JP

JP

Physics.

SI units.

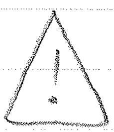
Quantity	Symbol for quantity	Unit	Unit abbreviation
length	l, d, x	metre	m
time	t	second	s
mass	m	kilogram	kg
Weight / Force	W, F	Newton	N
Work / Energy transfer	ΔE	Joule	J
Potential / Kinetic Energy	E_p, E_k	Joule	J
Charge	q, Q	Coulomb	C
Potential difference	V	Volt	V
E.M.F of a cell	$\mathcal{E}$	volt	V
Current	I	Ampère	A
Resistance	R	Ohm	Ω
Electrical Power	P	Watt	W
Mechanical Power	P	Watt	W
Frequency	f	Hertz	Hz
Moment of a force	Γ	Newton. metre	N.m

Prefixes

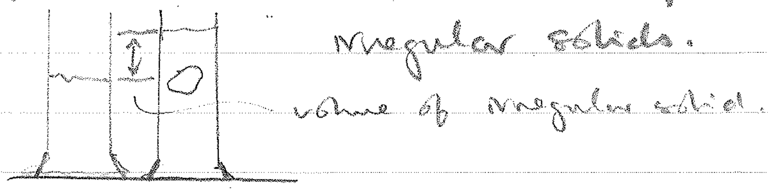
G	M	k	c	m	μ	n
giga-	mega-	kilo-	centi-	milli-	micro-	nano-
$\times 10^{+9}$	$\times 10^{+6}$	$\times 10^{+3}$	$\times 10^{-2}$	$\times 10^{-3}$	$\times 10^{-6}$	$\times 10^{-9}$
billions	millions	thousands	hundredths	thousandths	millionths	billionths

Density : Symbol ρ

$$\rho = \frac{\text{mass}}{\text{volume}} \quad \text{in } kg/m^3$$



Don't forget displacement vessel method for irregular solids.



JP

Distance, speed, acceleration, Force.

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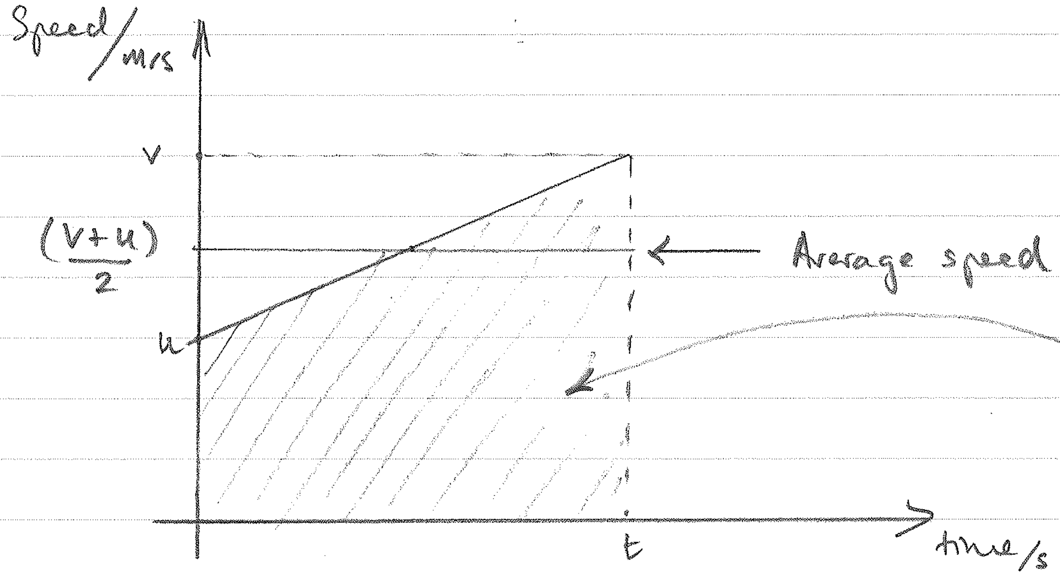
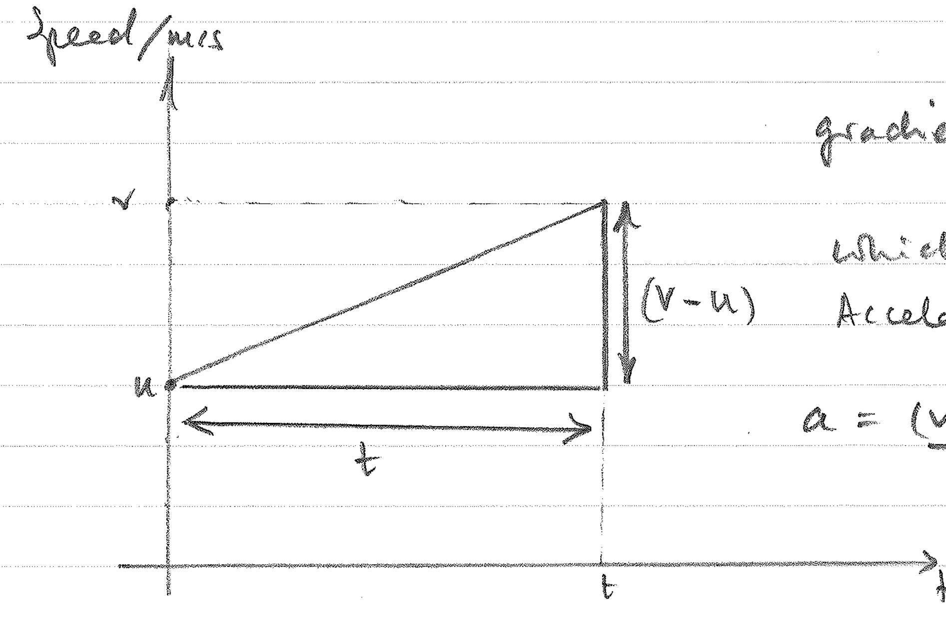
Average speed = $\frac{\text{distance}}{\text{time}}$ => distance = Average speed x time



distance = Average speed x time

$= \frac{(v+u)}{2} \times t$ = area of trapezium

* Distance travelled is area under a speed-time graph.



gradient = $\frac{(v-u)}{t}$

which is Acceleration.

$a = \frac{(v-u)}{t}$

* Acceleration is the gradient of a speed-time graph.

JP JP

Force = mass × acceleration
(N) (kg) (m/s²)

$F = m \times a$

Weight = mass × gravitational field strength.
(N) (kg) (N/kg) → This is 10N/kg on the Earth.

$W = m \times g$

<u>Work, Energy, Power (Mechanical)</u>

* (Work or transfer of mechanical energy) = Force × (distance moved in the direction of the force)

$\Delta E = F \times d$
(J) (N) (m)

* (Change in gravitational potential Energy) = mass × (gravitational field strength) × (change in height)

$\Delta E_p = m \times g \times \Delta h$
(J) = (kg) (N/kg) (m)

* Kinetic Energy = $\frac{1}{2}$ × mass × (speed)²

$E_k = \frac{1}{2} \times m \times v^2$
(J) = (kg) (m/s)²

JP JP

* Mechanical Power = $\frac{\text{Mechanical Work done}}{\text{time taken}}$

$$P = \frac{\Delta E}{t}$$

$$(W) = (J/s)$$

* Efficiency = $\frac{\text{Work out}}{\text{Work in}}$ = $\frac{\text{Power out}}{\text{Power in}}$

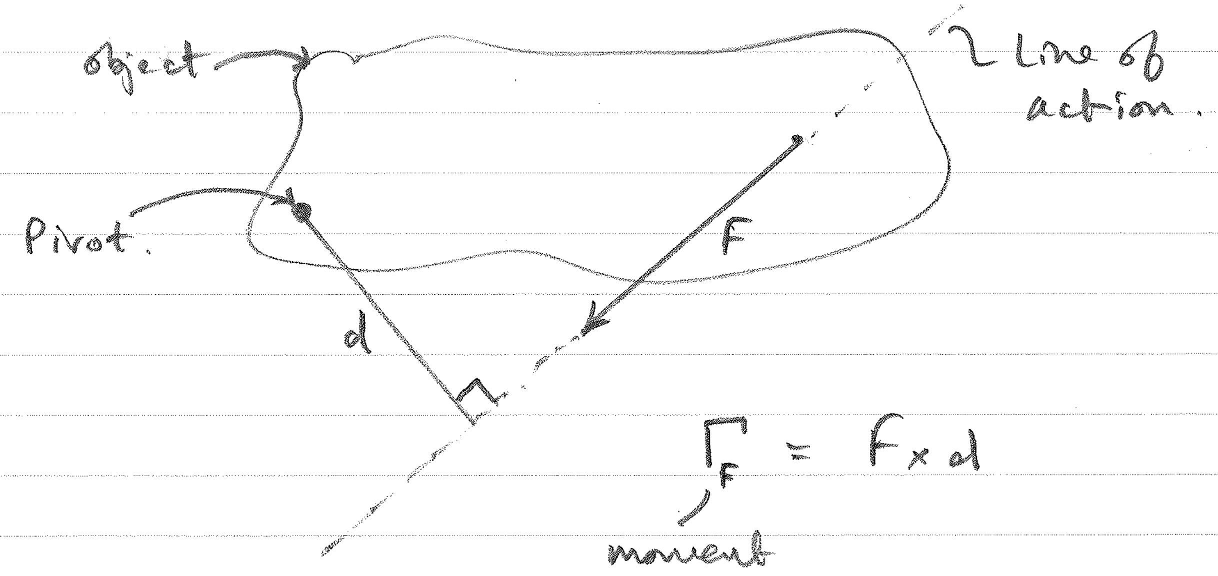
× 100 to get a %

<u>Mechanics</u>

* Resultant Force = mass × acceleration

<u>No</u> acceleration if there is <u>no</u> resultant force.

* (Moment about a pivot) = Force × (perpendicular distance of line of action of force from pivot)



$\Gamma_F = F \times d$

moment of F

* Equilibrium occurs if

$$\Gamma_A = \Gamma_C$$

Anticlockwise moments — Clockwise moments

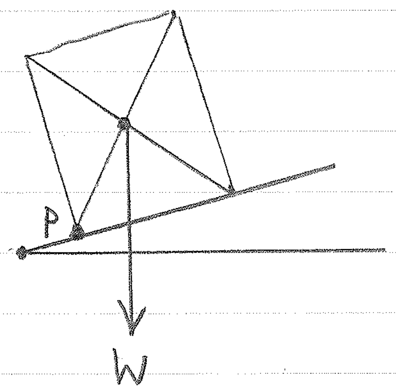
&

if

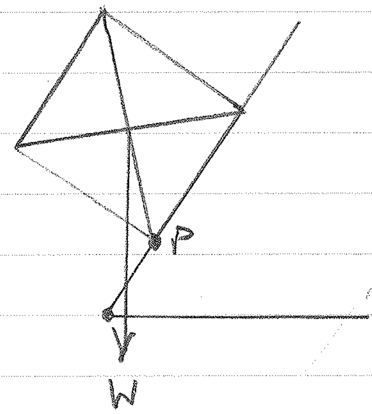
There are no resultant Forces.

∴ Bodies in equilibrium will not ROTATE or ACCELERATE.

* Stability



Will not topple.



Will topple.

P is like a pivot pt.

JP

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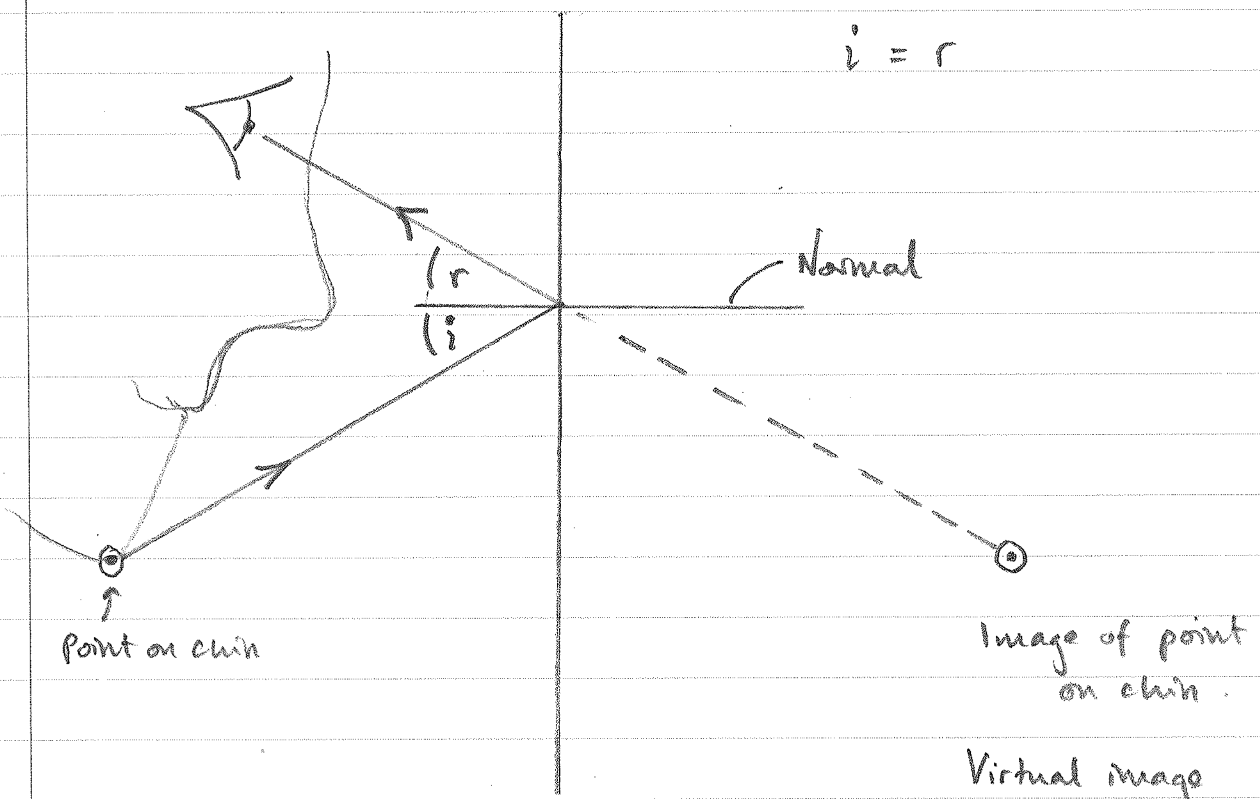
Optics

Laws of reflection

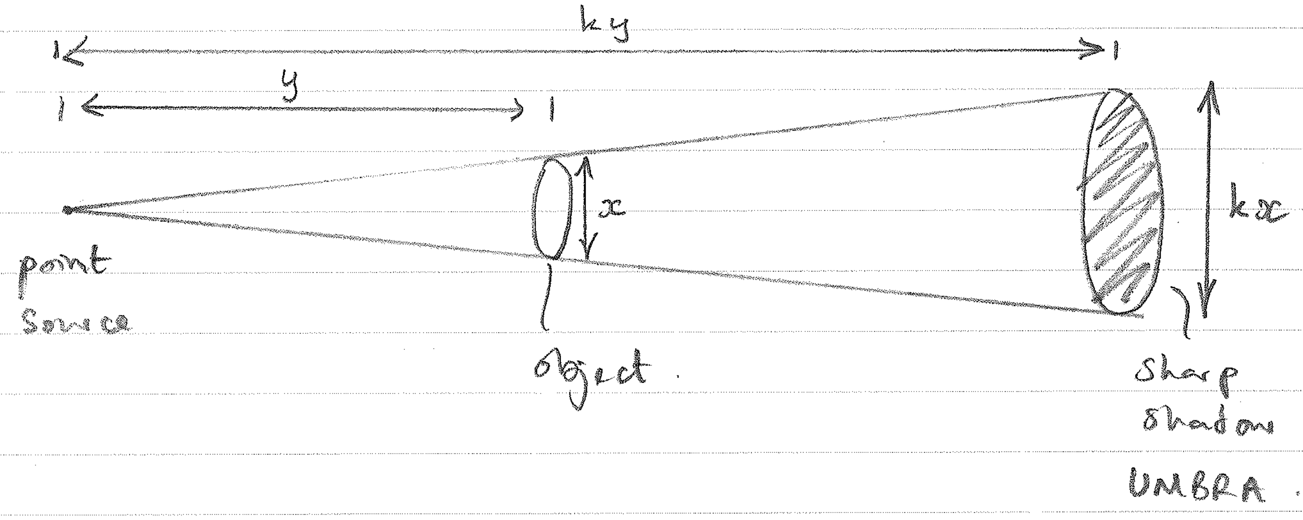
(i) incident angle = reflection angle

(ii) incident ray, reflected ray and normal all lie in the same plane.



Virtual image
As rays only appear to come from here.

Shadows : Remember: Similar triangles.



JP

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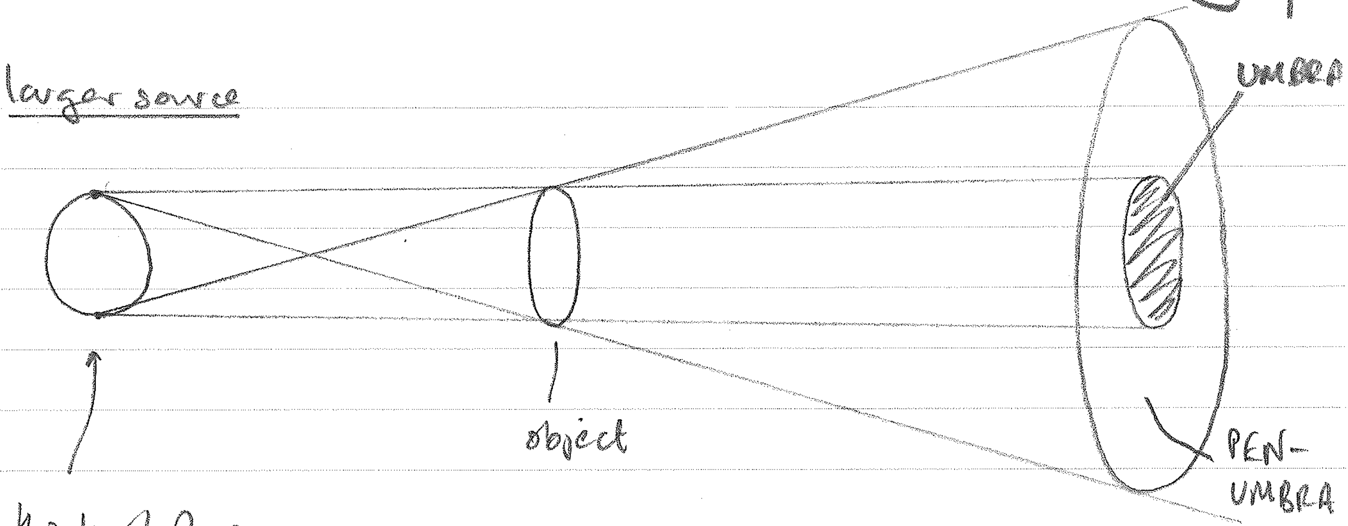
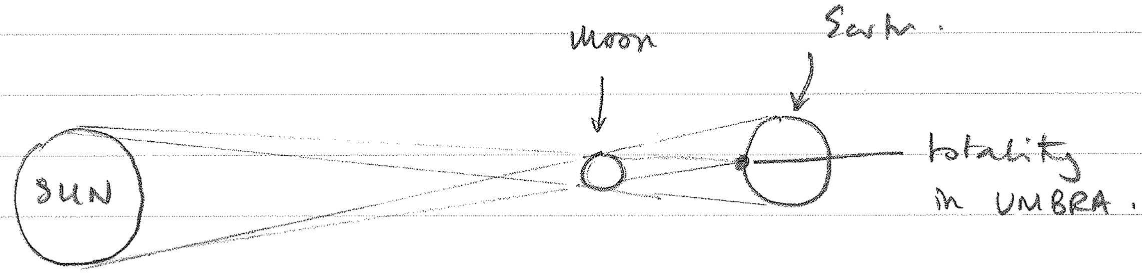
larger source



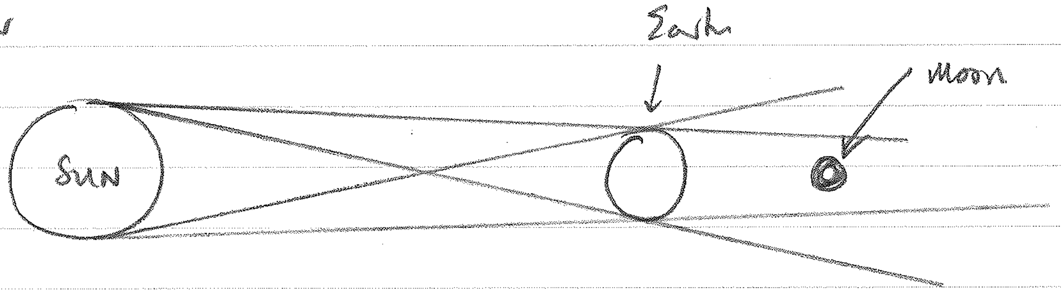
think of it as
made up of
lots of pt sources

Eclipses NA to scale.

Solar



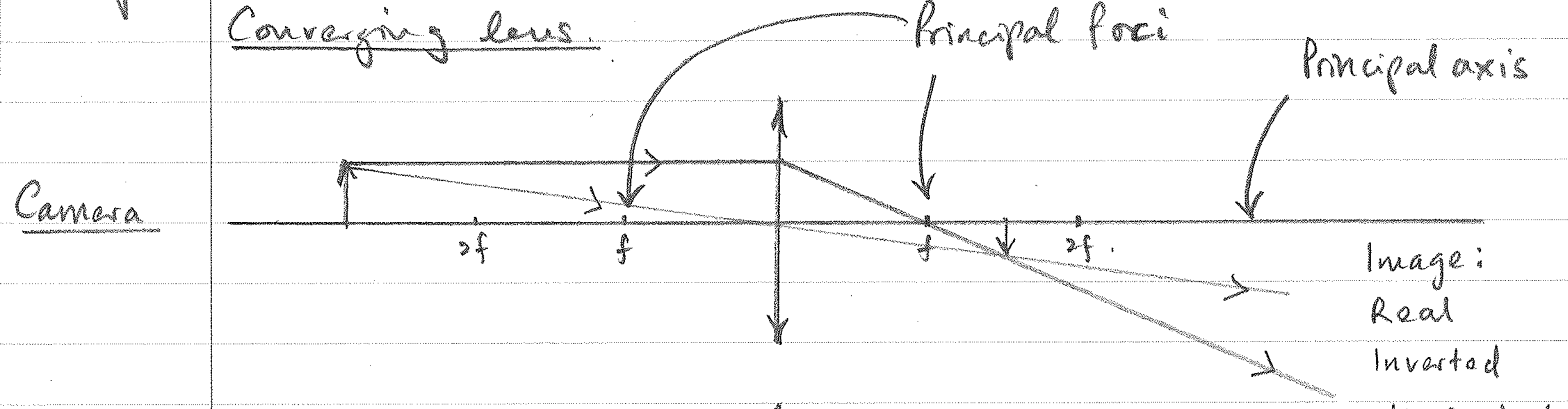
Lunar

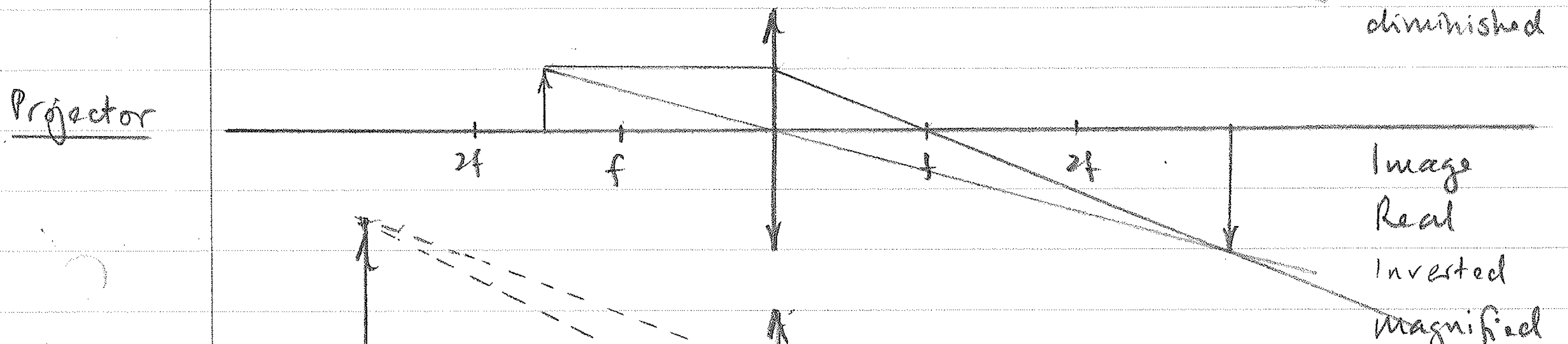


Can have total
and partial lunar
eclipses depending
on whether moon
passes into UMBRA
or PENUMBRA.

JP JP

Converging lens.





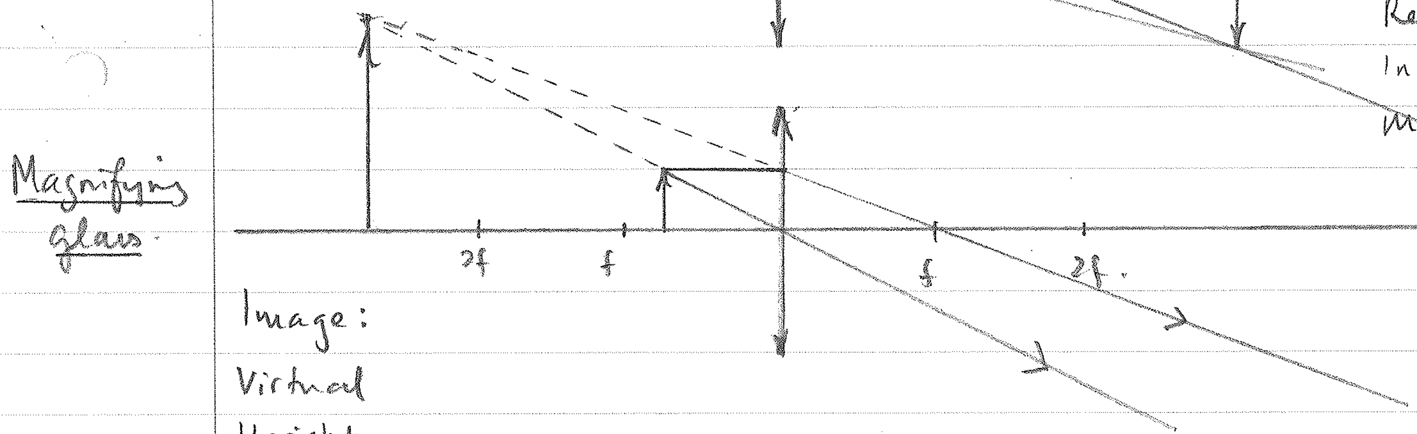
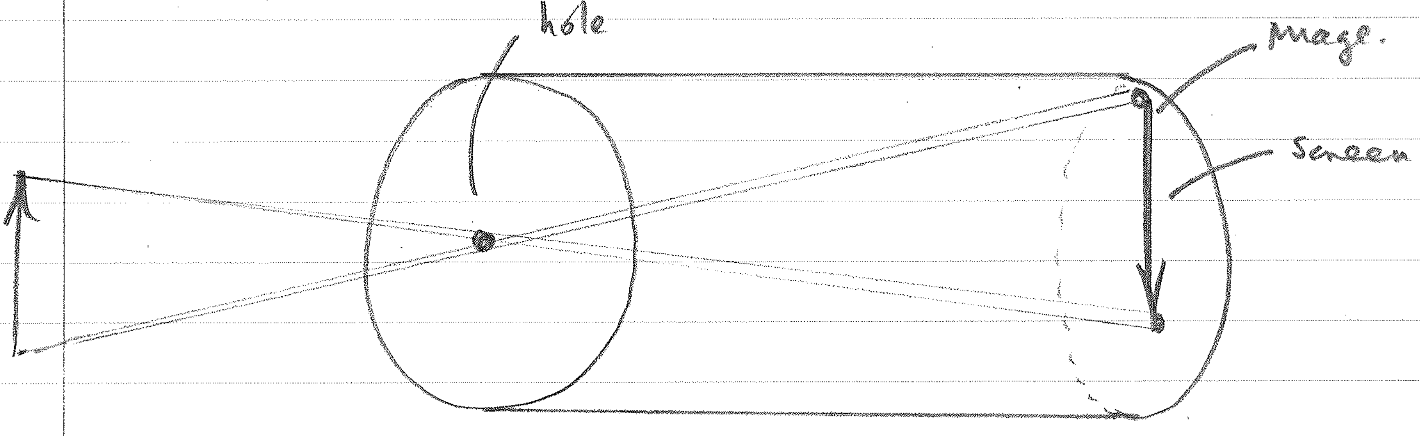


Image:
Virtual
Upright
Magnified.

Pin-hole Camera.



Putting another hole in front would lead to a separate image. ∴ a large hole is like lots of little holes next to each other and would ∴ cause lots of images to overlap. ∴ Image is blurred from a larger hole.

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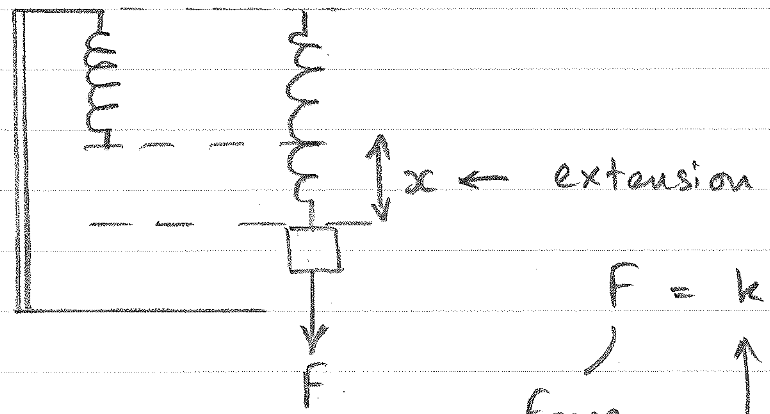
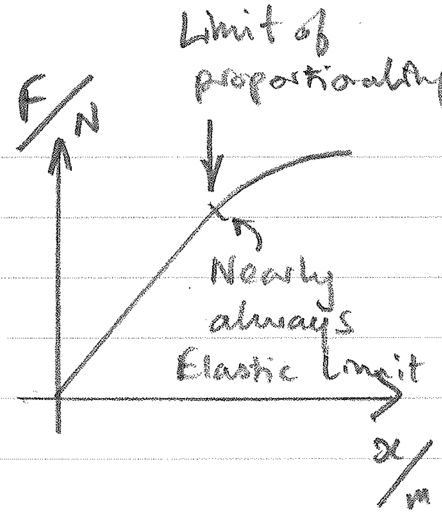
Hooke's law





$$F = kx$$

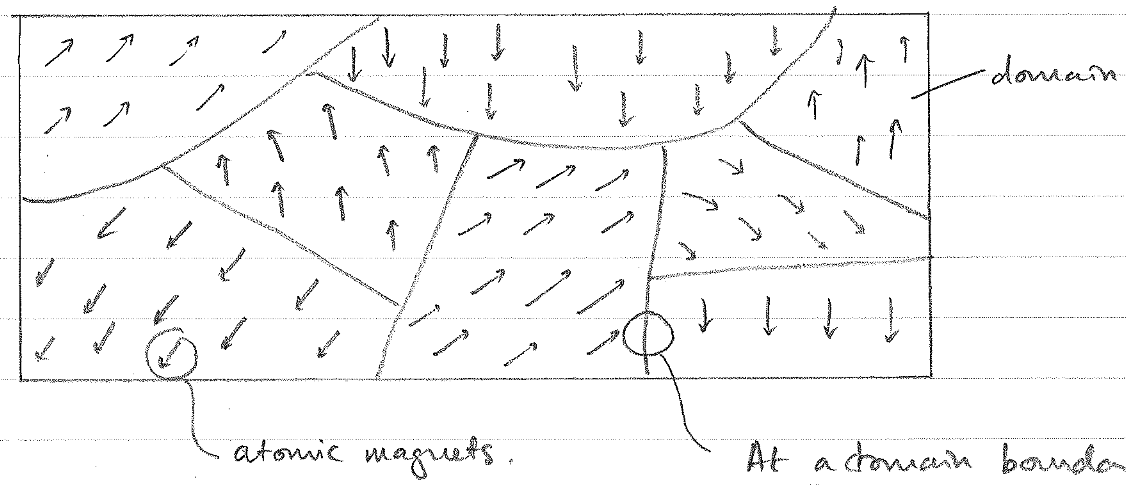
F: Force (N)
k: Stiffness of spring (N/m)
x: extension (m)

Elastic : goes back to original shape when deformed

Plastic : does not go back to original shape when deformed.

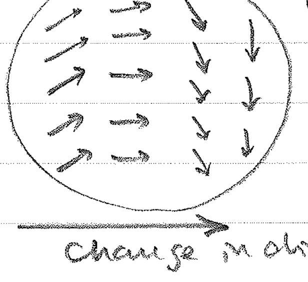
Hard and Soft magnetic materials

Magnetic material made up of domains.



At a domain boundary there is a gradual change in direction of atomic magnets.

Bar is magnetised when all the atomic magnets in all the domains line up.



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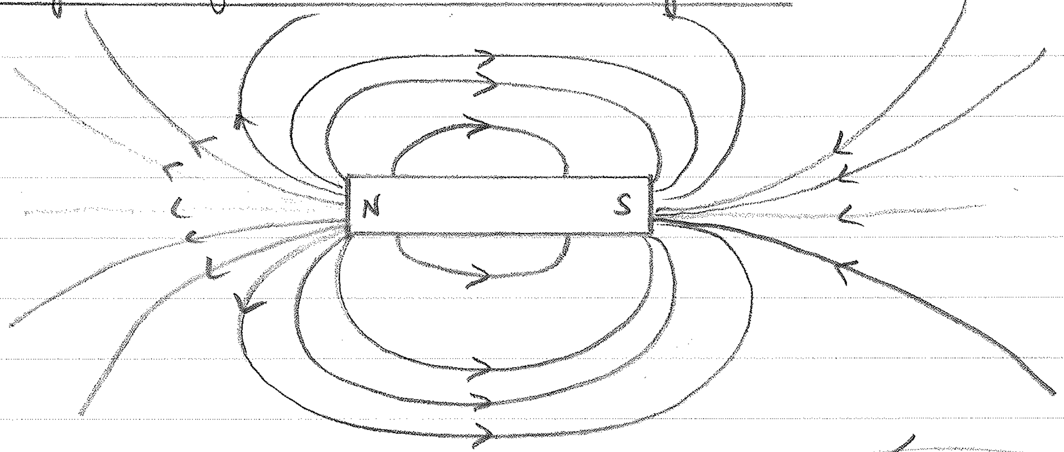
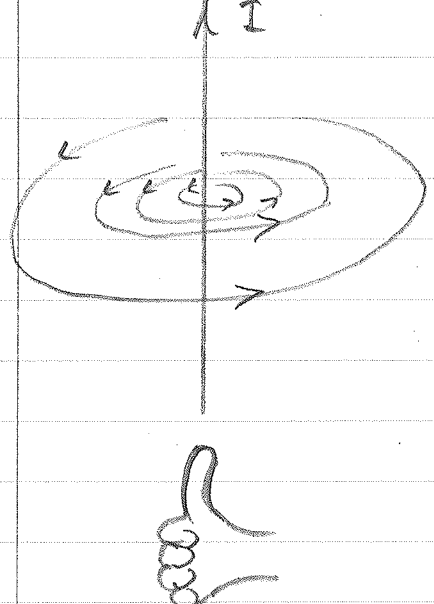
- In soft magnetic materials these boundaries move quite freely as the material is usually soft Iron so the bar is easily magnetised and de-magnetised.

- In Hard magnetic materials the boundaries don't move quite so freely. Hard magnetic materials have impurities that disrupt the movement of these boundaries. Example of this sort of material is Steel (Iron, with carbon impurities). Therefore Hard magnetic materials are harder to magnetize, but are also harder to demagnetise.

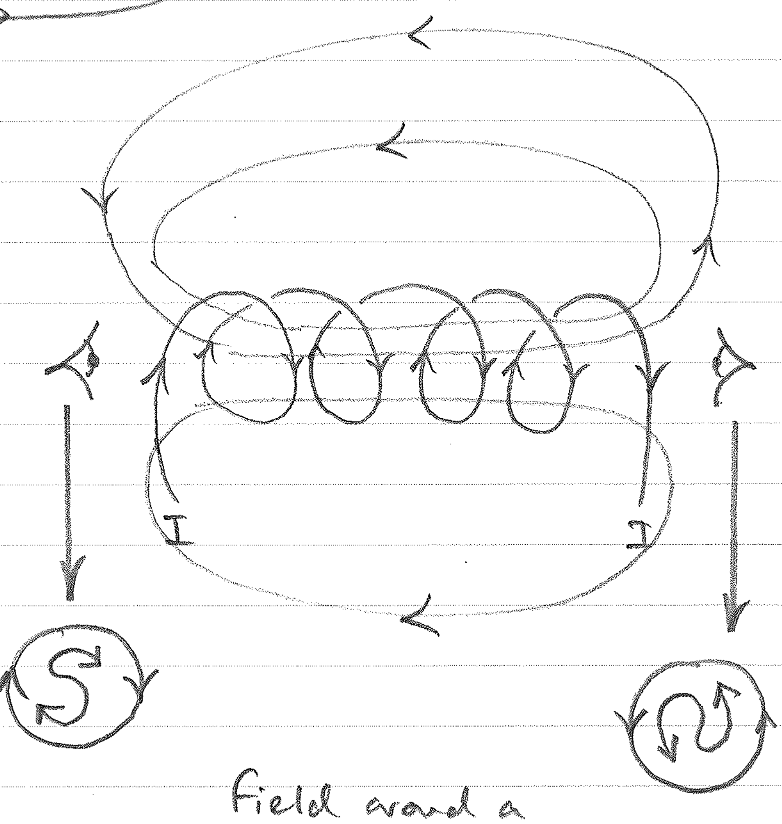
Magnetic field around bar magnets.



Field around wires



Right-hand grip



Field around a solenoid.

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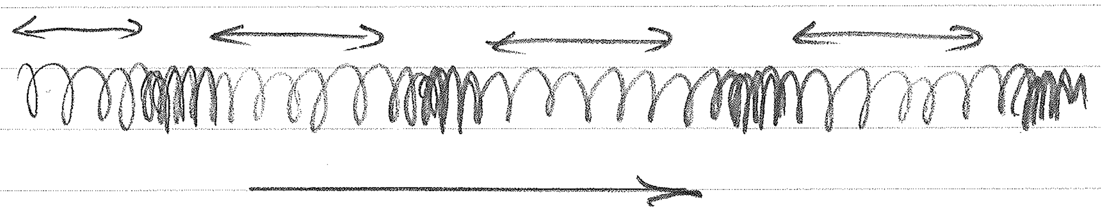
<u>Waves, light and Sound.</u>

PROPAGATION implies passage through something.

Slinky waves:

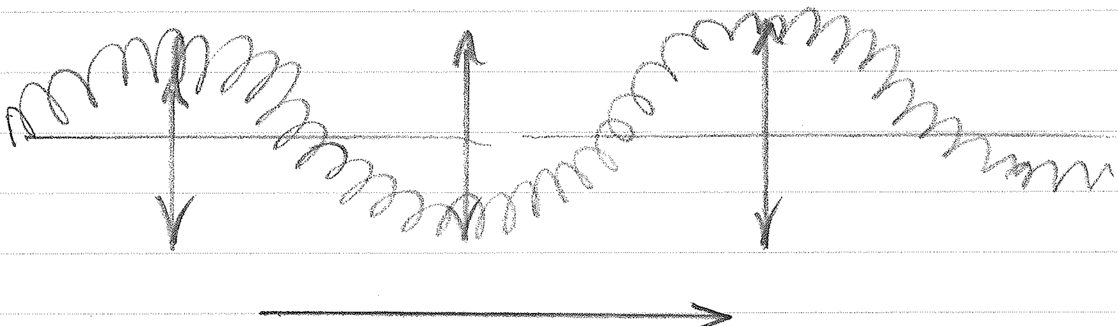
Longitudinal



Direction of propagation

- oscillations <u>along</u> the direction of propagation

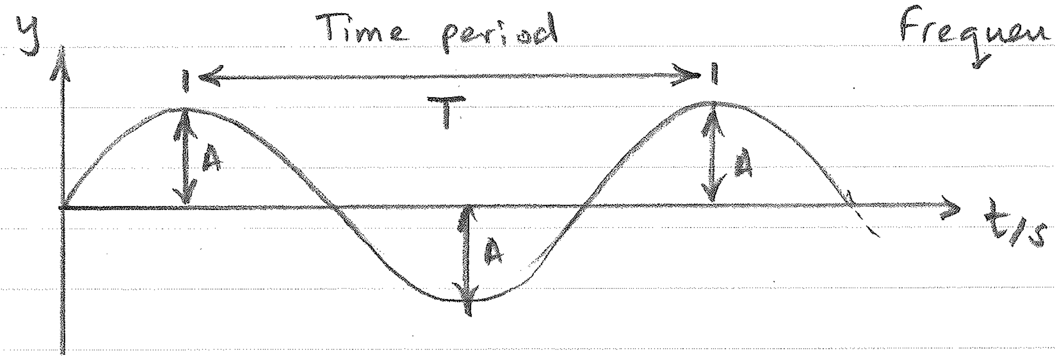
Transverse



Direction of propagation

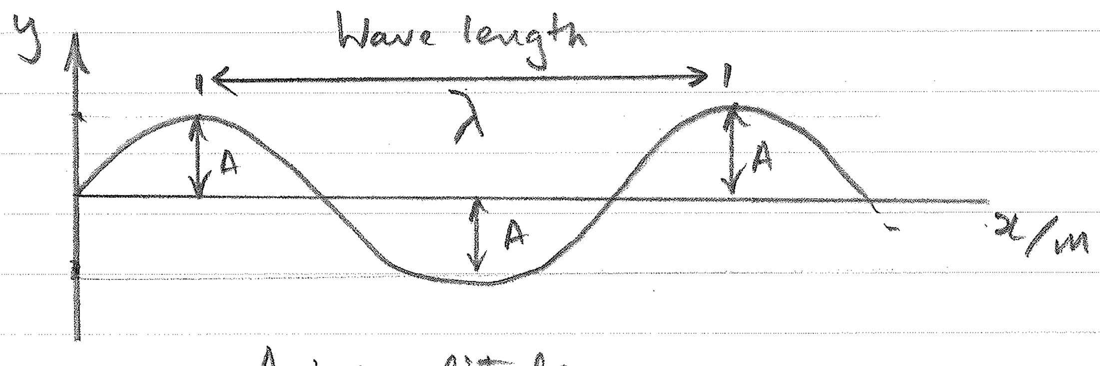
- oscillations perpendicular to the direction of propagation.

Wave in time



Frequency = $\frac{1}{T}$

Wave in space.



A : amplitude.

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Speed of a wave = frequency x wavelength

$$v = f \times \lambda$$

(m/s) (Hz) (m)

Typical speeds for sound in air : 330 m/s

in water : 1500 m/s

in steel : 5000 m/s.

Not to be tested, but might help to see why.

$$v = \sqrt{\frac{E}{\rho}}$$

E ← Elastic modulus

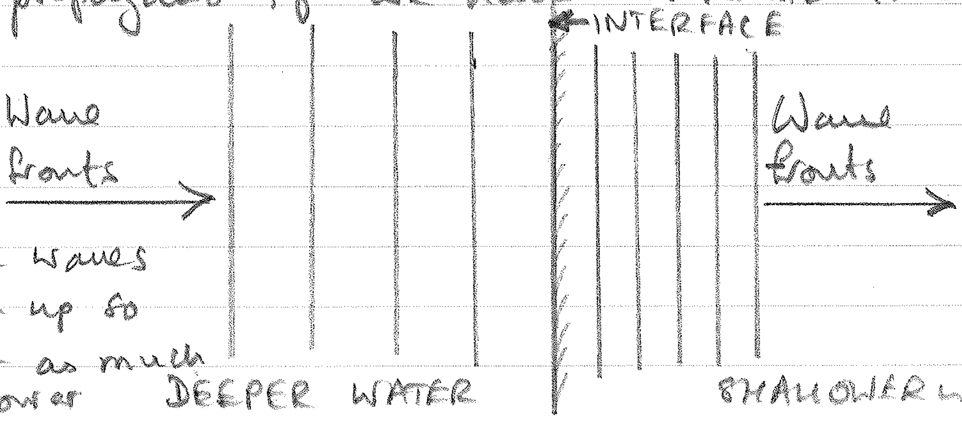
ρ ← density.

ρ increases going from gas → solid

E increases FASTER!

Refraction

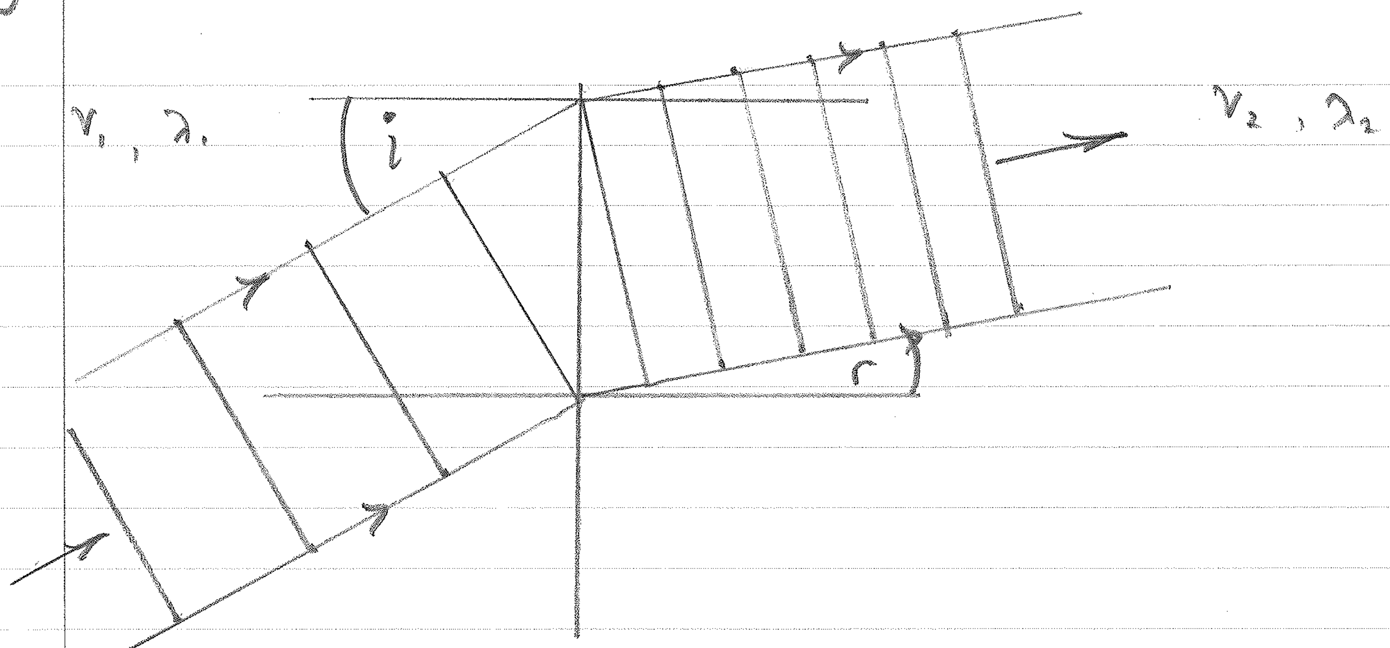
A change in speed of propagation can lead to a change in direction of propagation. This is called REFRACTION. There is no change in direction of propagation if we have NORMAL INCIDENCE:



Water ripples move more slowly over shallower water.

⚠ Notice waves bunch up so λ shorter as much as speed lower

JP



ratio of speeds = ratio of wavelengths = refractive index

$$\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = n$$

n also given by angles i and r

$$n = \frac{\sin(i)}{\sin(r)}$$

Electricity and Magnetism

* 1 amp = 1 coulomb per second

1 A = 1 C/s

* 1 volt = 1 joule per coulomb

1 V = 1 J/C

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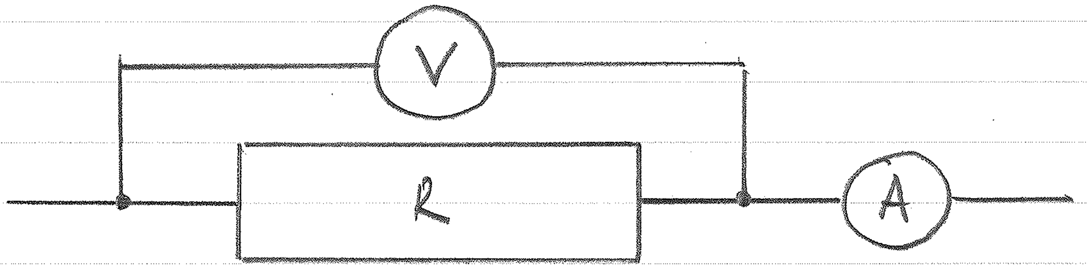
Electrical power = $\frac{\text{Electrical energy transferred}}{\text{time taken to make transfer}}$

$$(W) = \frac{(J)}{(s)}$$

* 1 W = 1 J/s



If p.d. across R is V and current through R is I then:

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

$$(\Omega) = \frac{(V)}{(A)}$$

Power here is the rate of electrical energy transfer from the electrical field in the circuit to heat dissipated into the surroundings.

POWER = P.d × current

$$P = V \times I$$

P → Energy transferred per unit time

V → Energy transferred by each coulomb as it passes through the resistor

I → The number of coulombs passing through the resistor per second.

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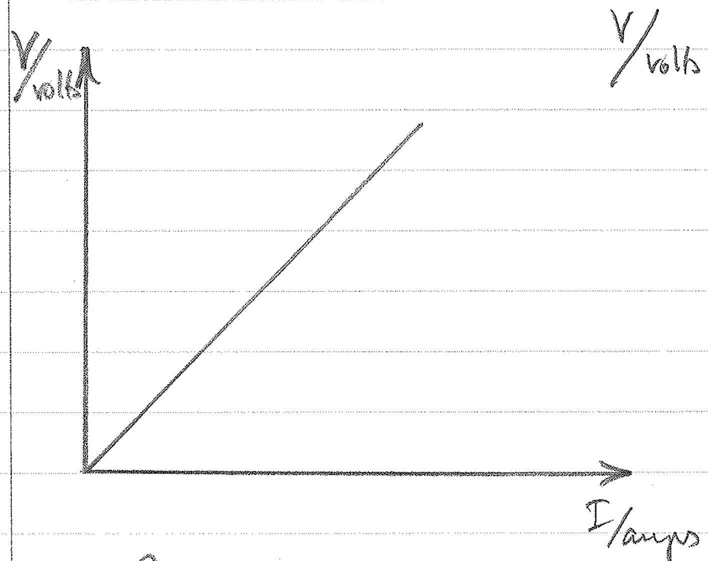
So, Electrical energy transferred is given by:

Electrical Energy (J) = $V \times I \times t$

- V — p.d
- I — current
- t — time. (seconds)

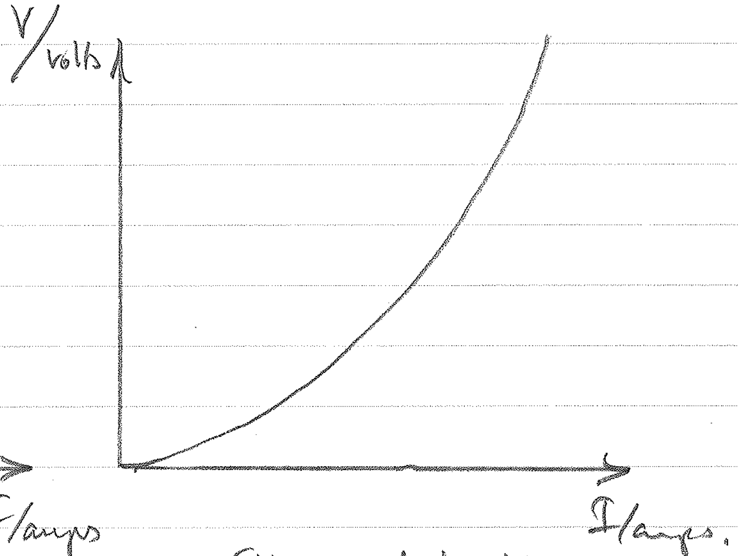
$V \times I$ = power (J/s)

V - I characteristics



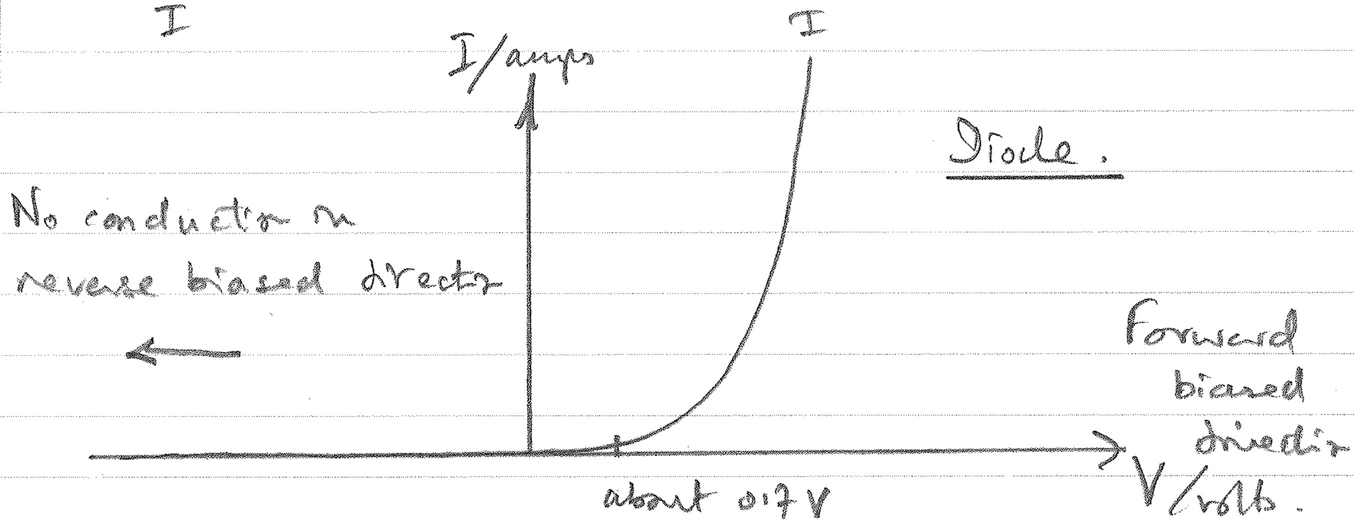
Resistor

$\frac{V}{I}$ constant



Filament bulb

$\frac{V}{I}$ rises as I rises



no conduction until we pass a minimum, then $\frac{V}{I}$ ↓ as I ↑

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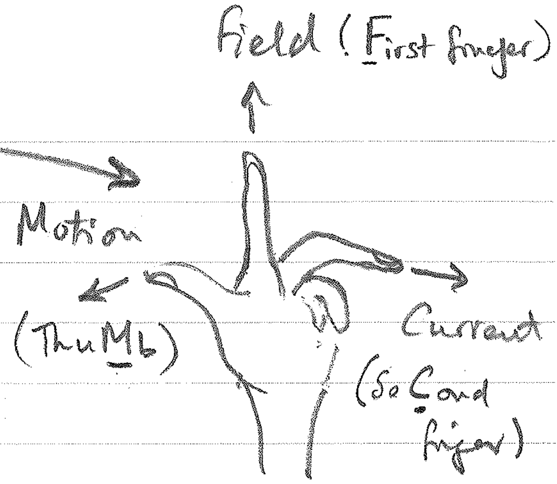
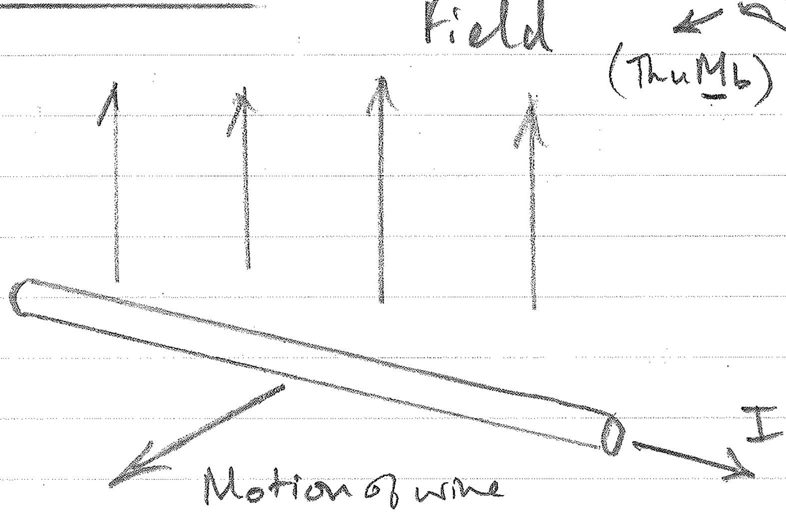
Electromagnetism

Left-hand rule.





D.C. motor : look up details on your card board model.

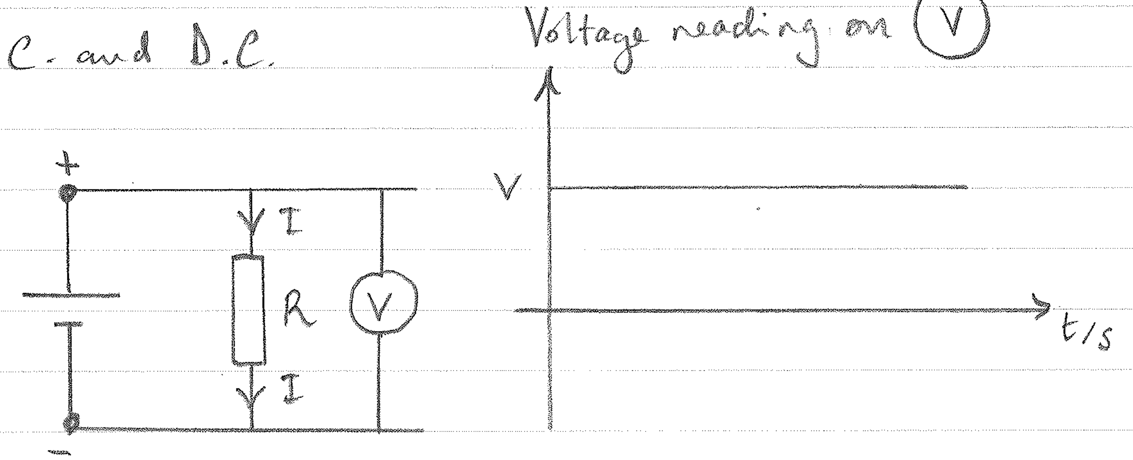
MP

Physics.

Electricity and Magnetism

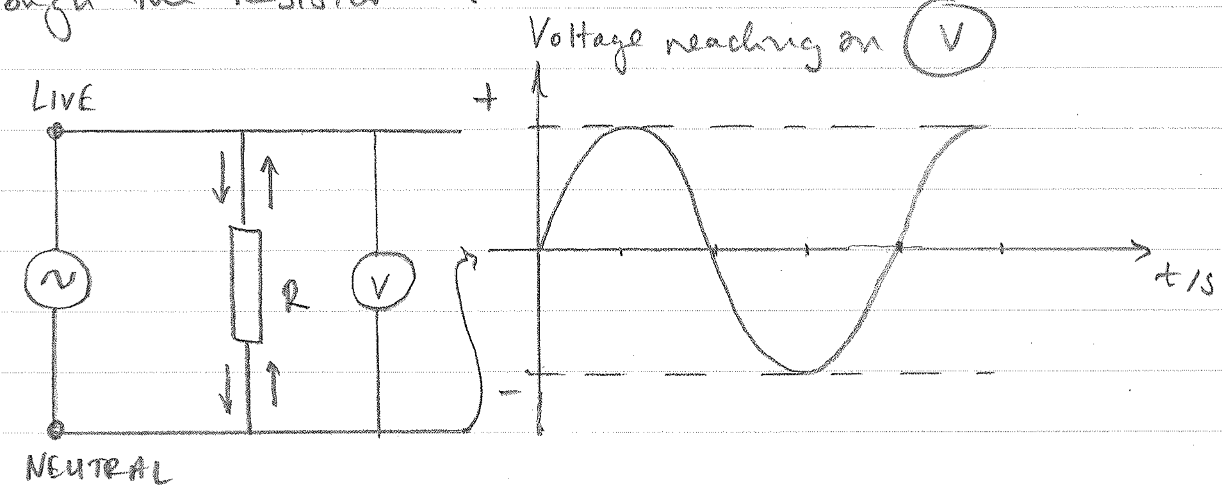
A.C. and D.C.

D.C.



D.C. as this would lead to a Direct Current, I, through the resistor R.

A.C.



ZERO volts is the REFERENCE point called NEUTRAL. The voltage reading on the voltmeter can now go positive or negative with respect to the ZERO VOLTS REFERENCE called NEUTRAL.

However, because the voltage across the resistor can now be positive and negative, the current will flow back and forth as shown, as it is the direction of this voltage that drives the current in the first place

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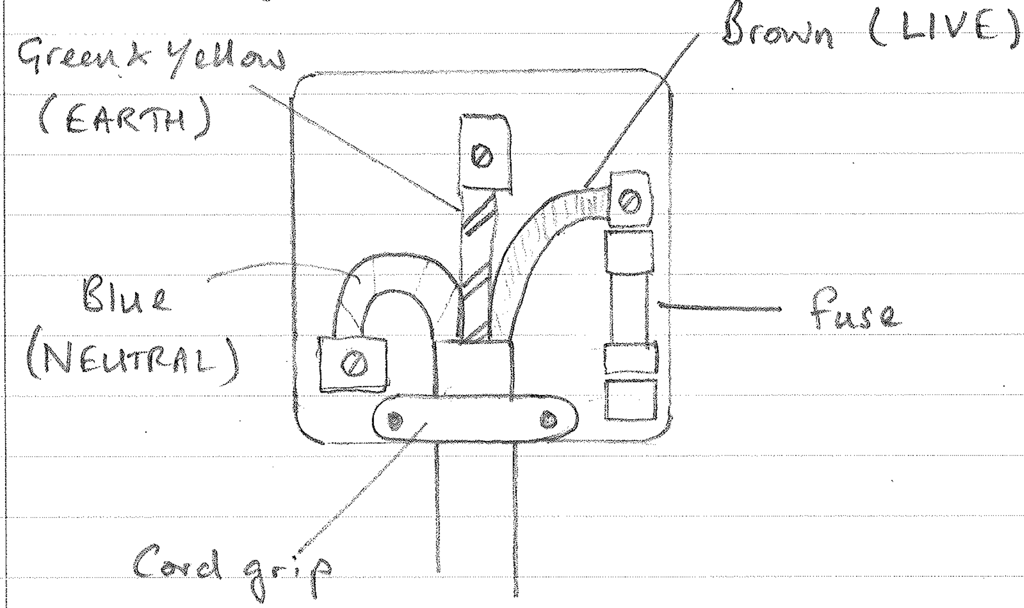
3-pin plug



Fuse

The fuse works by melting when the current exceeds a certain threshold, which might occur when there is a fault. Most of the time this occurs when the insulation in the flex breaks down (due to excessive flexing) and LIVE and NEUTRAL wires touch. When this happens a very large current passes and the flex catches fire. We have to make sure the rating of the fuse is right.

Use Electrical power = I × V

Electrical power → Power rating on side of appliance.

I → current to be calculated

V → voltage (230V for domestic supply)

then choose a fuse of appropiate current.

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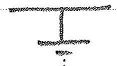
Earth



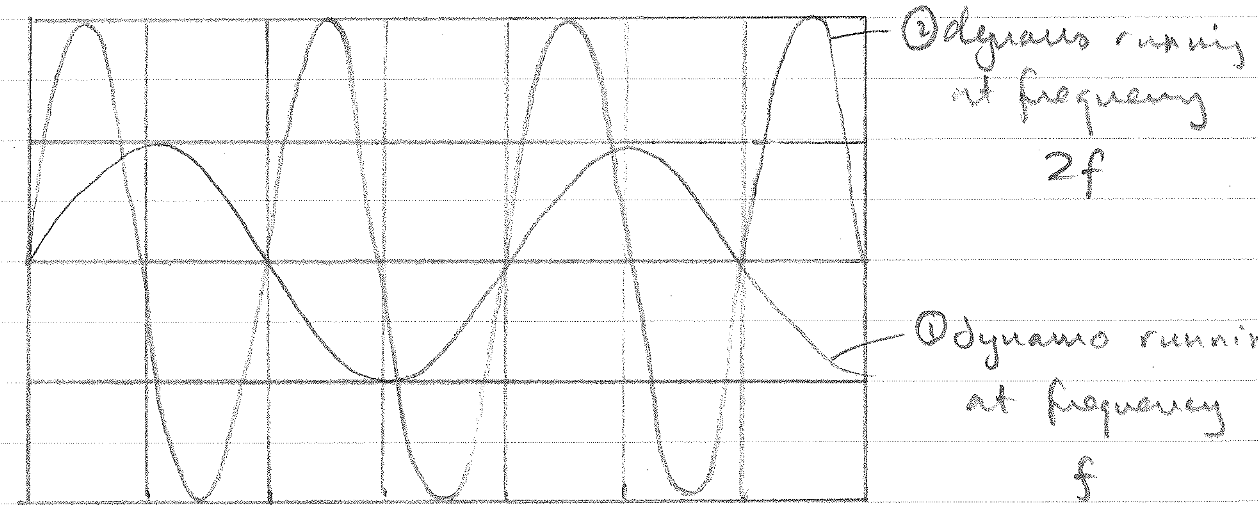
If an appliance has a metal casing then it's prudent to attach the casing to Earth. By doing this we make the casing always at Earth potential so that if ever a live wire were to become loose and make contact with the casing a large current would instantly flow blowing the fuse. The connection to 'Earth' is made via the Earth wire.

EM induction (Electromagnetic induction)

FARADAY'S LAW OF EM INDUCTION (+ LENZ'S LAW)

The E.M.F induced in a coil is proportional to the rate of change of magnetic field through the coil **and** IS ALWAYS INDUCED IN SUCH A WAY AS TO OPPOSE THE CHANGE PRODUCING IT.

The p.d. across a dynamo looked like this:



Y-amplification here is 1 V per division

Time base is 1 ms / div.

Signal ① amplitude = 1 division (in the vertical direction)
time period = 4 divisions to repeat a wave

MP

Signal ① has a time period of 4 div. × 1 ms/div

$= 4\ ms$

$\therefore$ frequency $= \dfrac{1}{4\ ms} = \dfrac{1}{4 \times 10^{-3} s} = 0.25 \times 10^{3} Hz$

$= \underline{250\ Hz}$

$\therefore$ Signal ① is a 250 Hz signal of amplitude 1V.

Signal ② repeats after 2 divisions so its frequency is <u>500Hz</u>

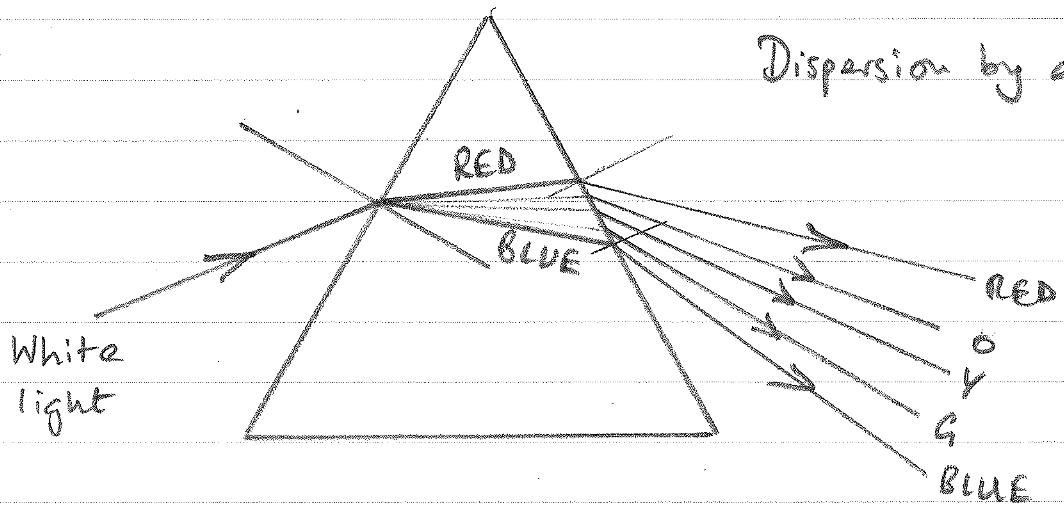
⚠ Notice its amplitude is 2V because the magnetic field through the coil in the dynamo is changing <u>twice</u> as fast so the E.M.F induced has <u>twice</u> the amplitude.

<u>Waves and Optics</u>

See JP notes "Optics" and "Waves, light and Sound".

<u>Dispersion</u> : Basically blue light travels slower in glass than red light so it is <u>refracted</u> more.

Dispersion by a prism.



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Monochromatic: light of one frequency (one colour)

Electromagnetic Spectrum

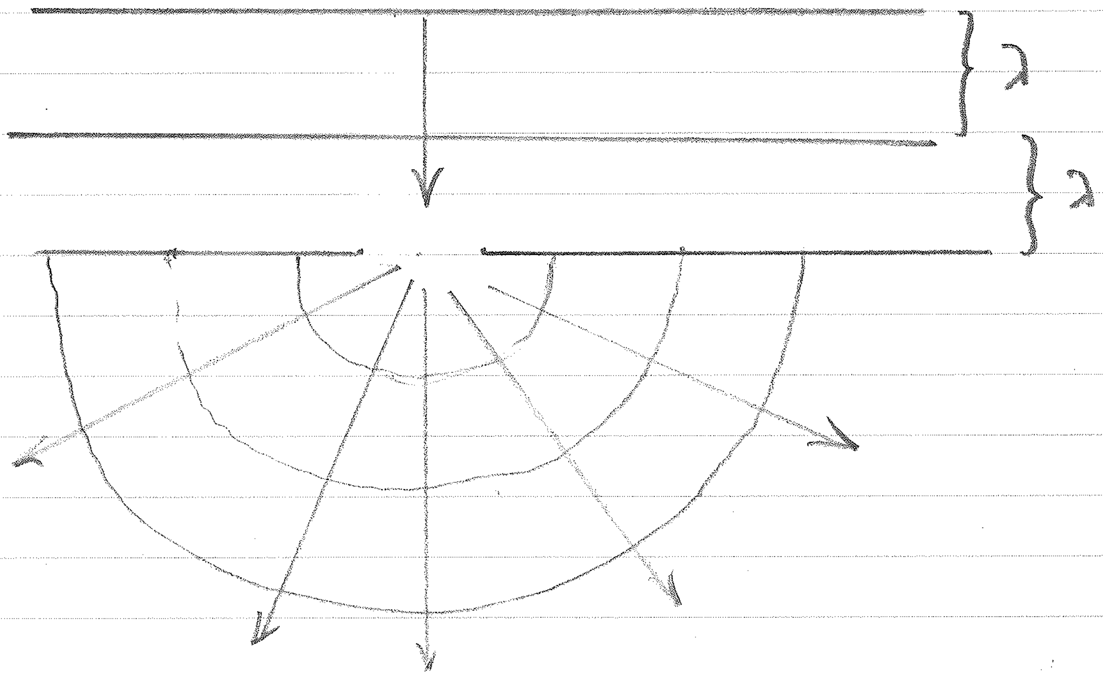
See Waves, light and Sound

Name	Wavelength in air in metres	Uses
γ ray	$10^{-13} - 10^{-11}$	Medicine tracer and cancer treatment
X-ray	$10^{-12} - 10^{-8}$	Medical imaging
U-V	$10^{-8} - 10^{-7}$	Spectroscopy
Visible light	$(4-7) \times 10^{-7}$	Photography
I-R	$10^{-7} - 10^{-3}$	heating, photography
Micro waves	$10^{-3} - 10^{2}$	Cooking, communications
Radio	$10^{2} - 10^{5}$	Communication.

MP

Diffraction.

When a gap is of a size that is about the same as the wave length of a plane wave we get:



Waves spread out! This is DIFFRACTION

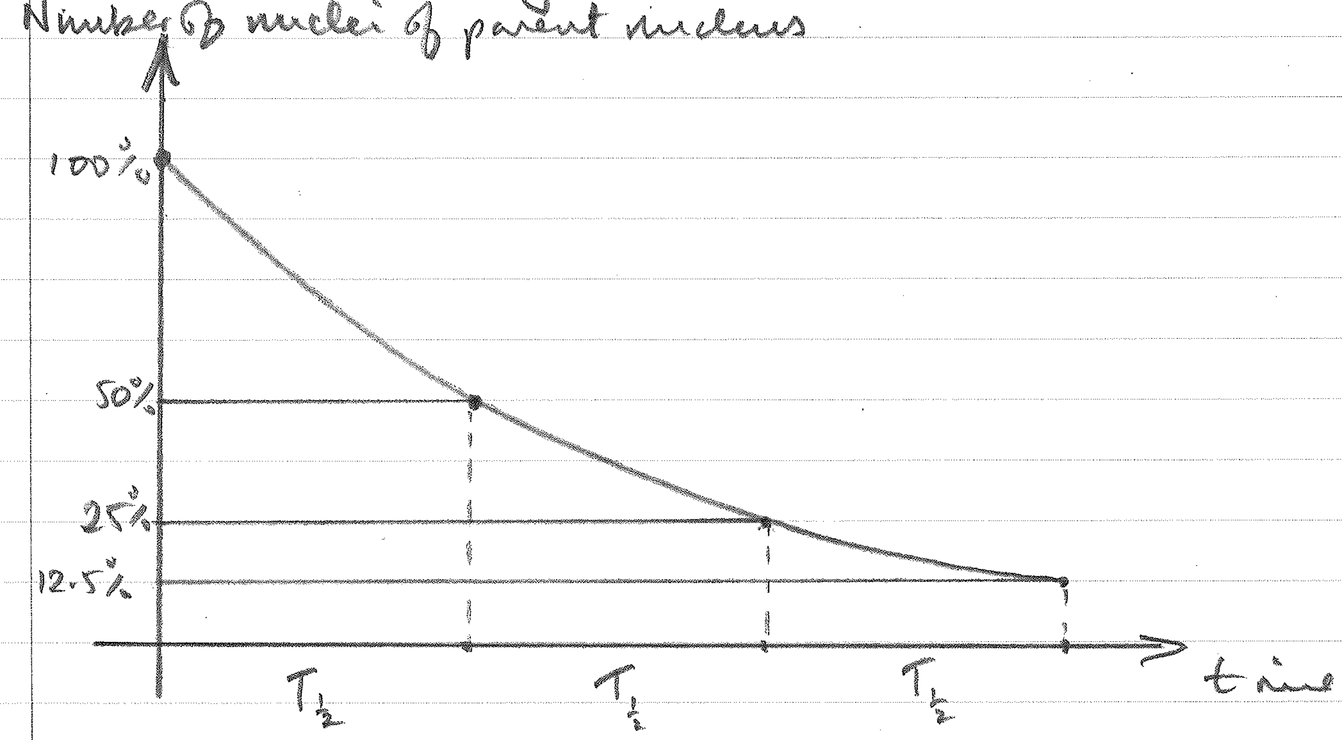
Light does not diffract around corners because its wave length is very short ($4-7 \times 10^{-7}$ m), BUT sound and radio waves certainly do diffract around buildings and hills.

REMEMBER:

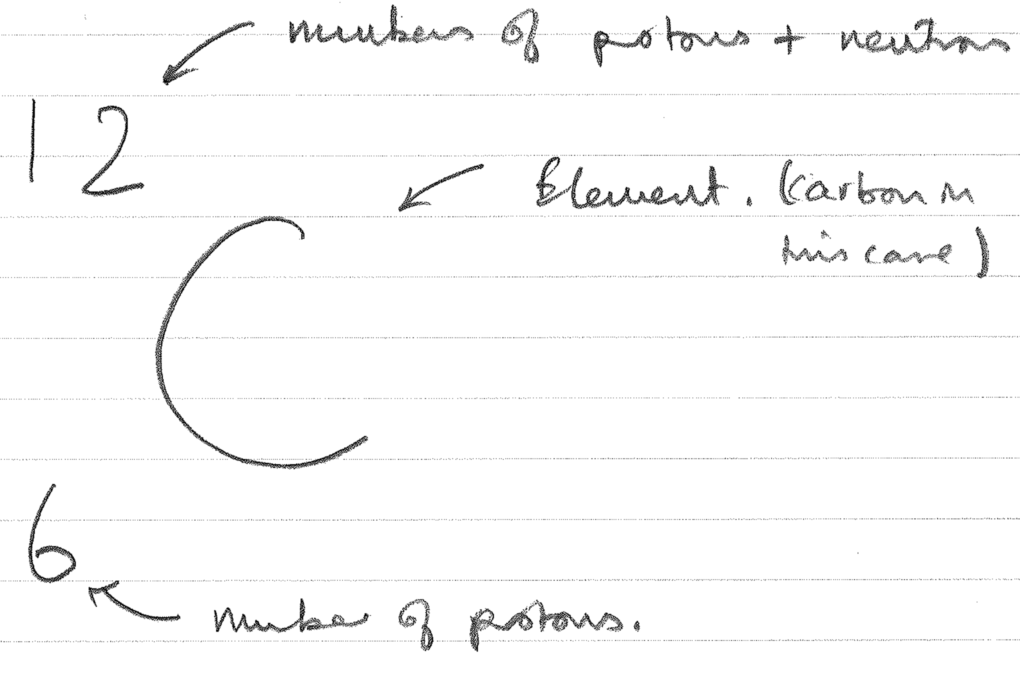
- Light is an electromagnetic wave that is TRANSVERSE and moves at 3×10^8 m/s (This is true of RADIO waves as well!)
- Sound is a LONGITUDINAL pressure wave

MP

Radioactive decay



$T_{\frac{1}{2}}$: half life, time for $\frac{1}{2}$ of the original number of nuclei to decay.
After 3 half-lives we have 12.5% of the original.



MP

Atomic and Nuclear physics.

α, β, γ

Radiation	Composition	
α	Helium nucleus	2 protons and 2 neutrons
β	electron	-
γ	Electromagnetic wave of v.high frequency.	-

α : highly ionising ∴ not very penetrating
stopped by paper or a few cm of air

β : less ionising than α ∴ more penetrating
stopped by few mm of Al.

γ : less ionising still ∴ v. penetrating
stopped by lead or concrete.

__Background and Safety:__ Most of background radiation comes from natural sources like rocks and cosmic ray radiation. It must be accounted for when we do experiments as it will be a constant signal in our data. The best way to keep yourself safe from radioactive sources is to __KEEP YOUR DISTANCE__.

MP

Background and Safety cont.

For α and β the surrounding medium will scatter the radiation and as long as you keep at a safe distance you'll receive little. γ radiation is less scattered, but the source will generally be a small object which is radiating in all directions. By keeping away or as far as possible away you can reduce the risk. Hence use tongs to handle sources in the lab. Put sources back in sealed cases after use and have them 'near' people as little as possible.

Decay equations

ISOTOPE OF URANIUM

$^{234}_{92}U$ is another.

Same proton #

different neutron #

- α example

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

Uranium-238 decays to Thorium-288 by α decay

- β example

ISOTOPE OF CARBON $^{12}_{6}C$ is another

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

Carbon-14 decays to nitrogen-14 by β decay.

- γ example.

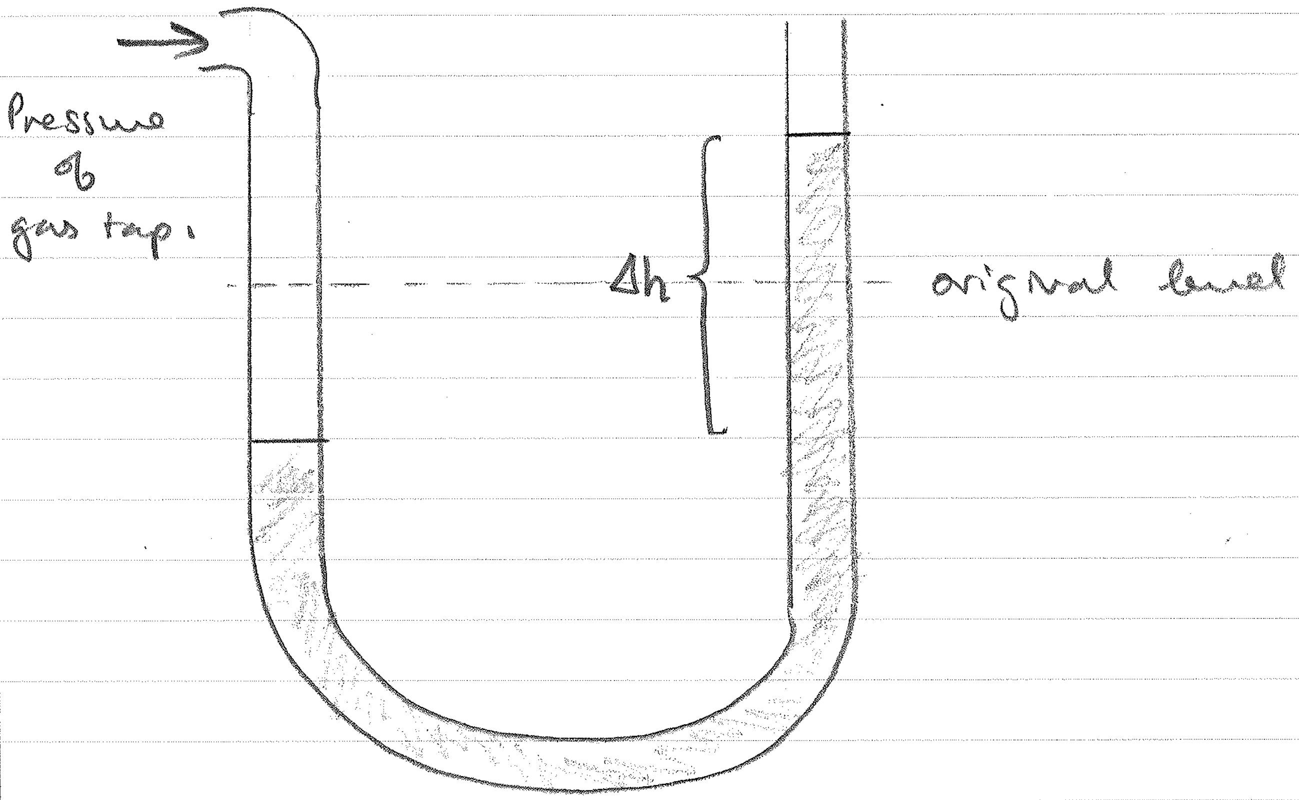
$$^{99}Tc^{*} \longrightarrow ^{99}Tc + ^{0}_{0}\gamma$$

Technecium-99 excited decays to Technecium-99 de-excited by γ.

MP

Hooke's law: See JP sheets.

Pressure at a depth in a fluid



$$\Delta p = \rho g \Delta h$$

Δp ← difference in pressure between the two limbs of the manometer

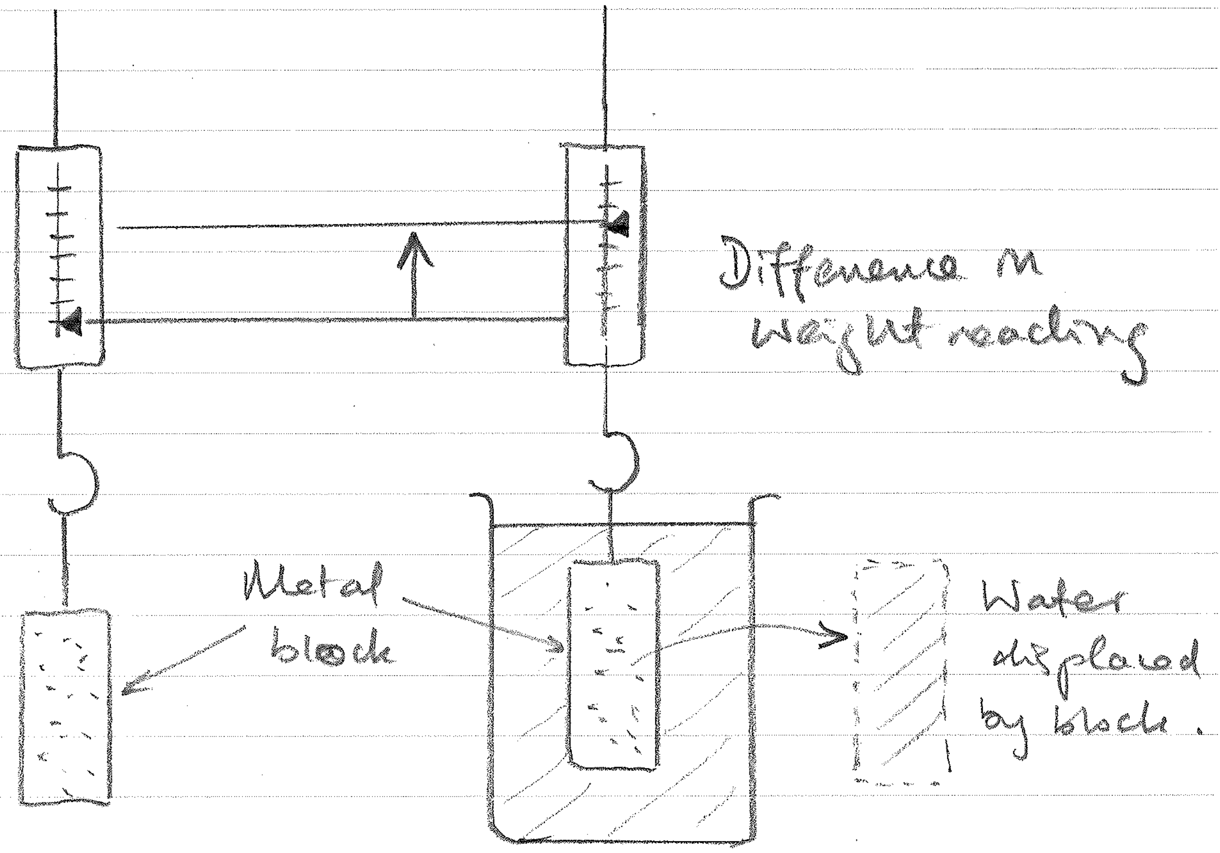
↑ This of course is the pressure of the gas main.

ρ ← density of liquid

g ← gravitational field strength. (10 N/kg)

MP

Archimedes



The difference in weight reading is equal to the weight of water displaced.

MP

See JP electrical work. BUT

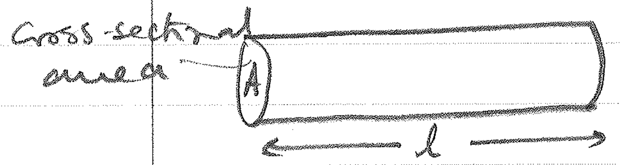
- Extra Electrical

* Resistors in series and parallel

$$R_T = R_1 + R_2 + R_3 \ldots$$

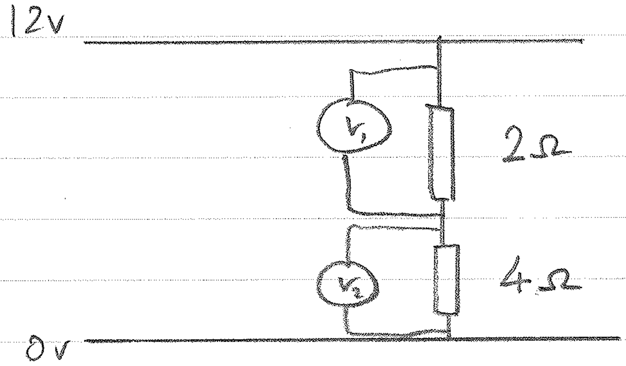
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$$

* Resistance of a wire. $R \propto$ length $\quad R \propto \frac{1}{\text{Area}}$



$$R = \text{constant} \times \frac{l}{A}.$$

* Potential divider: <u>EXAMPLE</u>



Voltage across here is $\frac{2}{6}$ of the voltage across because 2Ω is $\frac{2}{6}$ of the total resistance

$\therefore$ (V1) reading = 4v

(V2) " = 8v

- <u>Extra Forces and motion</u>

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

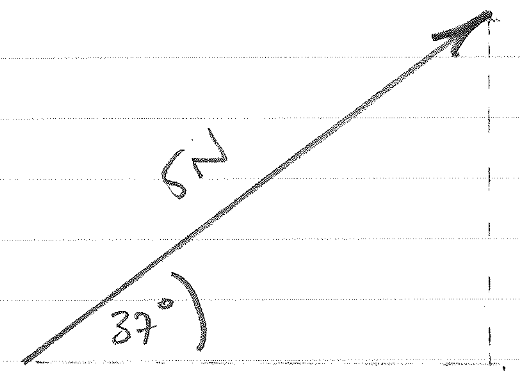
also remember from JP

$$s = \frac{(u+v)}{2} \times t$$

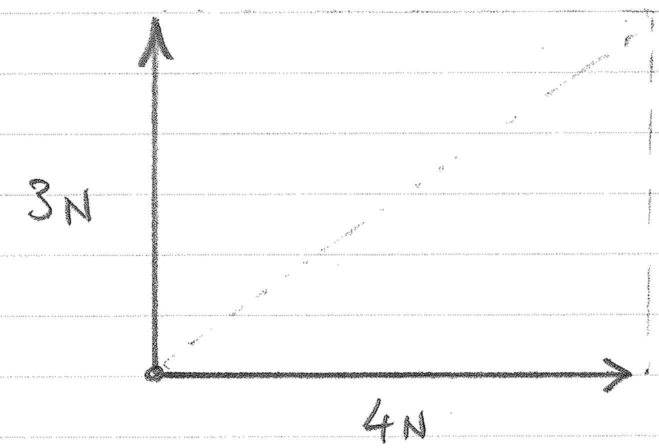
$$a = \frac{v-u}{t}$$

MP

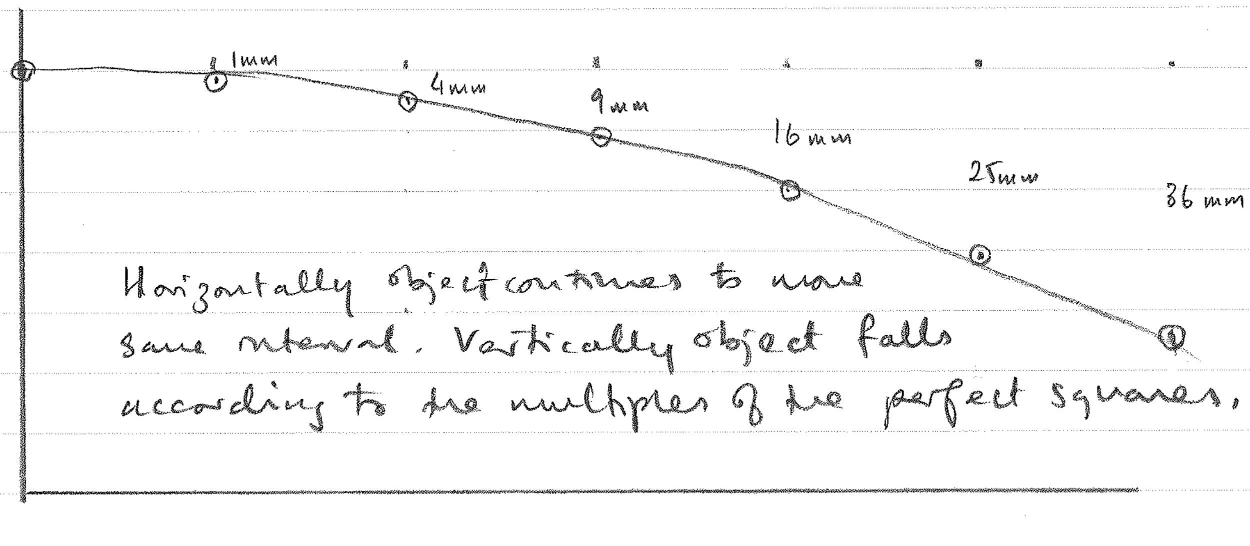
Vectors.



This force can be thought of as the simultaneous effect of :



Projectile motion



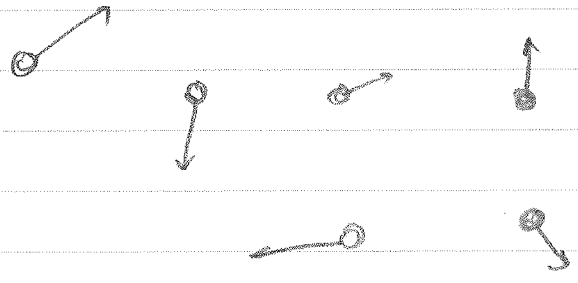
PARABOLA

Horizontally object continues to move same interval. Vertically object falls according to the multiples of the perfect squares.

MP.

Matter & Thermal Physics

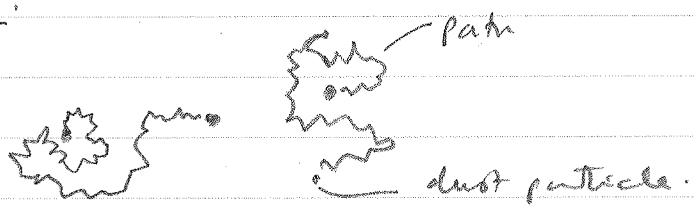
Kinetic theory.



- random distribution of speeds
- random distribution of directions.

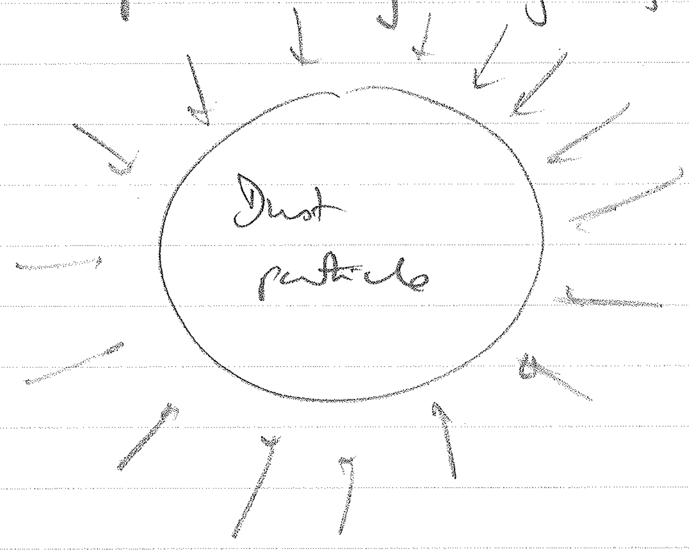
Molecules are in constant random motion

Brownian motion.



dust or pollen has motion like this under a microscope.

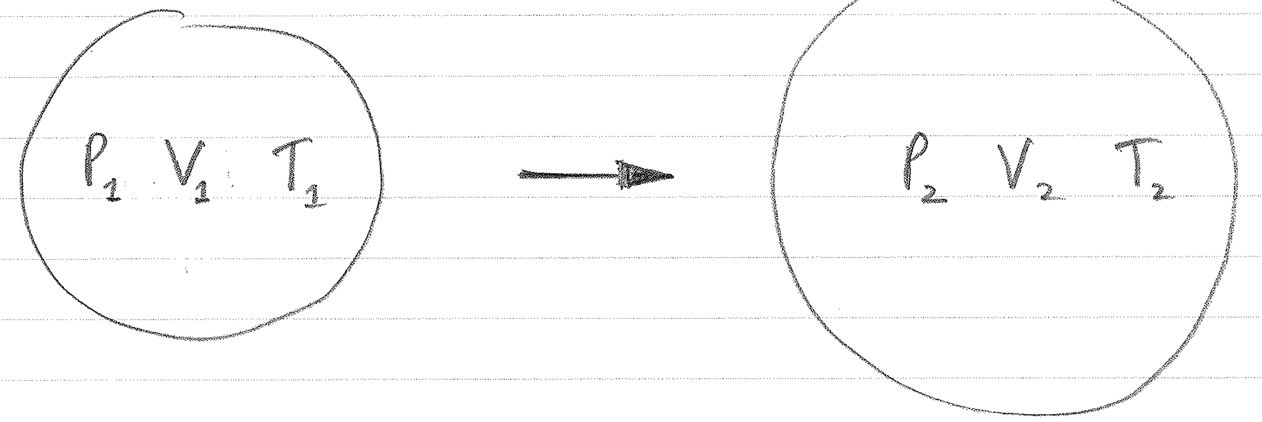
This is explained by imagining that the particle is being bombarded by molecules in random motion and the distribution of impacts on the surface is also random so the particle is nudged in a random way. Hence the jerky motion.



Gas laws: for a fixed mass of gas

$$\frac{P \times V}{T} = \text{constant}$$

T MUST BE IN KELVIN!



if P is in Pa

V " " m^3

T " " K

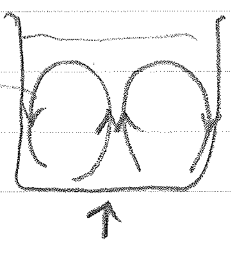
then $$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = 8{\cdot}31\ J/mol\,K$$

for 1 mol of gas.

Conduction Transfer of heat energy by electrons and vibration of ions

Convection Transfer of heat energy by movement of fluids due to differences in density.

Convection currents.



lower density hot liquid rises and cooler liquid falls.

MP

Radiation: Emission of I-R radiation.

Evaporation.

Particles in a liquid have a distribution of energies. The temperature is a measure of the average kinetic energy of the molecules, but there will be some molecules that have kinetic energies above the average. Some of these more energetic molecules escape from the surface of the liquid. This is evaporation. As we are loosing molecules we will drop the average kinetic energy across the liquid so the liquid also cools. A draft increases this loss and cools more rapidly.

Specific heat capacity.

Energy required to raise the temperature of 1 kg of substance by 1°C.

$$\Delta Q = m\, c\, \Delta T$$

mass (m); temperature rise (ΔT); energy supplied (ΔQ); specific heat capacity (c)

Specific latent heat (fusion and vaporisation)

Energy required to change the state (without change in temperature) of 1 kg of a substance from liquid → gas (vaporisation)

or

solid → liquid (fusion).

MP

Cooling curve for melted wax