Solids, Liquids & Gases

03/09/19

Solids

Particles that make up solids vibrate about fixed positions because they have kinetic energy, as they are not at 0°K (Absolute Zero). It is difficult to change the shape of a solid.

Liquids

In a liquid, the particles are still close together, but they can move more freely than in solids. In general, liquids are incompressible.

Gases

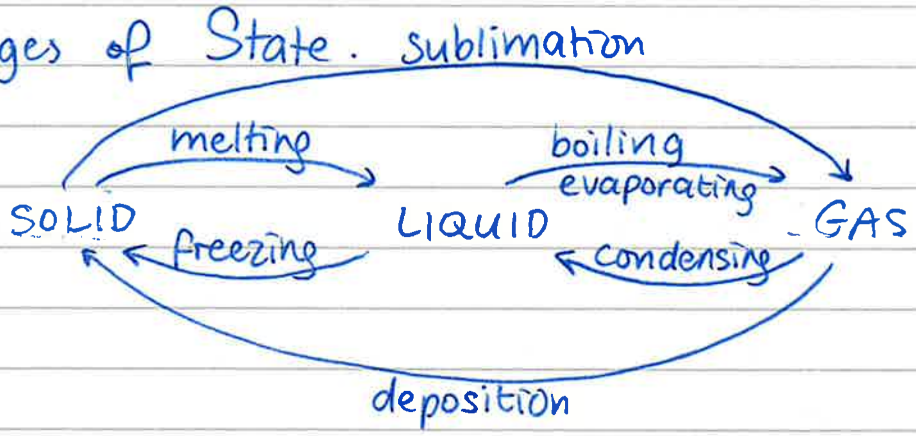
In a gas, the particles are very far apart. There are no inter-atomic or inter-molecular forces of attraction. The motion of the particles is random. Gases can be compressed. The average gas particle experiences millions of collisions per second (at RTP). They travel at speeds of hundreds of metres per second.

Heating

When a material is heated, its internal energy increases. This can cause the particles in that material to gain kinetic energy, causing them to speed up. This can cause the material to expand. Alternatively, the particles may move far enough from each other that the material changes state.

Temperature is a measure of the average kinetic energy of a group of particles.

Changes of State.



Specific Heat Capacity

Different materials are better/worse at storing internal energy. For the same increase in internal energy, some materials will heat up more than others.

Specific heat capacity is defined as

$$Q = mc\Delta T$$

Q : Heat transferred (J)
m : mass (kg)
c : specific heat capacity (J/kgK or $Jkg^{-1}K^{-1}$)
ΔT : change in temperature (°C/°K)

$c = \frac{Q}{m\Delta t}$ this is the heat transferred per kilogram per degree kelvin/centigrade.

Specific Heat Capacity H/W 07/09/19

1. $Q = mc\Delta T$
   $Q = 2 \times 390 \times 5$
   $Q = 3900J$ ✓

2. $Q = mc\Delta T$
   $Q = 3 \times 1040 \times 25$
   $Q = 78kJ$ ✓

3. $c = \frac{Q}{m\Delta T}$
   $c = \frac{7200}{1 \times 8}$
   $c = 900 J/kg/K$ ✓
   ∴ Aluminium

4. The one with 300g water ✓

5. $\begin{cases} E = IVt \\ Q = mc\Delta T \end{cases}$
   $IVt = 0.3 \times 4186 \times 78$
   $13 \times 230 \times t = 97952.4$
   $t = 32.76s$ assuming excellent {heat / energy} transfer. ✓

6. $13 \times 230 \times 32.76 = x \times 3900 \times 78$
   $x = 0.322$
   $= 322g$. ✓

7. Zinc goes from 200°C to x°C
   Water goes from 20°C to x°C
   $-(0.3(x-200) \times 380) = 1(x-20) \times 4186$
   $-114(x-200) = 4186x - 83720$
   $-4186x - 114x = -83720 - 22800$
   $-4300x = -106520$
   $x = \underline{\underline{24.8°C}}$ ✓

   The water only immediately surrounding the zinc block will boil. This sollution assumes immediate flawless transfer of energey.
   The water won't boil

8

9 $-114.(100-x) = 80 \times 4186$

$x = 3037°C$, which is above the melting point of zinc.

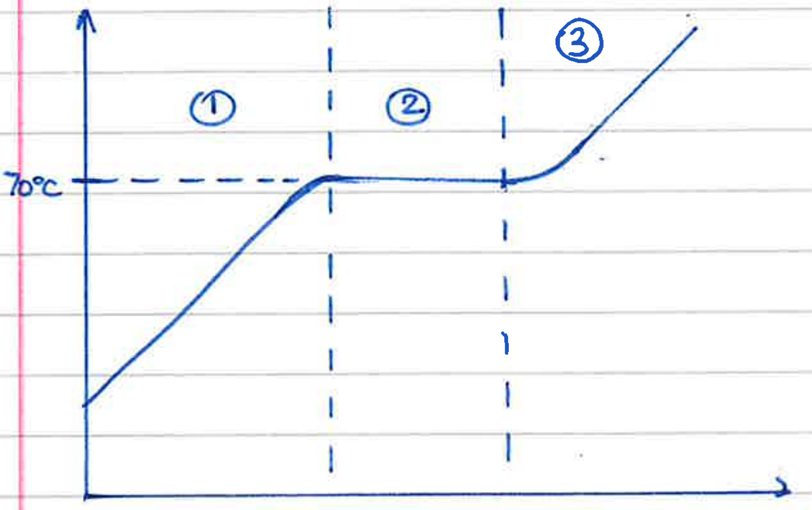
Good work

$\frac{10}{10}$

Heating Curves

10/09/19

Heating Curve for Stearic Acid



Region ① - Solid

The heat energy increases the kinetic energy of the particles.

⇒ the temperature rises

Region ②

Region ③

The amount of heat energy (ΔQ) required to change 1kg of a substance from solid (or liquid) to liquid (or gas) is called the LATENT HEAT of FUSION (OR VAPORISATION)

$$\Delta Q = mL$$

Heat Energy = mass × specific latent heat of fusion / vaporisation

[J] [kg] [J/kg]

For water

$L_{fusion} = 334 \text{ kJ/kg}$

$L_{vaporisation} = 2300 \text{kJ/kg}$

Pressure in Liquids & Gases 17/9/19

Pressure = Force ÷ Area

$p = \frac{F}{A}$

p : pressure (Pa or Nm^{-2})
F : force (N)
A : area (m^2)

In liquids & gases, random particle collisions involve a change in momentum. $F=ma$

$F = \frac{d(mv)}{dt}$

Pressure in liquids & gasses acts in all directions because the random collisions happen in all directions.

Derivation of pressure in fluids due to gravity

$$p = \frac{\rho V g}{A}$$

$$p = \frac{\rho A h g}{A}$$

$$p = \rho g h$$

Charles' Law

23/9/19

Temp / °C	Volume / ml
20	~~24~~ 24
34	~~32~~ 26
40	~~26~~ 28
48	30
58	32.5
70	35.5
74	3~~8~~7
80	38.5
90	40
95	41.5
98	43.5

For a constant number of moles of an ideal gas at a constant pressure,

Temperature $\propto$ Volume

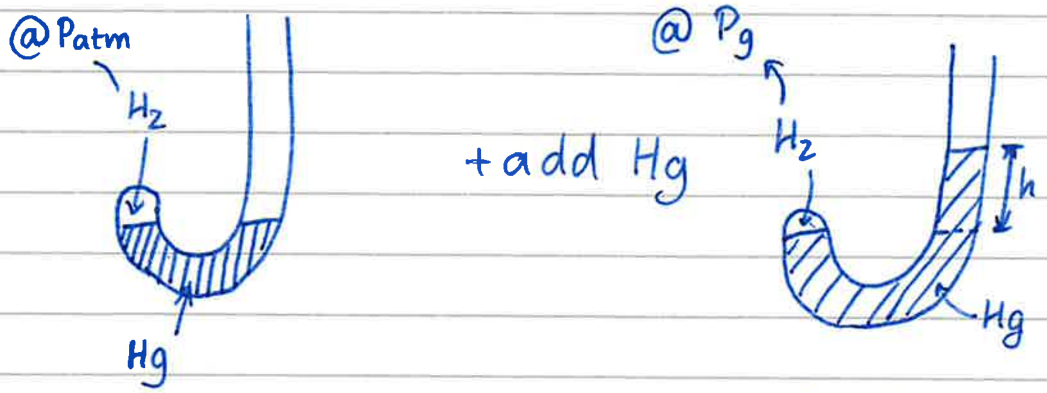
Or more succinctly,

$T \propto V$ @ constant n, p

$\Rightarrow$ $T = kV$ OR $V = kT$

Robert Boyle

24/9/19



$$\rho_{mercury} = 13{,}000\,kg/m^3$$

$$P_g = \rho_{Hg}\,g\,h + P_{atm}$$

Boyle compared pressure & volume

Experiment

Volume/ml	Pressure/kPa
0	668.1
5	373.2
10	187.6
15	129.4
20	97.7

Sample data

Volume/ml	Pressure/atm
1000	0.5
800	0.625
500	1.0
250	2.0
100	5.0
62.5	8.0
50	10.0

Boyle's law

$$\left.\begin{array}{l} P \propto \frac{1}{V} \\ \text{or } PV = k \end{array}\right\} \text{@ constant } T \text{ \& } n$$

Question

10 dm^3 of Helium at RTP is compressed using a pump into a 2 dm^3 container
$0.002 m^3$

$10\ dm^3 = 10{,}000 cm^3$
$2\ dm^3 = 2{,}000\ cm^3$

What is the pressure of the gas in the container?

$$P_1V_1 = P_2V_2$$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{100\ 000 \times 10}{2} = 500kPa$$

Astronomy / Astrophysics 8/10/19

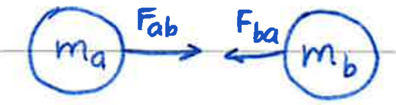
$$v = \frac{2\pi r}{T}$$

v : Orbital speed (ms^{-1})
r : Orbital radius (m)
T : Orbital period (s)

$$W = mg$$

W : weight (N)
m : mass (kg)
g : 'gravitational field strength' ($N kg^{-1}$ OR $m s^{-2}$)

Newton's law of gravitation
Factors that affect the attractive gravitational force between two objects include:



F_{ab} & F_{ba} are newton pairs.

$$F \propto \frac{m_a m_b}{r^2} \quad \text{OR}$$

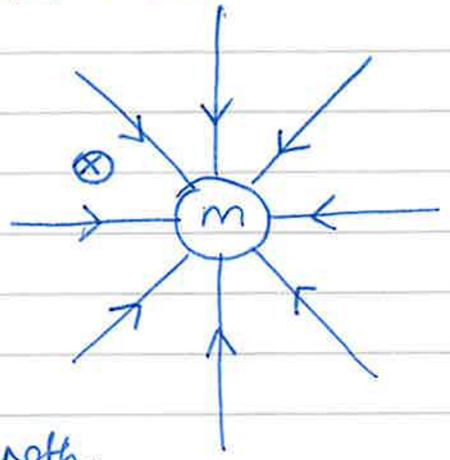
$$F = \frac{G m_a m_b}{r^2}$$

m_a : mass of A (kg)
m_b : mass of B (kg)
r : distance between A and B (m)
G : [universal] gravitational constant ($Nm^2 kg^{-2}$)

Gravitational Fields

9/10/19

Direction of lines represents the direction force would be on another mass at that point.



The density of lines per area represents field strength.

Gravitation

29/10/19

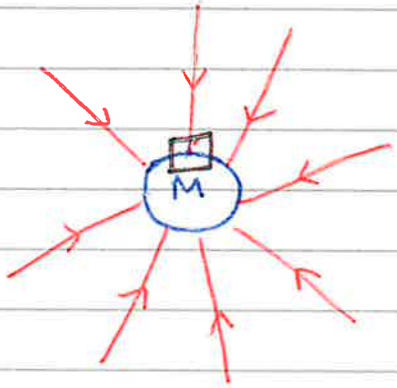
$W = mg$ ← what is g?

$$g = \frac{\text{force}}{\text{mass}}$$

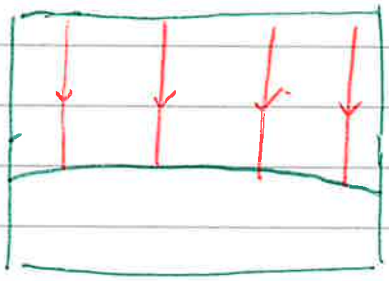
We previously discovered that $F = \frac{Gm_1m_2}{r^2}$

$$g = \frac{Gm_1m_2}{r^2 m_2}$$

$g = \frac{GM}{r^2}$ ← g at planet surface



At surface



there is a uniform gravitational field.

↓

constant, no matter the position. only true because earth is spherical.

Bonus:

$$GPE = -\frac{Gm_1m_2}{r}$$

Very well-kept notes

10/10

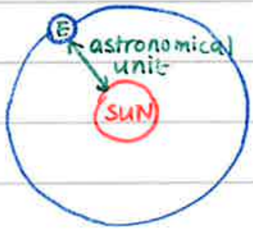
Absolute & Apparent Magnitude 31/10/19

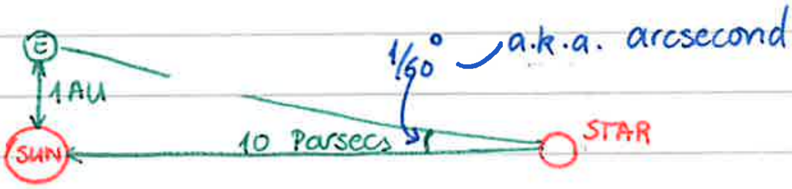
Apparent Magnitude of a star is how it appears when viewed from Earth

Absolute Magnitude is how intense a star is when viewed from 10 parsecs away.

$$\text{Intensity} = \frac{\text{Power}}{\text{Area}}$$

I : Intensity (Wm^{-2})
P : Power (W)
A : Area (m^2)





$$1 \div \sqrt{1^2 + 10p} = \arcsin(1/60)$$

$$1 \div \arcsin(1/60) = \sqrt{1^2 + 10p}$$

$$1 \div \arcsin(1/60)^2 = 1 + 10p$$

$$(1 \div \arcsin(1/60)^2 - 1) \div 10 = p$$

$$p =$$

Stellar Evolution

04/11/19

1. Nebula

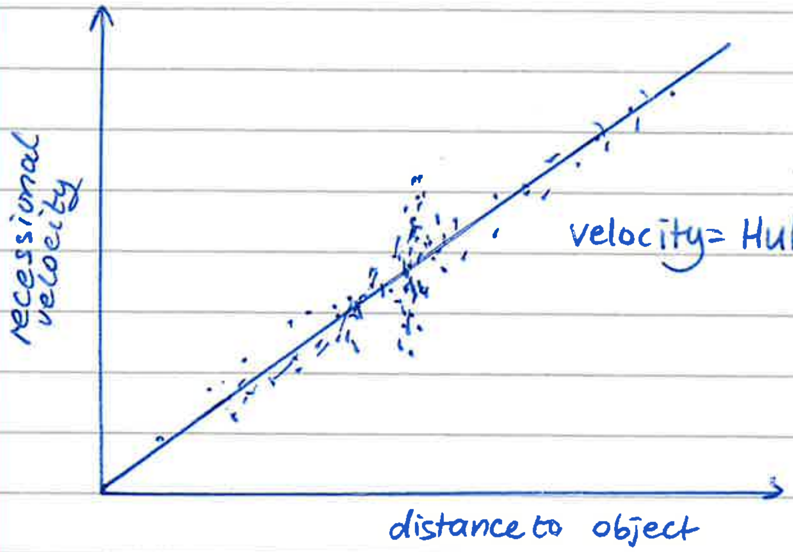
A cloud of hydrogen gas forms and steadily the force of gravity increases.

As this nebula becomes denser the temperature at the centre allows for hydrogen nuclei to fuse together and form helium nuclei. This process releases a large amount of energy. and an outward force known as 'radiation pressure'

2. Once the 'radiation pressure' balances the gravity force, the cloud stops becoming denser and a stable star is formed.

Hubble's Law

05/11/19

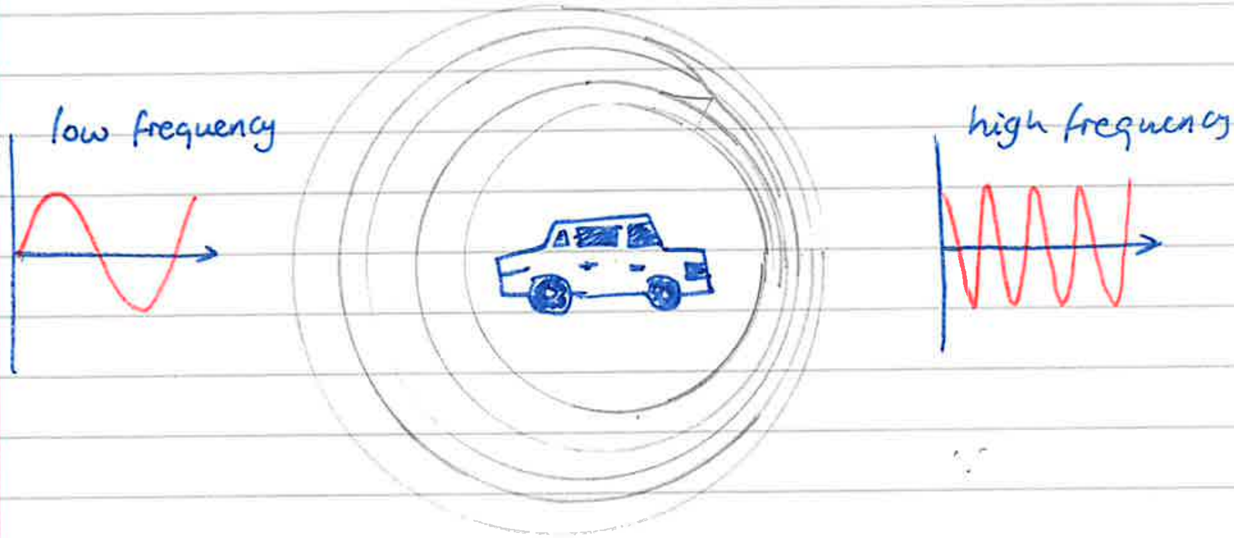


velocity = Hubble's constant × distance.

Hubbles constant = 160km s^{-1} $Mlyrs^{-1}$

Doppler Effect

06/11/19



Specific elements absorb specific frequencies, We can measure the observed shift in the ABSORPTION LINES from the light of a star. This shift corresponds directly to a 'radial velocity'

Steady State Theory 13/11/19

The Steady State Theory states that the Universe has always existed and constantly creates matter as it expands. This idea is supported by redshift but not by CMBR. The Steady State Theory has lost support since the discovery of CMBR.

Radioactivity

14/11/19

Some nuclei are *unstable*. These high-energy nuclei can release some of their energy as radiation in order to become stable.

'Isotopes' are nuclei of the same element (with the same number of protons) but a different number of neutrons.

There are three kinds of nuclear radiation:

Type	Particle & Symbol	Ionising Power	Penetrating Power
Alpha	$^{4}_{2}\alpha$ Helium nucleus	High	Low blocked by paper OR few cm of air.
Beta	$^{0}_{-1}\beta$ electron $^{0}_{+1}\beta$ positron [opposite]	Medium	Medium few mms of aluminium
Gamma	$^{0}_{0}\gamma$ photon Gamma ray	Low	High few cms of lead.

$^{4}_{2}He$

4 ← atomic mass

2 ← number of protons / atomic number

An ion is an atom that has a different No. of protons compared to electrons.
Ions are CHARGED particles

Activity, or rate, is the detected number of ionisation events per second, measured in Becquerels (unit: Bq)

Background Radiation 19/11/19

Background radiation is the radiation that is always present in the environment around us, from sources such as space, the air, the ground and the food we eat.

The average annual radiation does in the UK is 2.5 millisieverts. 73% of it comes from natural sources. The largest single source of natural radiation is Radon gas from the ground; the average dose a year in the UK from radon is 1.2 millisieverts.

Half-life

26/11/19

Total Nº of rolls	Total Nº of decayed nuclei	Nº of decayed nuclei	Nº of remaining nuclei
0	0	18	120
1	18	16	102
2	34	16	86
3	50	13	70
4	63	12	57
5	75	10	45
6	85	3	35
7	88	4	32
8	92	4	28
9	96	4	24
10	100	2	20
11	102	2	18
12	104	4	16
13	108	4	12
14	112	1	8
15	113	0	7
16	113	1	7
17	114	1	6
18	115	2	5
19	117	0	3
20	117	0	3

Radioactive decay

28/11/19

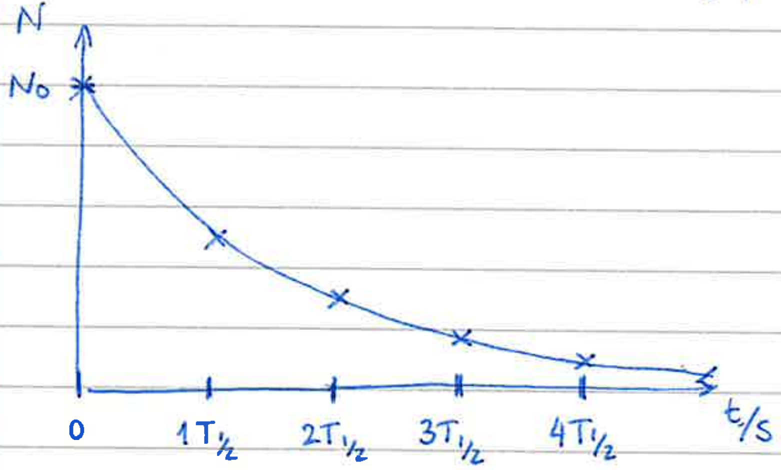
α	${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}J + {}^{4}_{2}\alpha$
β^-	${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}J + {}^{0}_{-1}\beta$
β^+	${}^{A}_{Z}X \rightarrow {}^{A}_{Z-1}J + {}^{0}_{+1}\beta$
γ	${}^{A}_{Z}X^{\overset{\text{excited state}}{*}} \rightarrow {}^{A}_{Z}X + {}^{0}_{0}\gamma$

E.g.

α ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$

β ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta$

$N = N_0 e^{-\lambda t}$ or $N = N_0 \times \left(\frac{1}{2}\right)^{\overset{\text{number of half-lifes}}{t}/\underset{\text{halflife}}{T_{\frac{1}{2}}}}$



Radioactivity and wildlife 3/12/19

The radiation in Artic seabirds' droppings came from the radioactive fish and crustaceans they were eating.

The samples contained ten times as much radioactive as other samples from the area. This wouldn't occur naturally. They found caesium-137 which doesn't occur naturally.

Nuclear weapon tests in the mid-20th century contaminated places far away all around the world because the particles were carried through the atmosphere.

Each isotope gives out gamma rays with a particular energy or wavelength.

A total of 520 atmospheric nuclear explosions were set off in the years up to 1980.

The simpler and smaller the organism, the higher the radiation dose to be lethal.

Bioaccumulation is when (potentially radioactive) substances pass higher up the food chain. e.g.

(air →) lichen → reindeer

Reindeer eat lots of lichen so they accumulate radioactive substances.

If a sample of potassium-40 was formed at the same time as the earth it would have gone through 3.46 half-lifes.

Radiation Dose

4/12/19

Background radiation is the radioactive radiation that is naturally occurring in the environment around us. It comes from sources such as radon and thoron gas inside buildings, the food we eat & cosmic rays from outer space.

Alpha particles are the most ionising type of radiation. However, α particles are very poorly penetrating, and are blocked by a mere few centimetres of air.

Nuclear Fission

10/12/19

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + 3\,^{1}_{0}n$$

If a slow-moving neutron is absorbed by a large, unstable nucleus, a fission event can be triggered.

The nucleus splits into at least two 'daughter nuclei', which move off with high kinetic energy. The neutrons ejected from the fission event can collide with other uranium nuclei to cause further chain reactions.

So that they may be absorbed by

In a nuclear reactor, a moderator (e.g. graphite) slows down fast-moving neutrons so that the control rods can X absorb the neutrons to prevent a runaway chain reaction.

No.

The control rods can be inserted/removed & necessary.

Fission reactions produce a lot of heat energy, which is used to heat water, turning it into steam. The steam turns a turbine that generates electricity.

Nuclear Fusion

11/12/19

In nuclear fusion, two nuclei with low mass numbers combine to produce a single nucleus with a higher mass number.

$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}He + ^{1}_{0}n + \gamma \text{ ray}$$

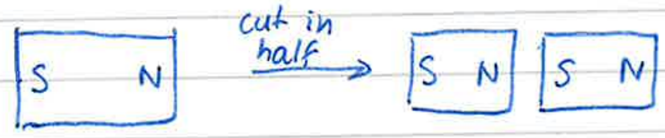
The temperature required for fusion in the Sun is around 1.5×10^{8} °K.

Pros for fusion	Cons for fusion
Limitless energy	Technology under development
Far safer than nuclear	More expensive to run than profi
Clean (no waste)	Little ^{3}H or ^{3}He on Earth
Very efficient	A big long-term investment

Magnetism

22/01/20

Magnets repel and attract other magnets.
They can also attract magnetic substances/materials.
Magnets have a North Pole and a South Pole.
Like poles repel, unlike poles attract



It is IMPOSSIBLE to isolate a magnetic pole
Magnetic materials contain ferromagnetic elements:
iron, Nickel, cobalt, (Neodymium)
and their alloys, e.g. steel.

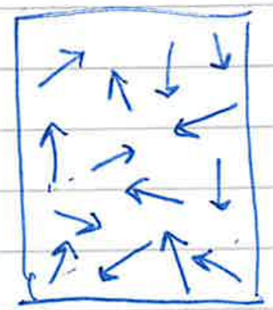
Two categories:

Magnetically hard	Magnetically soft
can be magnetised to become permanent magnets (until demagnetised)	can be induced to be magnetic (temporarily) when in a magnetic field.
e.g. Steel, Neodymium	e.g. Iron

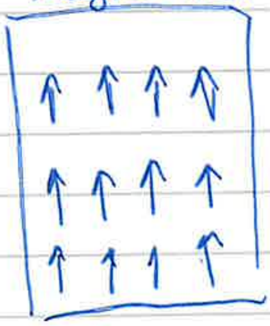
magnetic field ↓ a region of space in which magnetic poles experience forces

Inside a magnetic material, we find 'domains' where the ferromagnetic elements' fields point in the same direction/align.

Un-magnetised



Magnetised

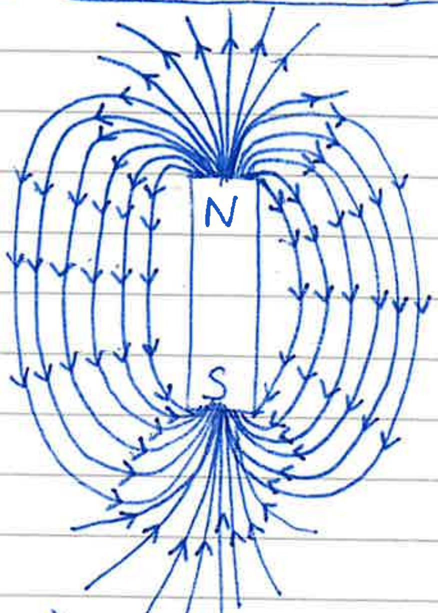


Magnetic Fields

28/01/20

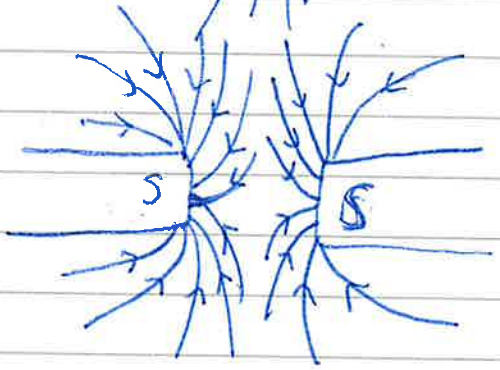
A magnetic field is a region of space in which magnets or magnetic materials experience forces.

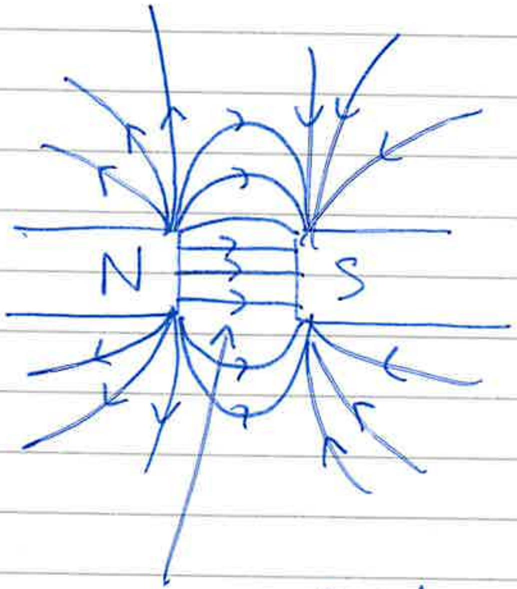
We can draw a representation of a field using a <u>Field Line Diagram</u>.



Arrows represent the direction a north pole would feel a force

Field strength is determined from the density of the lines





Magnetic Field lines always loop. They do not start and at the poles. Instead, they continue inside.

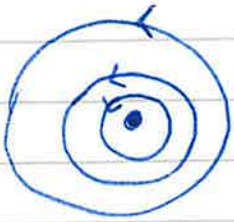
constant field strength
= uniform magnetic field

Electromagnetism

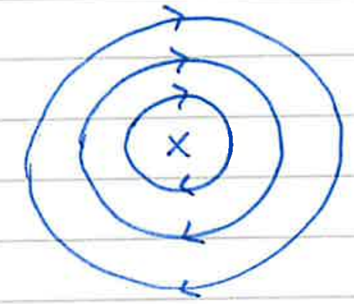
29/01/20

Currents have associated magnetic fields.

Out of the page

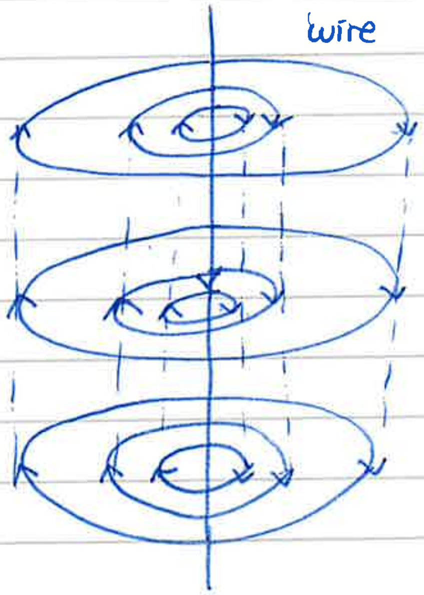


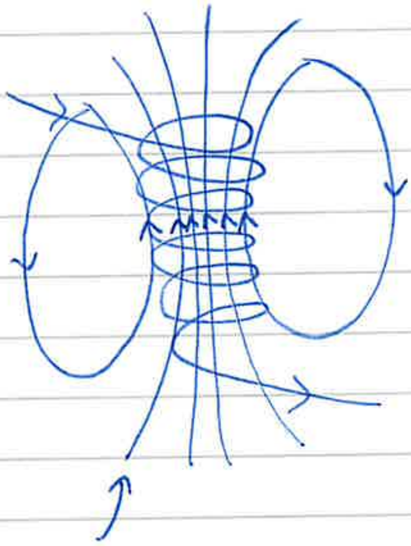
Into the page



thumb = current
finger curls in direction of field
right

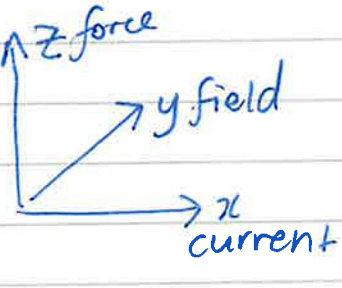
wire with current flowing down





SOLENOID

Fleming's LH rule



The 'moment' or turning effect of a force (also called a torque) is equal to the magnitude of the force multiplied by the perpendicular distance, between the line of action of the force and the axis of rotation.

Generator Effect 13/02/20

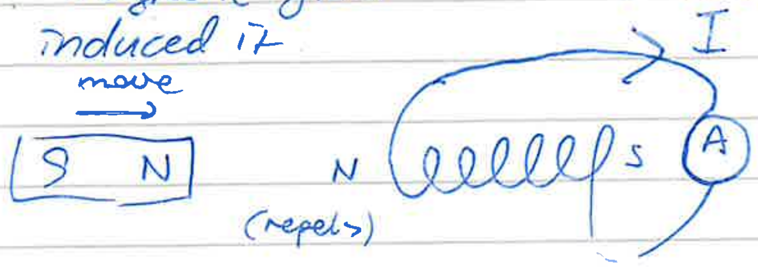
The Generator Effect otherwise known as electromagnet induction, occurs when a conducting wire moves in a magnetic field, or a 'stationary' wire is present in a changing magnetic field a voltage is induced in the wire. If there is a complete circuit, current will flow.

If the delocalised electrons in the bar are moved to the right, then they have an associated current to the ~~lft~~. A current to the left in this case would experience a force DOWN. The delocalised electrons move down. The downwards moving electrons have an associated current UPWARDS.

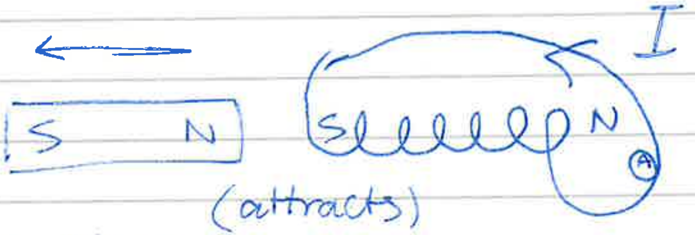
By Fleming's left hand rule the current feels a force to the left, in opposition to the original force applied to the bar

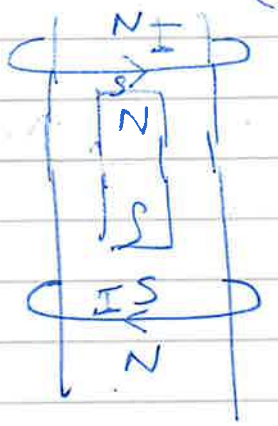
Lenz's Law 26/02/20

When a current is induced by a changing magnetic field, that current ALWAYS creates a magnetic field that OPPOSES the one that induced it



The coil creates a field such that the magnet's motion is opposed.





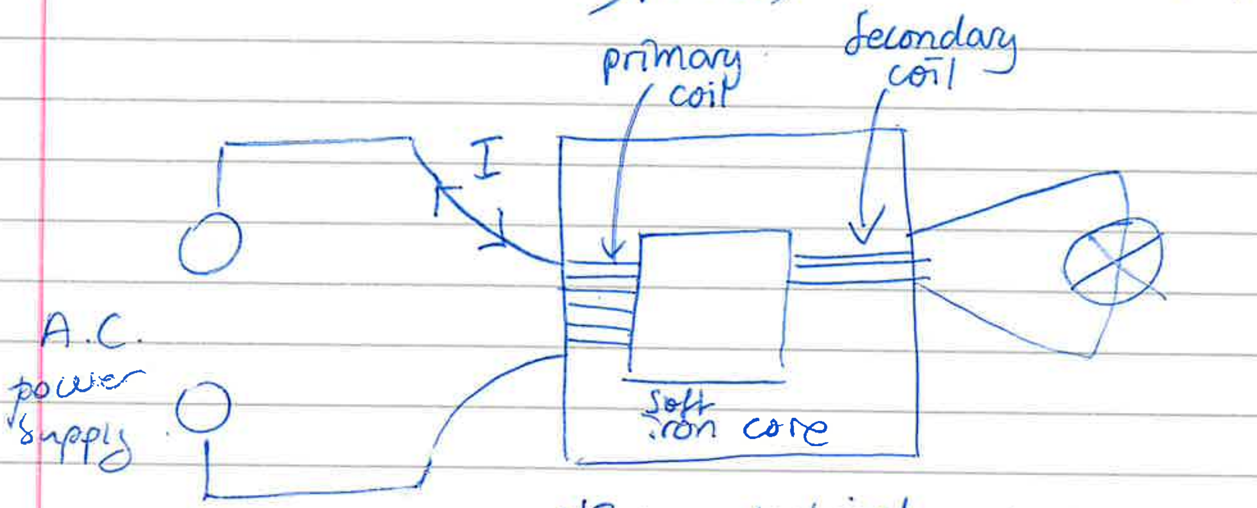
Magnet dropped into a tube of conductor metal (copper/aluminium)

All the magnets GPE is converted into Heat Energy in the tube. This is how magnetic brakes. in traichs / trains

The 'eddy currents" fields OPPOSE the motion.

Transformers

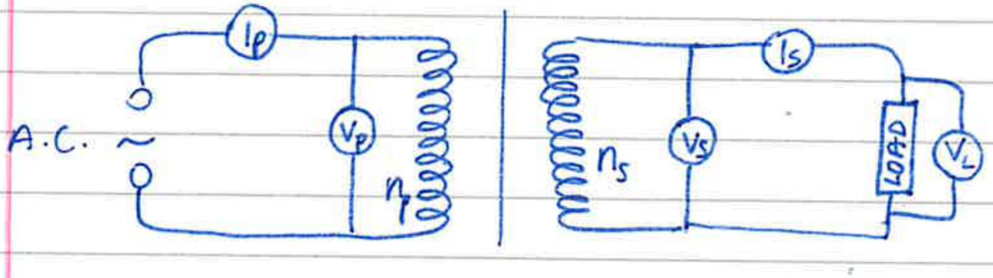
26/02/20



NB: no electrical contact between core and coils

The current in the primary coil alternates at 50Hz

The changing magnetic field in the soft iron core induces an alternating current in the secondary coil with an (amplitude) voltage that can be different depending on the number of coils.



$$\frac{V_s}{V_p} = \frac{n_s}{n_p}$$

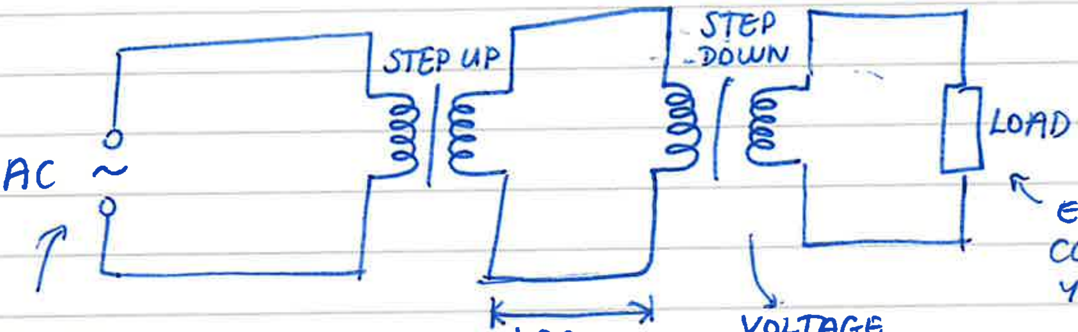
$$V_p I_p = V_s I_s$$

$V_L < V_s$

due to electrical heating of wires.

$P = I^2 R$

⇒ step up voltage to minimise current to minimise the power lost due to electrical heat.



POWER STATION GENERATES ELECTRICITY

MINIMIZE POWER LOSS ← THROUGH HEAT ENERGY USE LOW VOLTAGE.

VERY LONG HIGH VOLTAGE TRANSMISSION CABLES

VOLTAGE IS GRADUALLY STEPPED DOWN BEFORE IT REACHES YOUR HOME

ELECTRICITY CONSUMED IN YOUR HOME