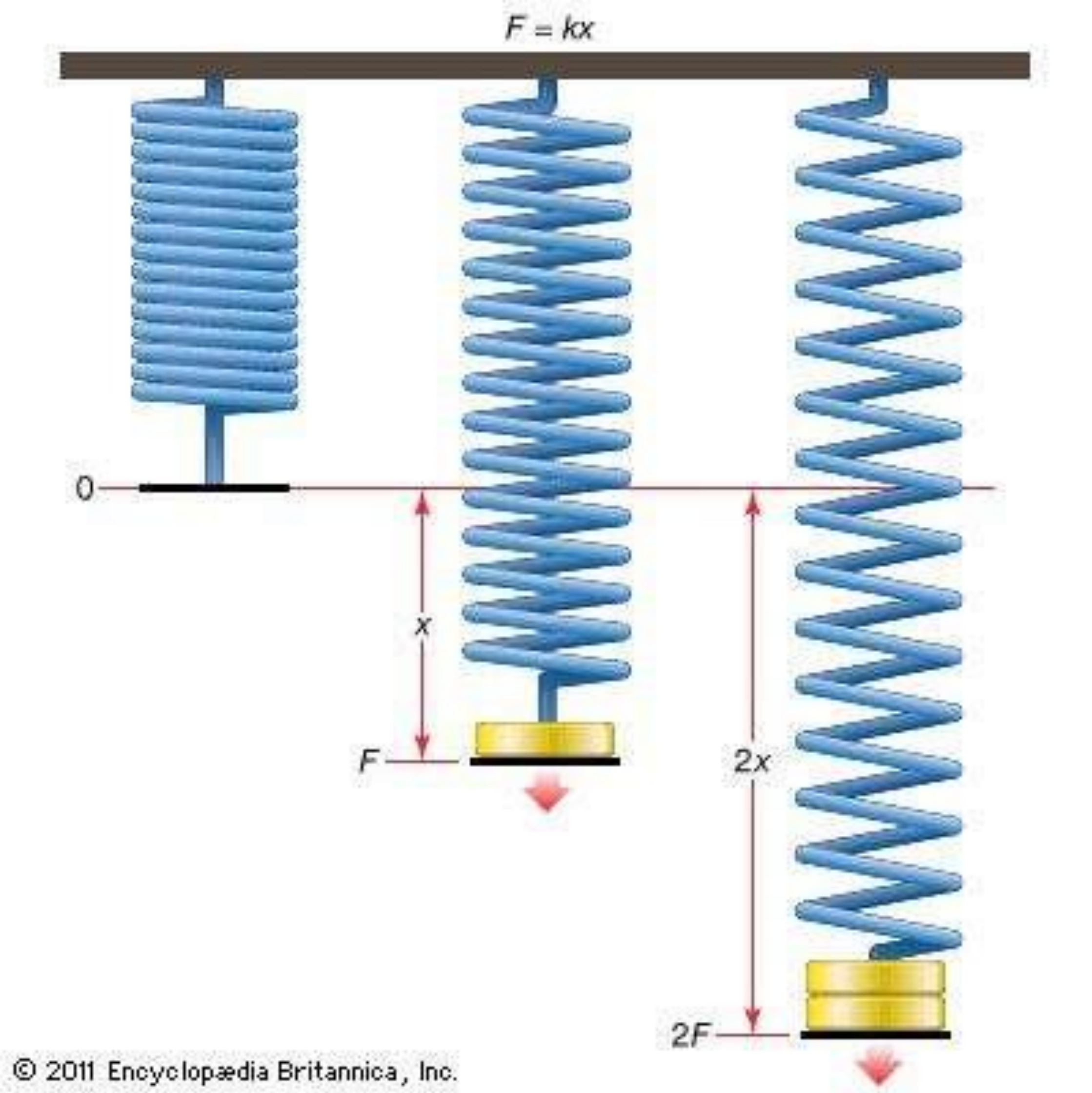
Hooke's Law

Hooke found that when you pull on a spring, the extension (extra length) gets bigger as the force gets bigger.

Force ∝ extension
(proportional to)

$$F = k \times \mathcal{X}$$

F is the force you apply
$\mathcal{X}$ is the extension

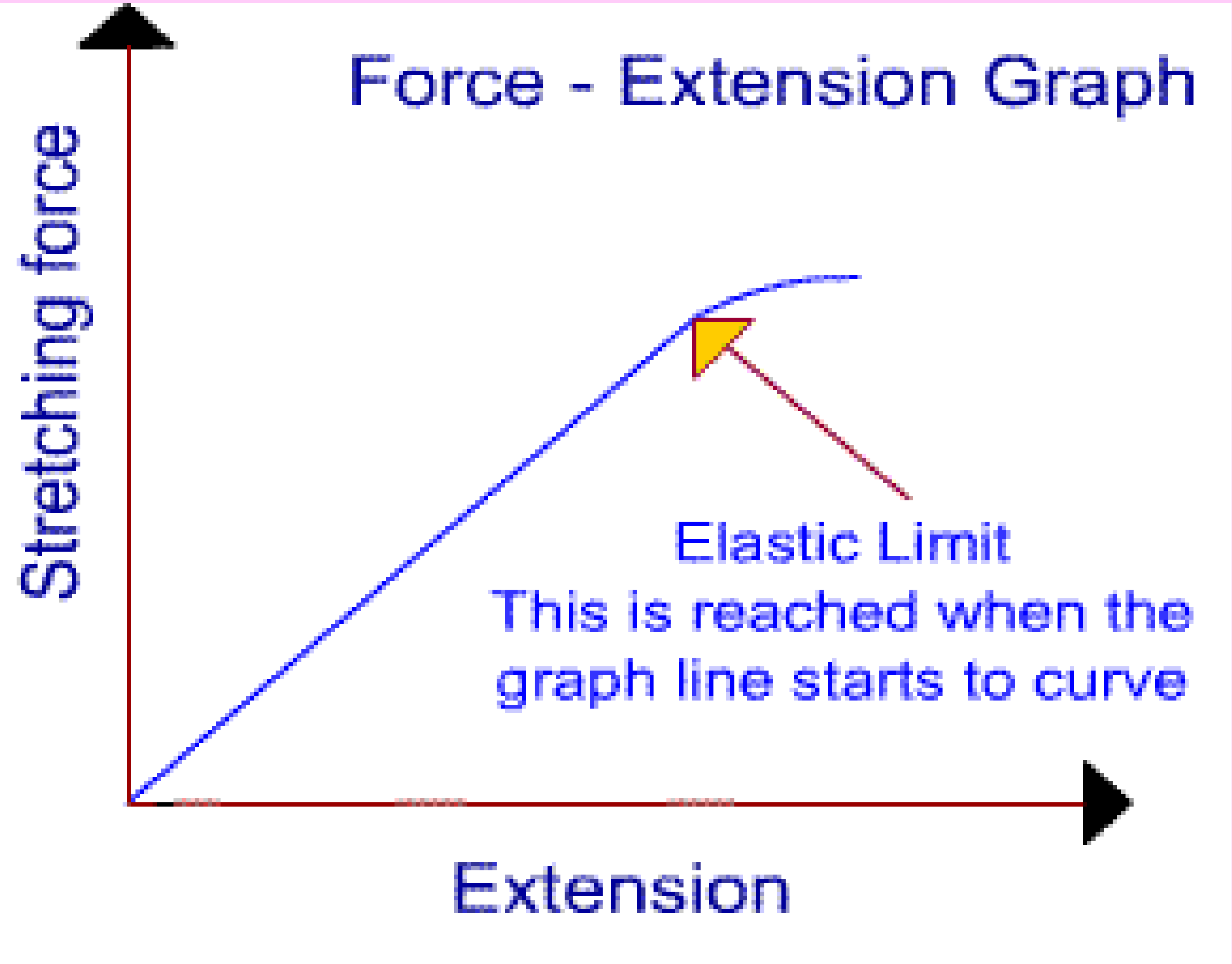


Hooke's Law

Hooke drew a graph to show his results

While it is straight, his Law works.

Once it starts to curve, the spring won't go back to its normal shape so his Law is then broken

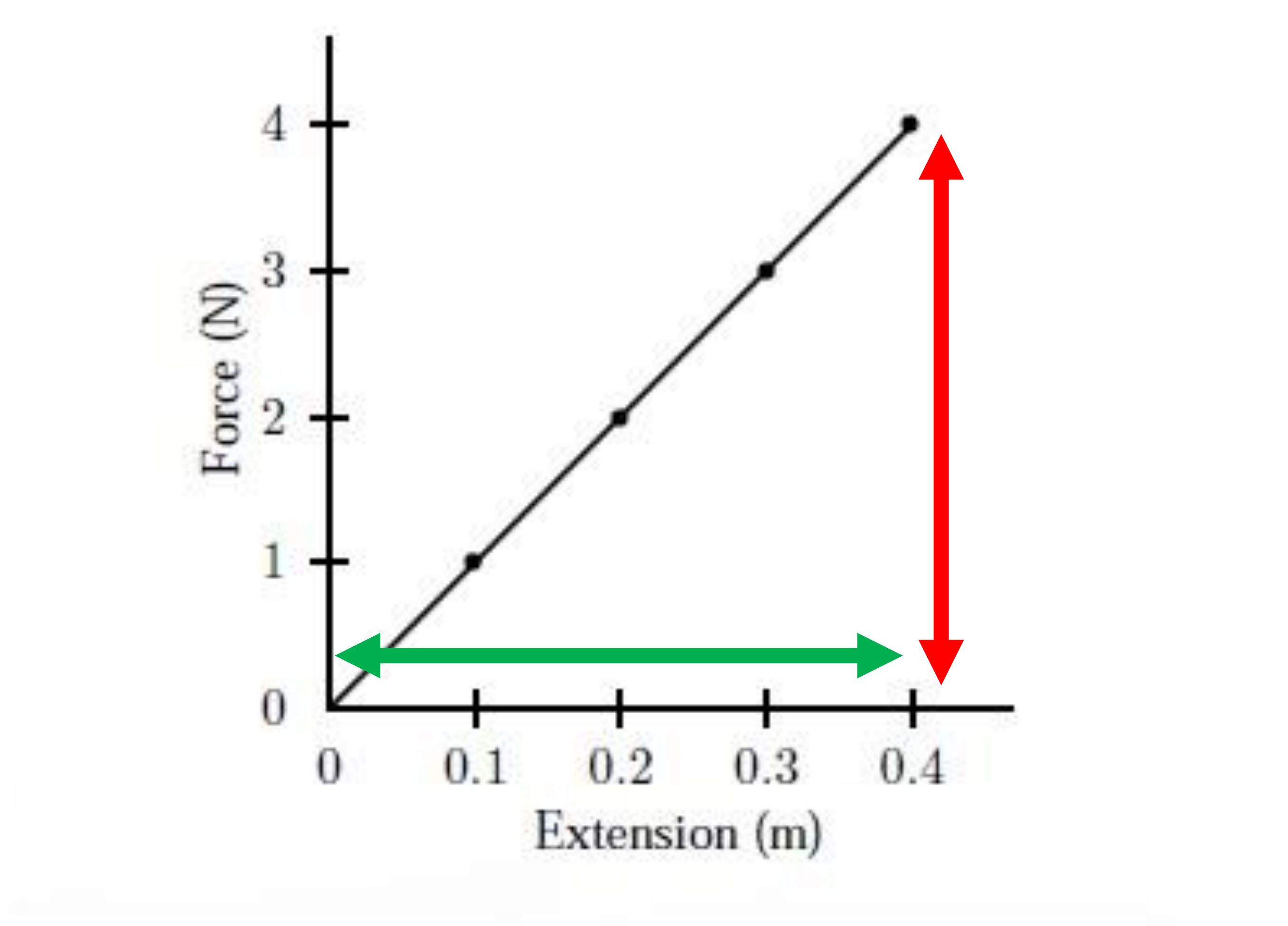


Hooke's Law

Hooke drew a graph to show his results

The gradient of the graph tells us what k, the spring constant is.

k = 4 / 0.4 = 10 N/m

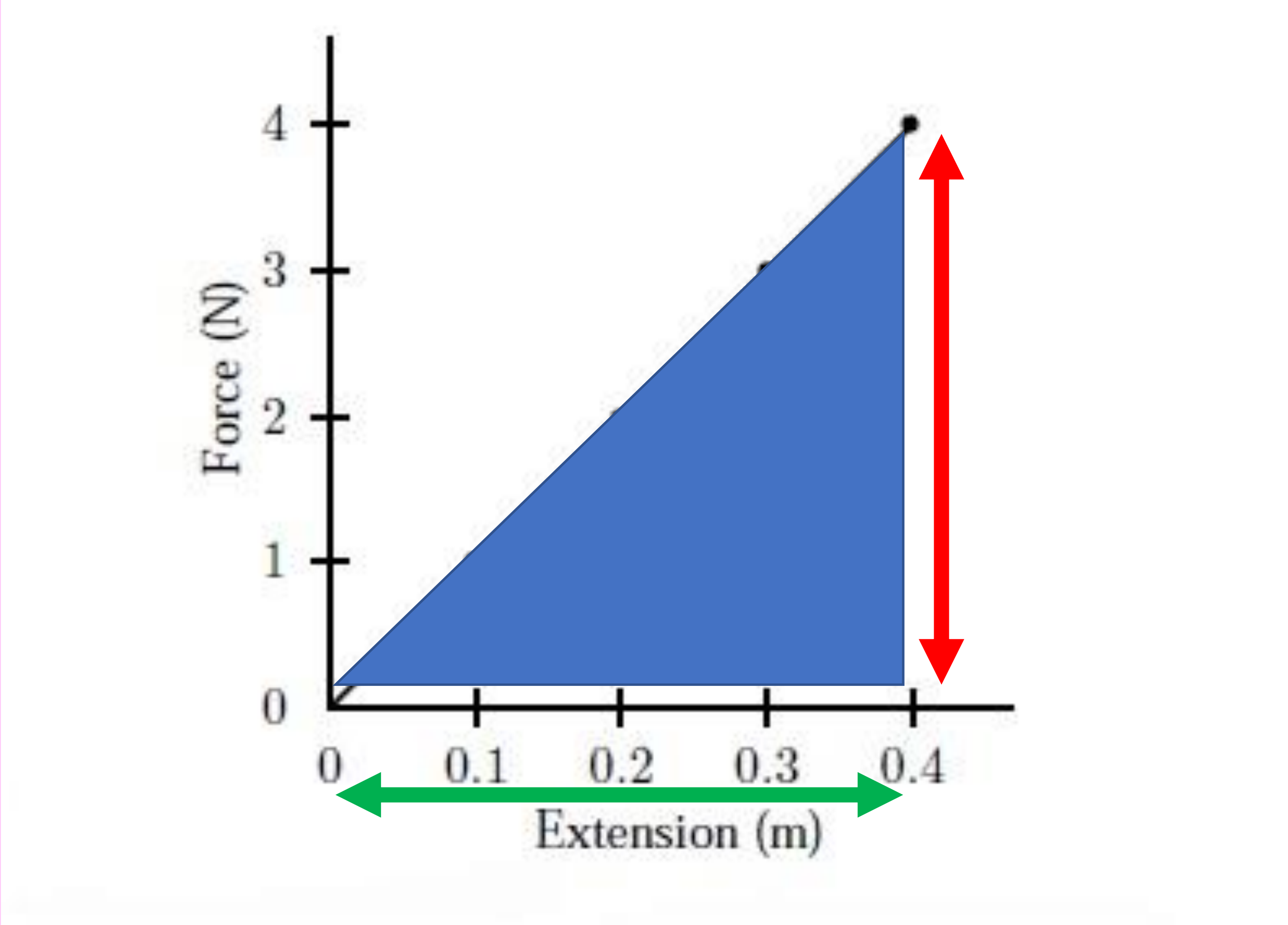


Hooke's Law

Hooke drew a graph to show his results

The area under the graph tells us how much energy is stored in the spring

$$E = \frac{4 \times 0.4}{2} = 0.8\ J$$



Remember…

Hooke's Law applies just as well to things being compressed!

Compression = being squashed

Tension = being stretched

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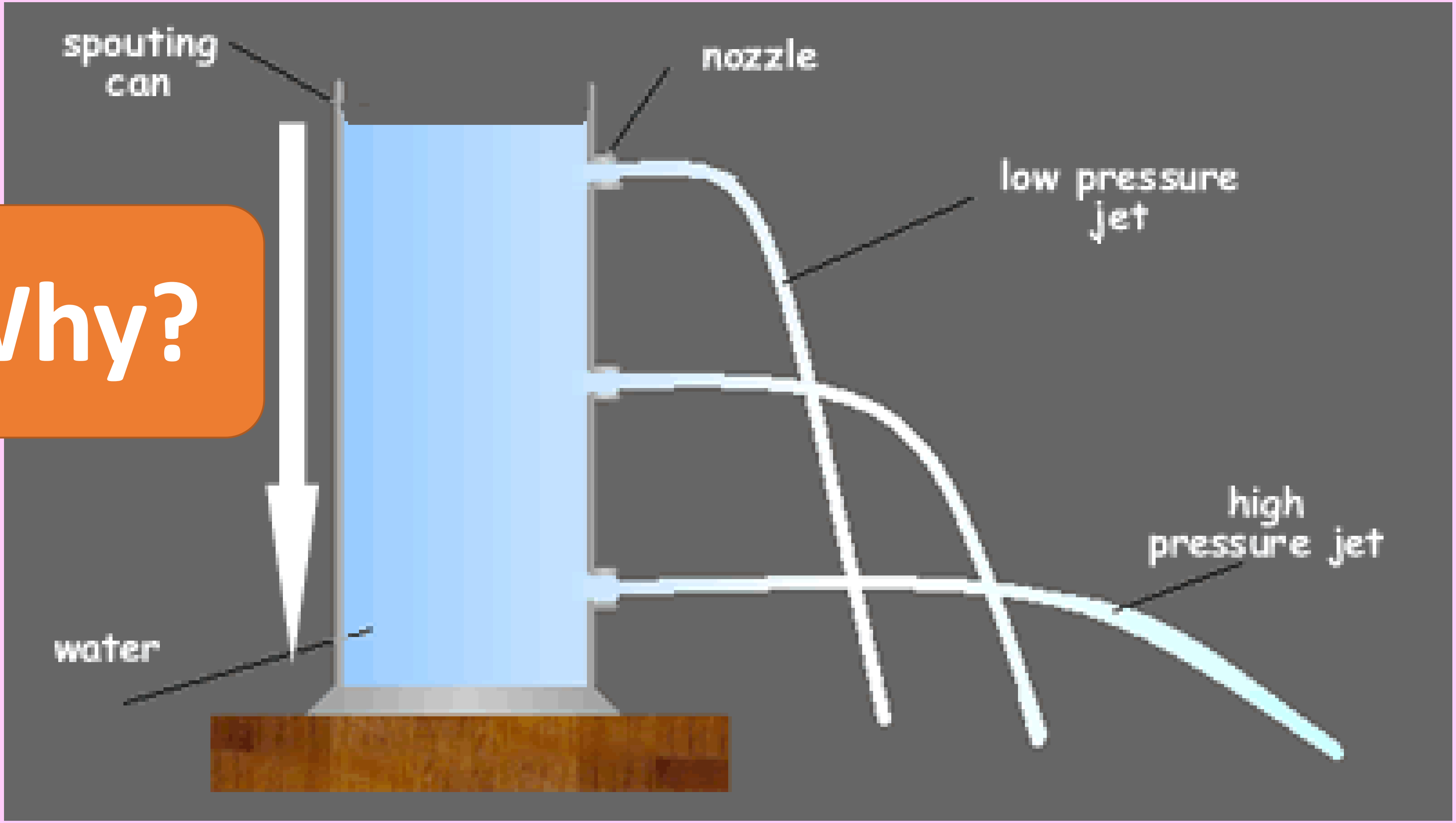
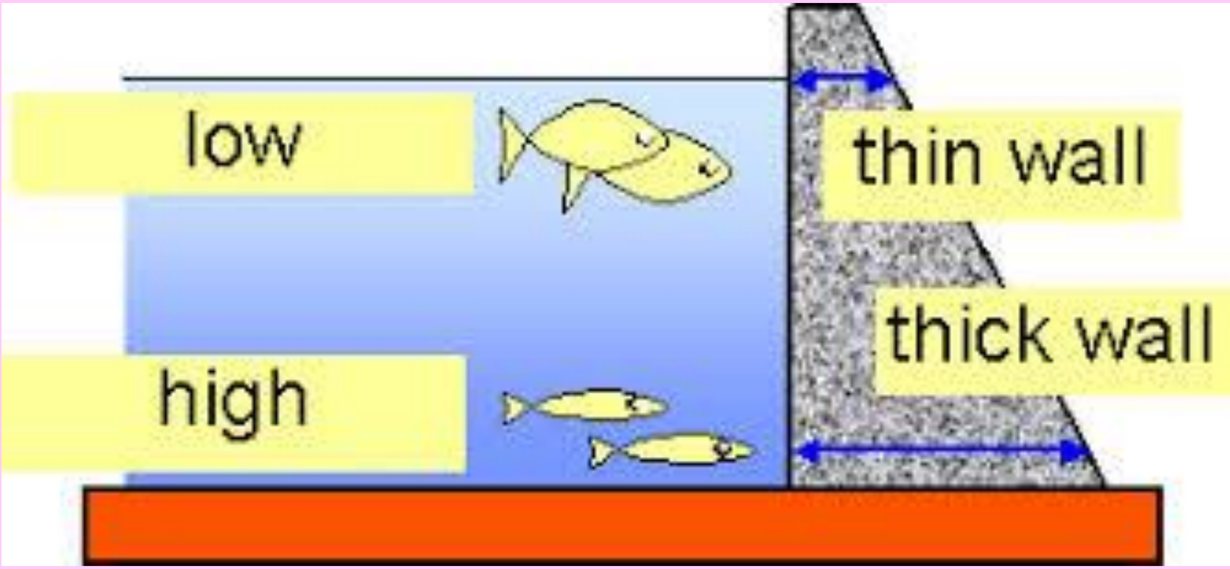
S Pressure in liquids



Why?

S Pressure with depth

As you go deeper under water, the weight of the water above presses down with more force. This increases the pressure.



$$\Delta p = \rho\ d\ g$$

Δp = change in pressure

ρ = density of liquid

d = depth

g = gravitational field strength

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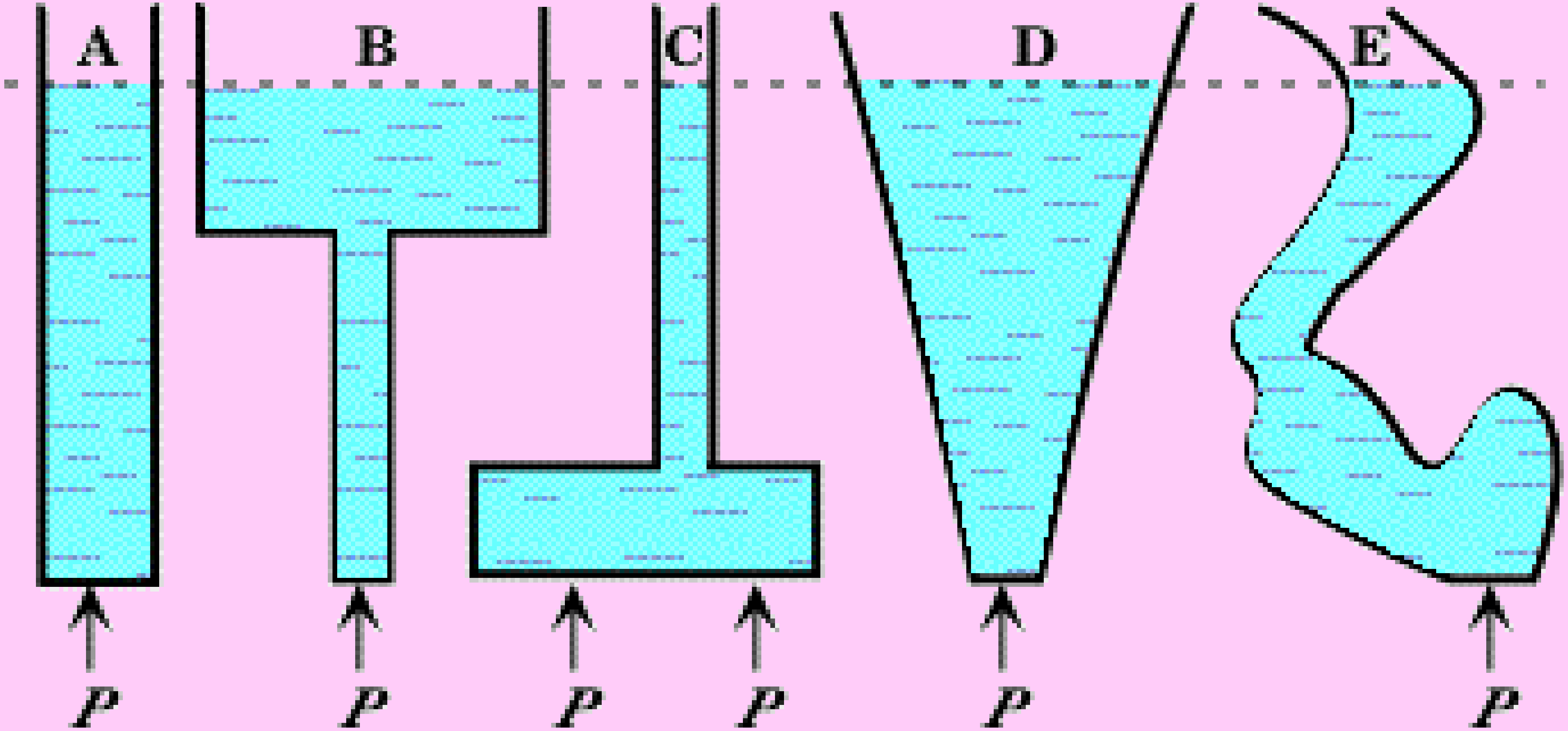
S Which vase has the greatest pressure?



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S Pressure in all directions is equal in a liquid

The water sprays out of the bag in all directions at the same pressure.

Only a hole in the bottom of the bag would go faster.

Why?

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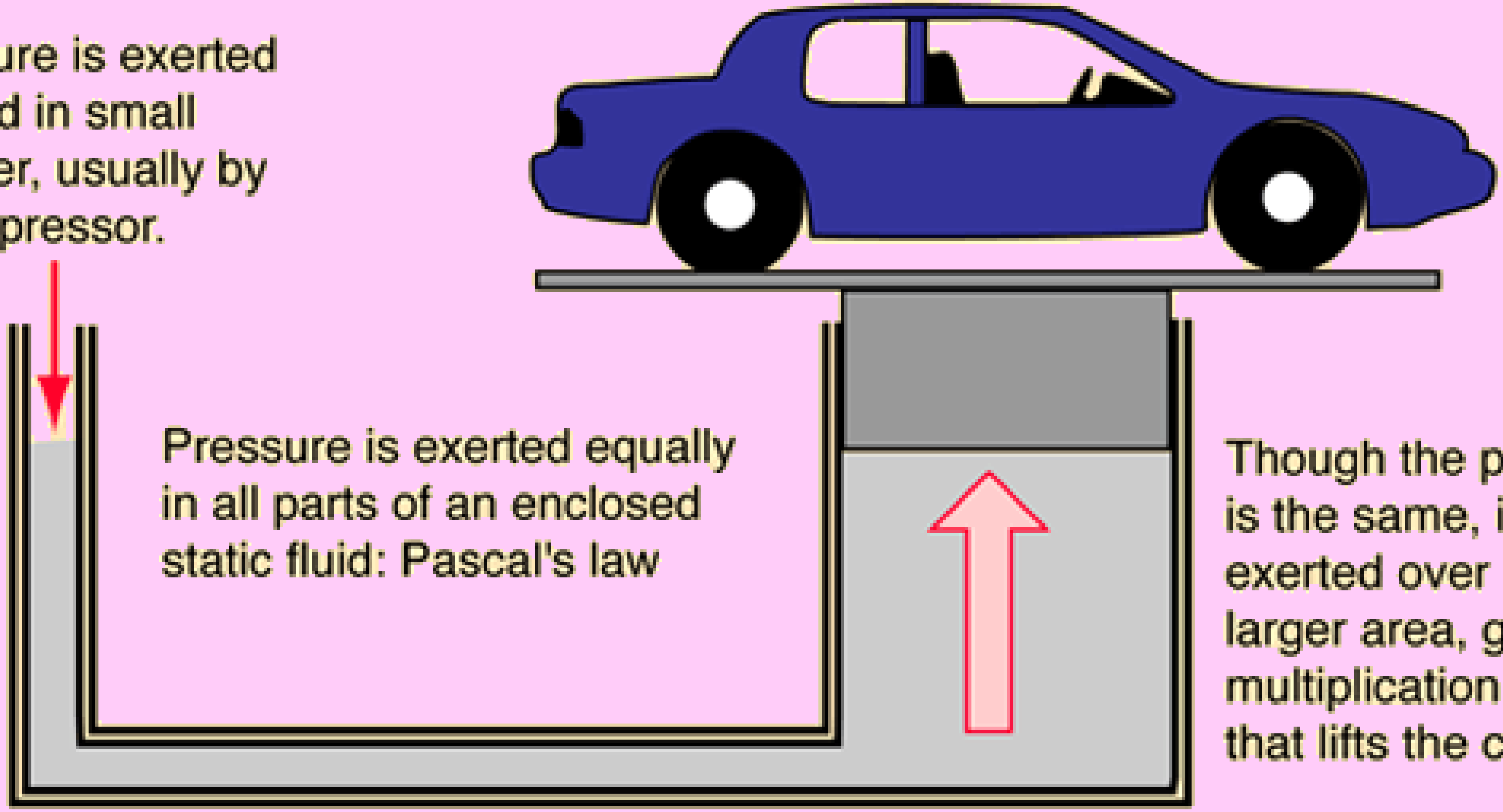
S Hydraulic lifts

Pressure is exerted on fluid in small cylinder, usually by a compressor.

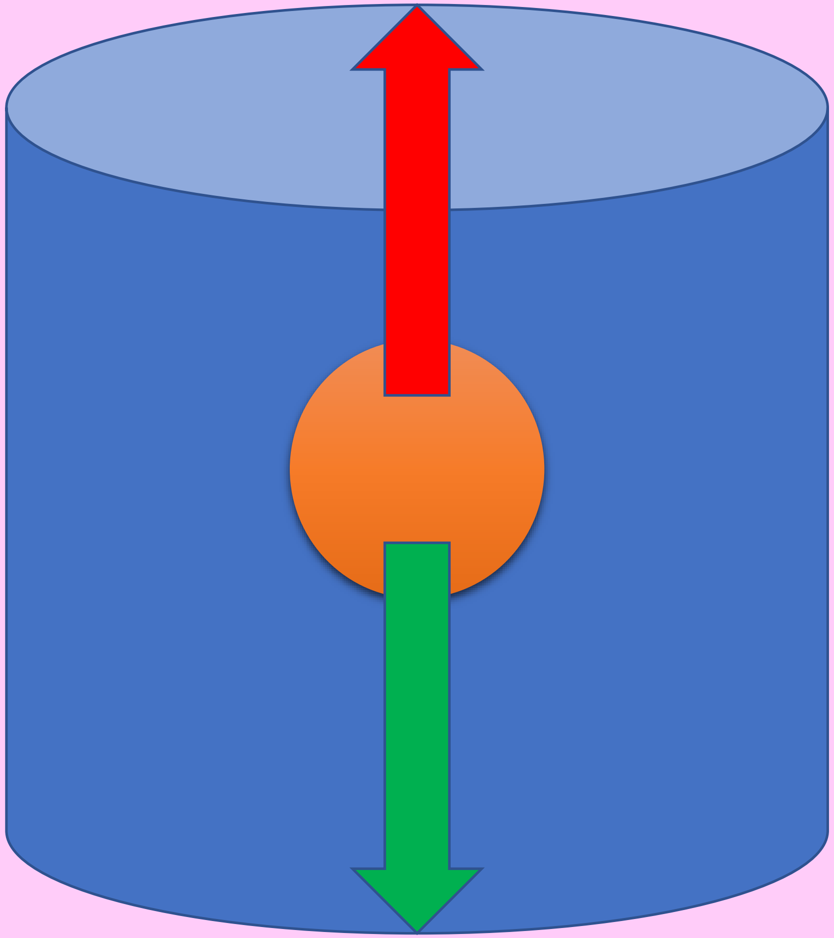


Pressure is exerted equally in all parts of an enclosed static fluid: Pascal's law

Though the pressure is the same, it is exerted over a much larger area, giving a multiplication of force that lifts the car.

The force in the small cylinder must be exerted over a much larger distance. A small force exerted over a large distance is traded for a large force over a small distance.

S Floating and sinking



Force downwards is the weight of the ball:

$F = m \times g$

but m can be worked out using the volume and density:

$$F = \rho_{ball} \times V \times g$$

Force upwards is the weight of the water the ball has pushed out of the way:

$$F = \rho_{water} \times V \times g$$