IMPORTANT EXAM TIPS - PHYSICS

~ Start Reading time with section 1 + 2
~ End reading time with section 3
and then begin the paper with section 3.
~ Skip explaining Qs that you dont immediately know as you will subconsciously be thinking about them as you go.

Significant Figures

Calcs - 3 sf
Estimates - 1 or 2 sf
Data Analysis - same sf as least accurate data

Experimental Error

Absolute Error = | Theoretical - Measured |

$$\% \text{ Error} = \frac{\text{Absolute Error}}{\text{Theoretical}}$$

Speed Conversion

$km\,h^{-1}$ $\xrightarrow{\div 3.6}$ $m\,s^{-1}$
$km\,h^{-1}$ $\xleftarrow{\times 3.6}$ $m\,s^{-1}$

Physics 3A Motion and Forces in a Gravitational Field.

The Principle of Conservation of Energy

~ Energy cannot be created or destroyed; it can only change form.

∴ E_p at top of rollercoaster = E_{ke} at bottom

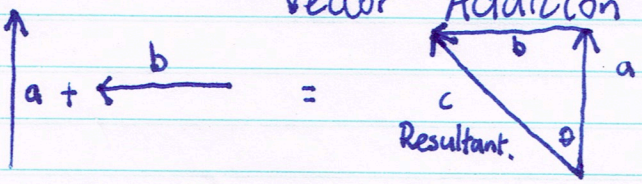
ie. $mgh = \frac{1}{2}mv^2$

Scalars and Vectors

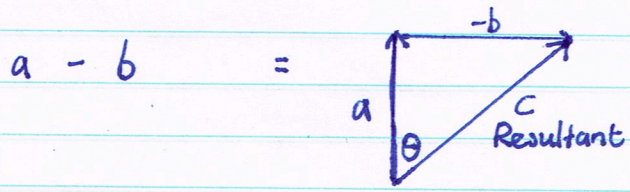
Scalar - A quantity fully described by its magnitude le. mass, temperature etc.

Vector - A quantity that can only be fully described by both a magnitude and direction. le. Velocity.

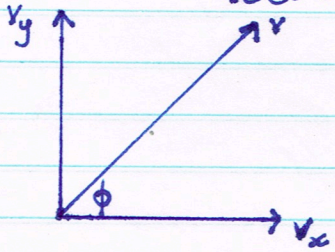
Vector Addition / Subtraction



* Abuse Pythagorous and Trig.



Vector Components



Horizontal - $v_x = v\cos\phi$

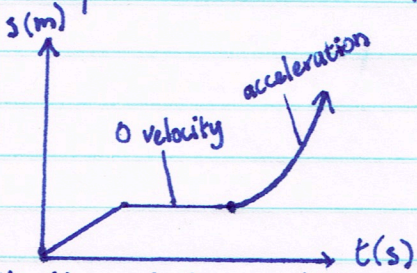
Vertical - $v_y = v\sin\phi$

Motion

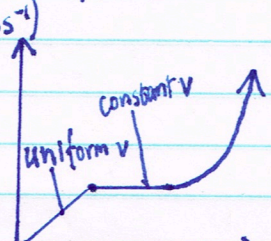
Eq^{N}s of Motion

1. $v = u + at$
2. $s = ut + \frac{1}{2}at^2$
3. $v^2 = u^2 + 2as$

Displacement and Velocity / Time Graphs:



* Slope Indicates Velocity.



* Slope Indicates Acceleration + Area Under Graph Indicates Disp.

Projectile Motion

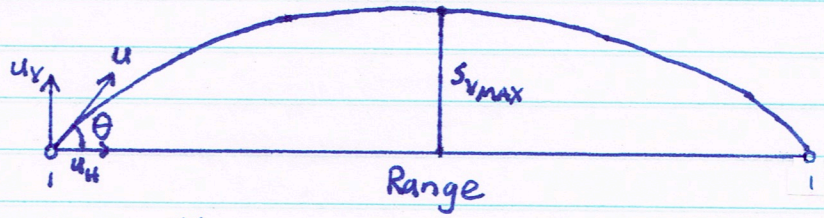
KEY CONCEPTS:

- Vertical + Horizontal Motions are independent of each other.
- Only time connects horizontal to vertical
- Only one force, weight - always down
- Parabolic trajectory
- Vector nature ↑ +ve ↓ -ve → +ve ← -ve
- $v_v = 0$ at max height

Method of Approach to a Projectile Motion Q.:

Vertical	Horizontal
s_v	s_H
u_v	u_H
v_v	v_H
g	a
t	t

Type 1. Start + Finish at Same Height

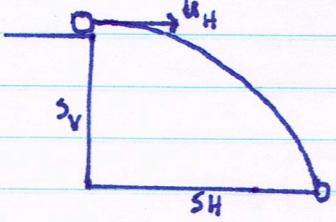


$u_v = -v_{v\,final}$

1). Find time using $t = \frac{v-u}{a}$

2). Solve for $s_{v_{MAX}}$ + Range

Type 2. Object Projected Horizontally off a Cliff



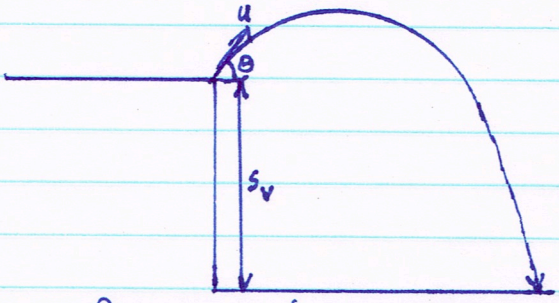
$u_v = 0$

1) Find v_v by using $v_v^2 = u_v^2 + 2gs_v$

2) Find t using $t = \frac{v-u}{g}$

3) Solve for s_H

Type 3 Projectile Finishes at Different Height.



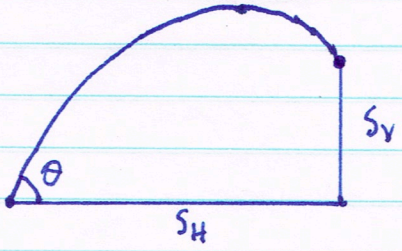
Process to find range:

1) $v_v^2 = u_v^2 + 2as_v$

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

3) $s_H = v_H t$

Type 4. Unknown Velocity *



1) $t = \frac{s_H}{u_H} = \frac{s_H}{u\cos\theta}$

2) $s_v = u_v t + \frac{1}{2} a t^2$

$s_v = u\sin\theta\left(\frac{s_H}{u\cos\theta}\right) + \frac{1}{2} \times -9.8 \times \left(\frac{s_H}{u\cos\theta}\right)^2$

$s_v = s_H \tan\theta - \frac{4.9 s_H^2}{u^2\cos^2\theta}$

3) Rearrange for u^2 after inputting values for s_v, s_H, θ.

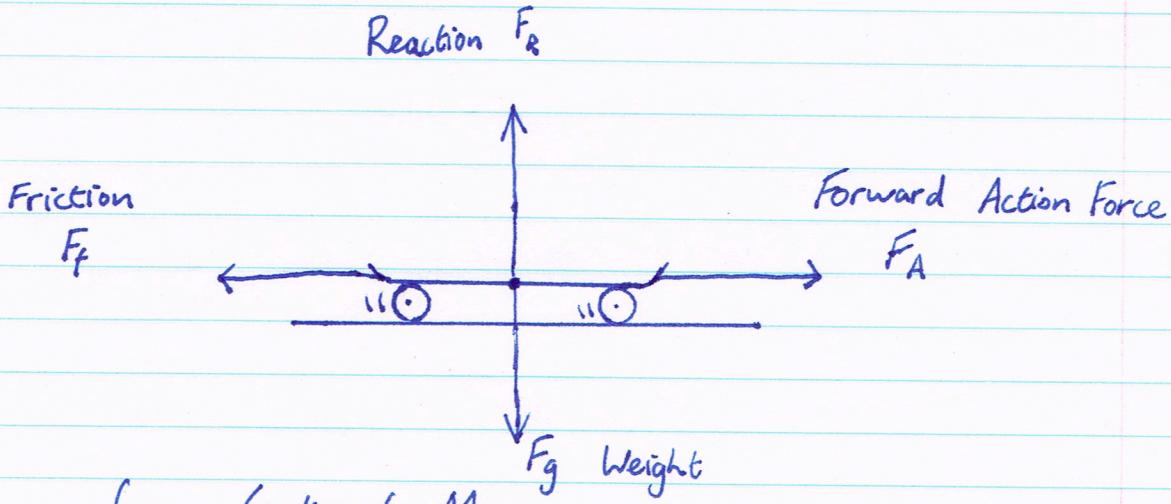
Projectile Air Resistance:

Force acts in opposite direction to the velocity of a projectile at any istant.

Thus shortens range / max height and gives flattened 2nd half of parabola.

* Remember 45° gives max range

Free Body Diagrams

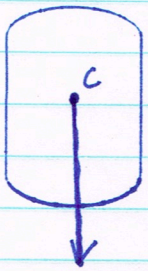


* Arrows from Centre of Mass

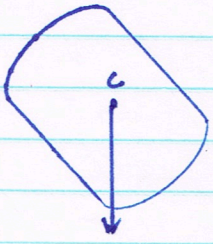
Centre of Mass

- The single point about which the body's mass is evenly distributed.

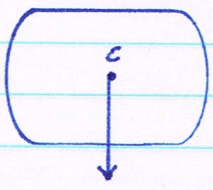
Stability (Static Equilibrium)



Stable - centre of mass over base
- sideways movement will cause C to be raised



Unstable - centre of mass over a pivot
- slight movement will lower C.



Neutral - sideways movement will not lower or raise C.

Centripetal Acceleration

* There is no centripetal force, it is the result of other forces.

Objects in circular motion have constantly changing velocities and are constantly accelerating towards the centre.

$$a_c = \frac{v^2}{r}$$ a_c = centripetal acceleration

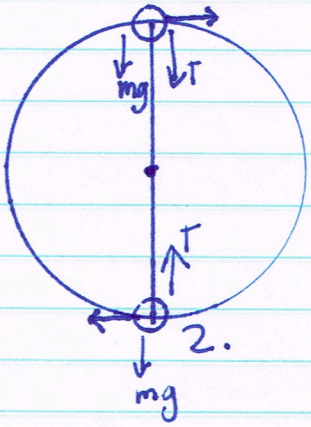
From $F = ma$

$$F_c = \frac{mv^2}{r}$$ F_c = centripetal force

Describing Circular Motion

- $T = \frac{1}{f}$
- $v = \frac{2\pi r}{T}$
- Hz = revolutions per second

Tension/Reaction F./1.



reaction F

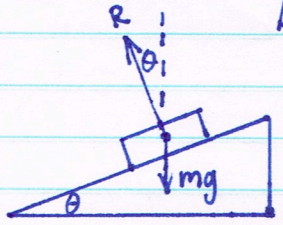
At 1. $R/T = F_c - mg$

$$= \frac{mv^2}{r} - mg$$

At 2. $R/T = F_c + mg$

$$= \frac{mv^2}{r} + mg$$

Banked Turn



$R\cos\theta = mg$ as $\Sigma F_y = 0$

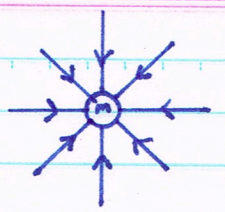
$R\sin\theta = F_c$

$$\frac{R\sin\theta}{R\cos\theta} = \frac{mv^2}{rmg}$$

$$\tan\theta = \frac{v^2}{rg}$$ *

Gravitation + Satellites

$$F = \frac{G m_1 m_2}{r^2}$$



Note: more arrows indicates a larger mass

g (gravitational field strength) $= \frac{F}{m}$

$$\Rightarrow g = \frac{Gm}{r^2}$$ Note: $F_g \propto \frac{1}{r^2}$

Achieving a stable orbit

$$\frac{m_1 v^2}{r} = \frac{G m_1 m_2}{r^2}$$

$$\Rightarrow v^2 = \frac{G m_2}{r} \quad \text{and} \quad v = \frac{2\pi r}{T}$$

$$\left(\frac{2\pi r}{T}\right)^2 = \frac{G m_2}{r}$$

$$T^2 = \frac{4\pi^2 r^3}{G m_2}$$ Keplers Law *

Geosynchrous - An orbit around a planet which has the same orbital period as the planets motion.

Geostationary - A geosynchrous orbit that remains stationary to a point on the planet.

Altitude $= r - r_{planet}$

Torques and Equilibrium

For an object to be in a static equilibrium:

$\Sigma F = 0$

and $\Sigma \tau = 0$

$\tau = F r$ where r is ⊥ distance.

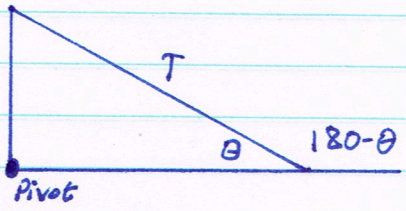
For Bridge Reaction / Window Cleaner Tension Qs, make one support the reference point, where:

$$\Sigma \tau_{CW} = \Sigma \tau_{ACW}$$

When force not perpendicular:

$\tau = F r \sin\theta$ ie. Cantilevers

θ does not matter as $\sin(\theta) = \sin(180-\theta)$



Physics 3A Electricity and Magnetism

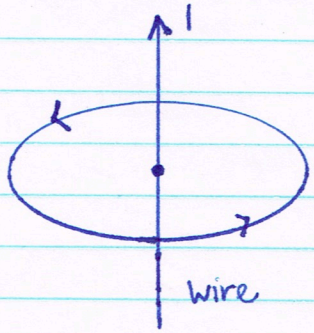
Magnets

- Attract iron objects
- Have two poles where magnetic effect is at its greatest.
- If left suspended and free to rotate, they will lign up with earths magnetic field.
- Like poles repel, unlike attract
- are made up of tiny magnetic domains which, when aligned, combine to create an overall magnetic effect.

Magnetic Fields

N → S - outside of magnet
S → N - inside of magnet

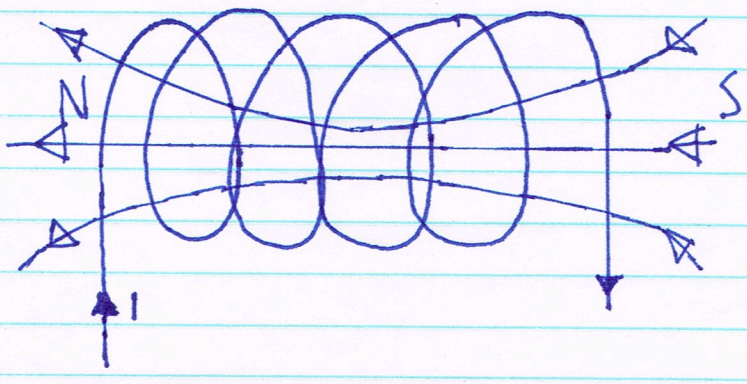
Note: earths magnetic poles are not aligned with the geographical poles and the magnetic field is south at the magnetic 'North' pole and visa-versa.



Right hand grip rule

- thumb is current
- fingers indicate magnetic field

Solenoid



RHGR.
- fingers direction of current in coils
- thumb indicates N

Magnetic Field Strength

$\Phi = BA$ where ϕ = magnetic flux (Wb)
B = magnetic flux density (T)
A = area (m^2) perpendicular to field

Conventional Current +ve to -ve
Always use this unless stated otherwise.

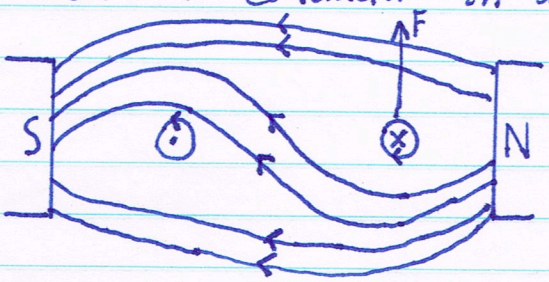
Direct Current - A current supply where the flow of charge is always in one direction.
For example, a battery.

Alternating Current - A current supply where the flow of charge alternates back and forth.
The effective voltage or 'the root mean square voltage is calculated by:

$$V_{RMS} = \frac{V_{peak}}{\sqrt{2}}$$

Power Loss = I^2R
∴ power is transferred at very high voltages to reduce this power loss.

Force on a conductor in a magnetic field.



~ Motor

$F = BIL$

RHGR
- Thumb is current in wire
- fingers is direction of magnetic field
- palm indicates force

Electromagnetic Induction

When a conductor moves through a magnetic field a force on both positive and negative charges is created This creates a potential difference, or induced EMF.

$$EMF\ (V) = l\,v\,B$$

RHGR
- Thumb is velocity
- Fingers are direction of field
- Palm is Force on positive charge.

In a Coil.

If a magnet is moved towards or away from a coil an EMF is created. If the circuit is complete, a current will flow.

Faradays Law:

$$EMF = -N\frac{\Delta\phi}{\Delta t}$$

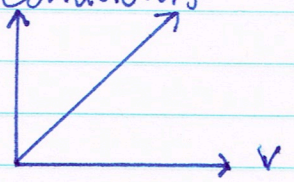
where N is the number of turns of coil

Lenz's Law: Accounts for -ve sign in above equation
The direction of an induced current is such as to always oppose the change that is producing it.

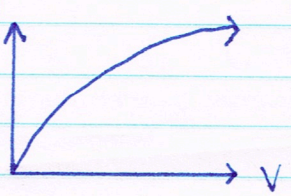
Remember in application for:
- Dropping magnet in copper tube
- Swinging a conductive plate through a magnetic field
- Induced current in a second solenoid
  - ↳ Basis of transformers

Ohmic Conductors

- Follow OHMS Law ie:

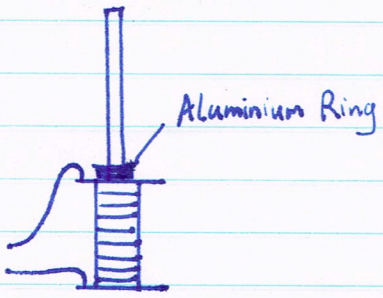


- Non-ohmic ie. a lightbulb
  Do not follow Ohms Law



V = IR
As I increases, temperature increases and thus the resistance.

Eddy Current - Emf induces current.

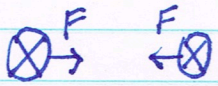


DC supply - ring jumps once
↳ EMF stops after initial $\Delta\phi$
AC supply - ring hovers
↳ EMF continues due to constantly alternating polarity

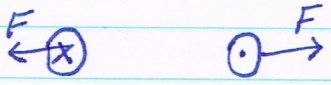
If ring has a split, eddy current cannot flow circularly and. ring remains stationary. Some eddy current is created and thus a magnet falls faster in a plastic pipe than an aluminium pipe with a cut down its length.

Two parallel wires

Same direction

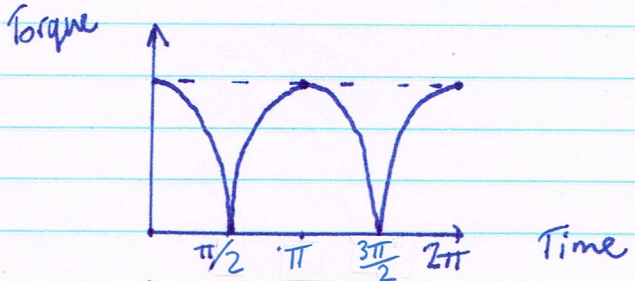


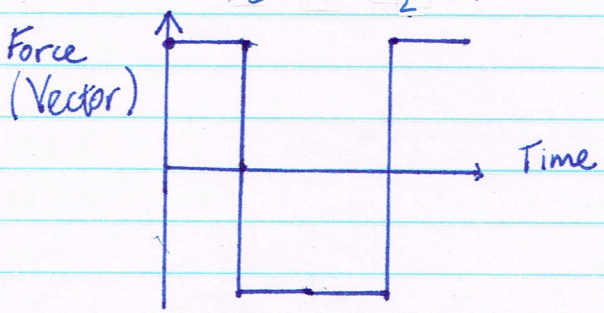
Opposite

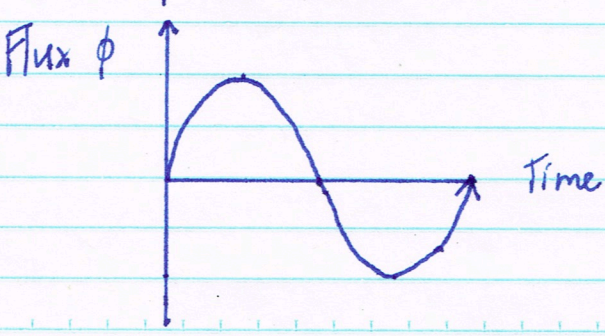


Motors

Electrical Energy → Kinetic Energy







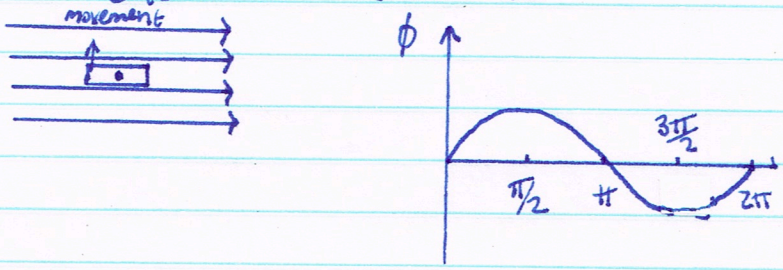
AC Motor
- Alternating current already changes the direction of flow to keep movement in one direction.
Two slip ring rings

DC Motor
- Needs a split ring commutator to reverse the current flow each 180° and keep force in the direction of movement.

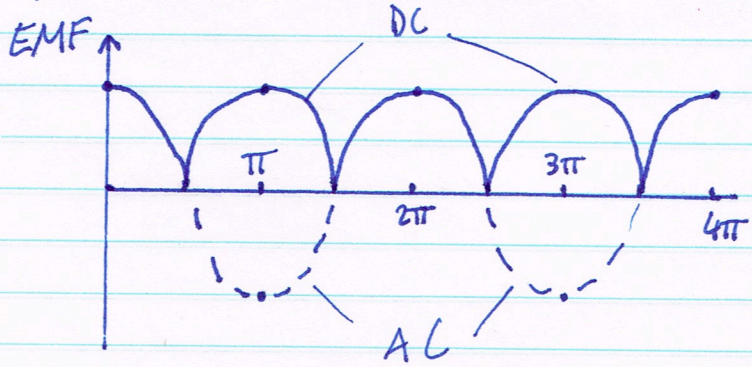
Generators

Kinetic energy → Electrical energy.

AC - Slip rings produce alternating current output.
Often called an alternator

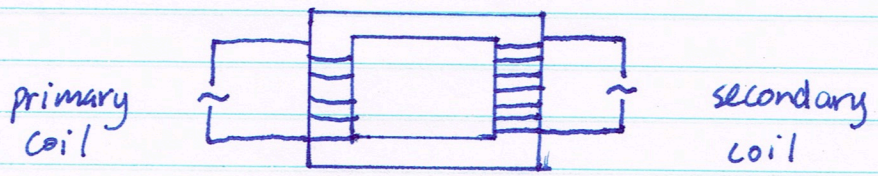


DC - Split ring commutator ensures all electrical output is in one direction.



Transformers

- Appliances can only handle a certain amount of voltage
- Transformers allow high voltages to be lowered for consumption.



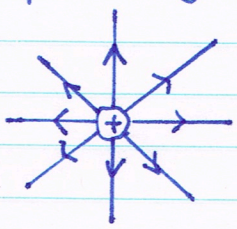
Laminated Iron Core - Increases flux between coils
- Laminations reduce eddy currents and minimise energy lost in heat.

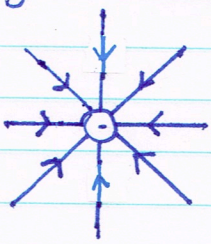
$$\frac{V_S}{V_P} \simeq \frac{N_S}{N_P}$$

Back Emf: An electromagnetic force in an inductive circuit in such a direction as to oppose any change of current in the circuit.

Electric fields

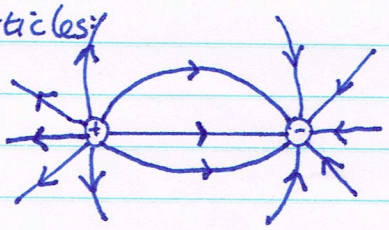
Electrostatic forces can be detected in the space around a charged object. The region in which such forces can be found is an electric field. The direction of the flux lines is the direction a positively charged body would move i.e.



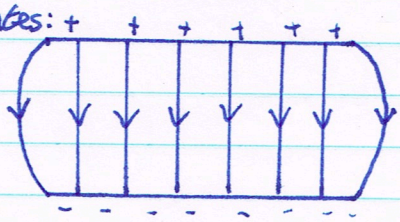


Electric Field Interaction

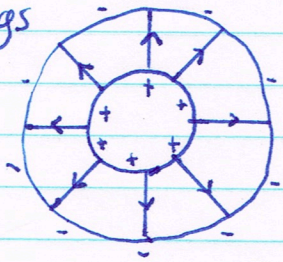
2 particles:



2 plates:



2 rings



Electric Field Strength - E (NC^{-1})

$$E = \frac{F}{q} \quad \text{or} \quad E = \frac{V}{d}$$

Electrical Potential Difference

$$V = \frac{W}{q}$$

$$P = VI$$

$$E = Pt \qquad \text{where } E \text{ is energy in J.}$$

$$E = VIt$$

Remember $a = \frac{F}{m}$

∴ projectile or alike questions can be asked about charged particles.

Physics 3B Motion + Forces is Electric and Magnetic Fields 14.)

Charged Particles In Magnetic Fields

RHGR : Fingers - Direction of field
Thumb - Velocity of positive particle - Left hand for -ve
Palm - Force

Deriving $F = Bvq$:

$v = \frac{s}{t} = \frac{l}{t}$ ① $l = vt$

$q = It$ ② $I = \frac{q}{t}$

$F = BIl$ → Sub ① and ② in
$\Rightarrow F = Bvq$

Circular Motion In Magnetic Field

$Bvq = \frac{mv^2}{r} \Rightarrow Bq = \frac{mv}{r}$

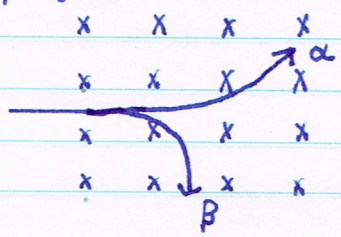
Accelerating Charged Particle

$E_K = W$
$\frac{1}{2}mv^2 = Vq$ Often q's to find v

Revision of Radiation

Radiation	Symbol	Charge	Structure	Stopped by
Alpha	α	+	Helium nuclei	10 cm of air
Beta	β	-	High speed e^-	Thin sheet of metal
Gamma	γ		EM radiation	Very thick pb or concrete barrier.

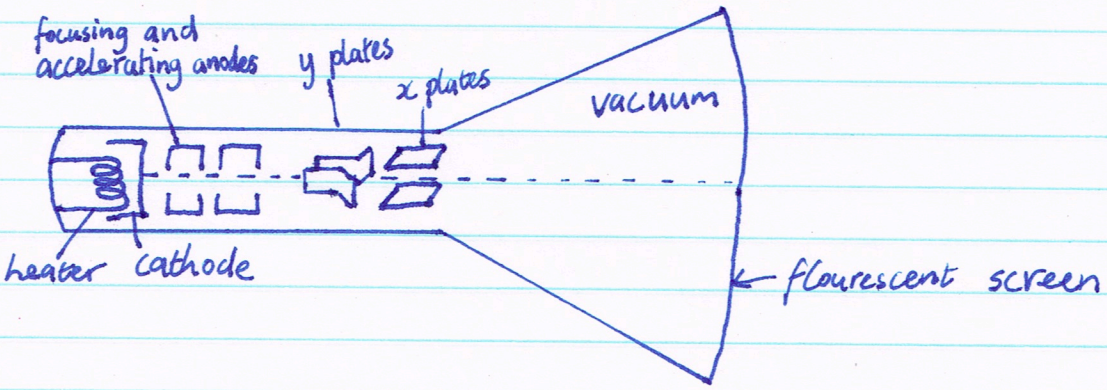
Possible questions about what radiation type is displayed. Ie.



Arcs due to different masses

Cathode Ray Oscilloscope (CRO)

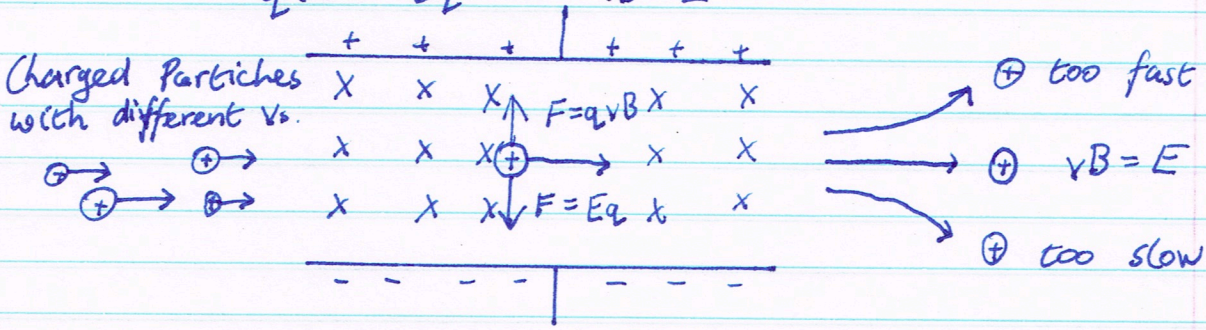
- Like a simple TV set and is used to display and measure electrical information



The Velocity Selector

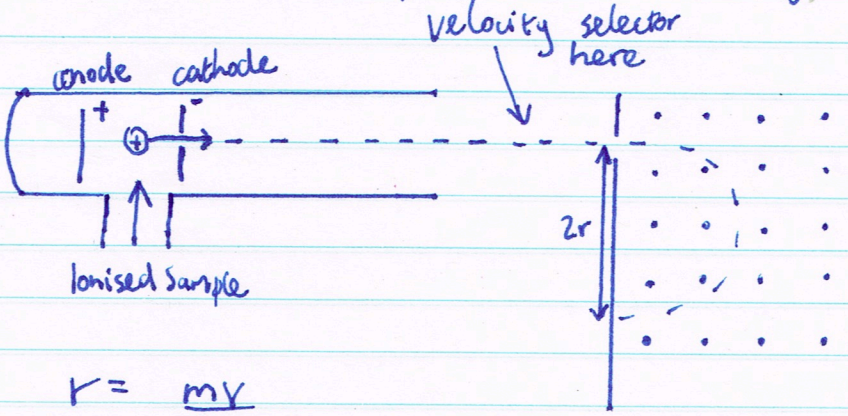
Equivalence between $F_{electric\ field}$ and $F_{magnetic\ field}$

$$qvB = Eq \rightarrow vB = E$$



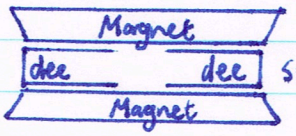
Mass Spectrometer

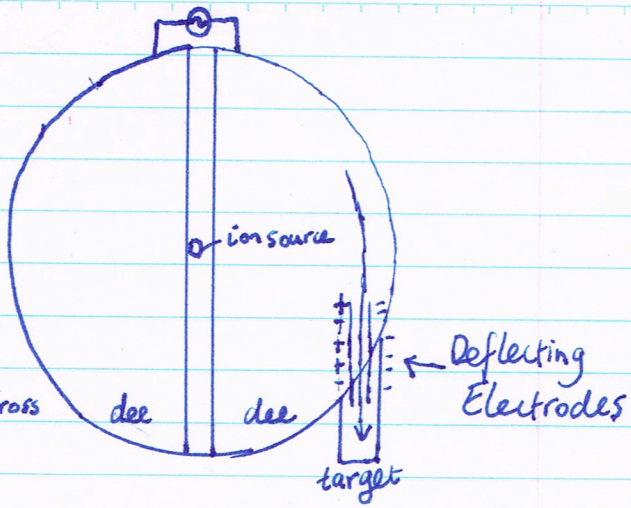
Process
1) Atom is ionised by knocking electrons off
2) Ions are accelerated and passed through a velocity selector
3) Deflected by magnetic field
4) Detection to find mass to charge ratio



$$r = \frac{mv}{Bq}$$

Cyclotrons





Increase in E_K only occurs inbetween dees.

$\therefore E_K$ = number of crosses × W of 1 cross

$= n \times Vq$

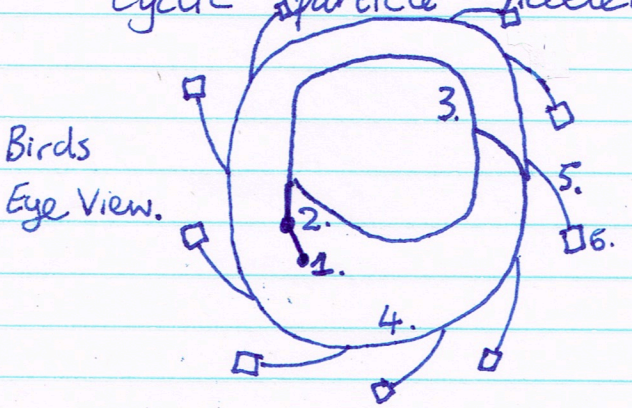
$T = \frac{2\pi m}{qB}$

$Freq = \frac{qB}{2\pi m}$

Alternating current is used so that the polarity of the dees always accelerates the particle when crossing the dees. $\therefore$ Freq current = Freq particle.

Synchrotron

Cyclic particle Accelerator



1. Electron Gun - 220000 V causes electrons to fire off cathode
2. Linear Accelerator (LINAC) - Microwave radio frequencies provide electrons with E_K ≈ almost speed of light.
3. Booster Ring - Increases energy of electrons from ~ 250 MeV to 2.9-6 GeV
4. Storage Ring - Electrons stored once they have enough energy to produce light
5. Beamline - projects electrons to target
6. End station - where the electrons are used for experiments, xrays etc.

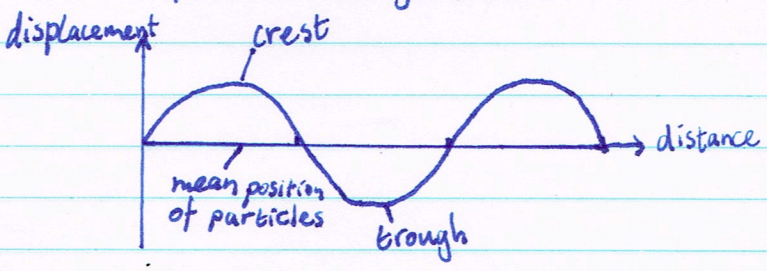
Physics 3B Particles, Waves and Quanta.

Waves

- A disturbance or vibration which transmits energy without the transport of matter
  - Mechanical Waves - travel through a medium due to the vibration of particles of the medium
    ie. Sound
  - Electromagnetic Waves - do not need a medium to travel through. ie. Light.
- A pulse is a single wave or disturbance.

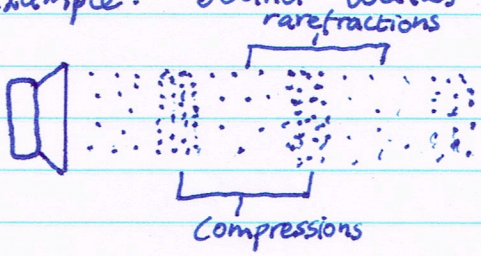
Types of Waves

Transverse - vibrates at right angles to direction of wave
Examples are Light, radio and water waves



Note: Crest to crest or trough to trough is the wavelength (λ)
If displacement-time graph this is the period (T)

Longitudinal - particles vibrate parallel to direction of energy.
Example: Sound Waves



Terms:

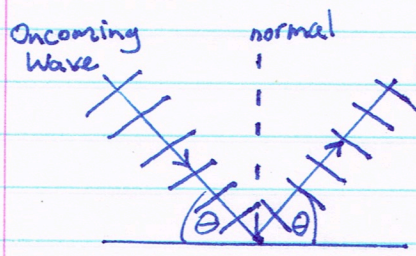
Displacement (s) - The distance from equilibrium position
Amplitude - The max displacement
Phase - The position and motion at any instant
Period (T) - Time taken for one complete cycle $T = \frac{1}{f}$
Frequency (f) - Number of cycles per second
Wavelength (λ) - Distance of one cycle
Wave velocity (v) - Velocity of disturbance in direction of energy.

Compression - high pressure area } Longitudinal
Rarefraction - low pressure area }

Crest - max vertical displacement } transverse
Trough - min vertical displacement }

Wave Behavior

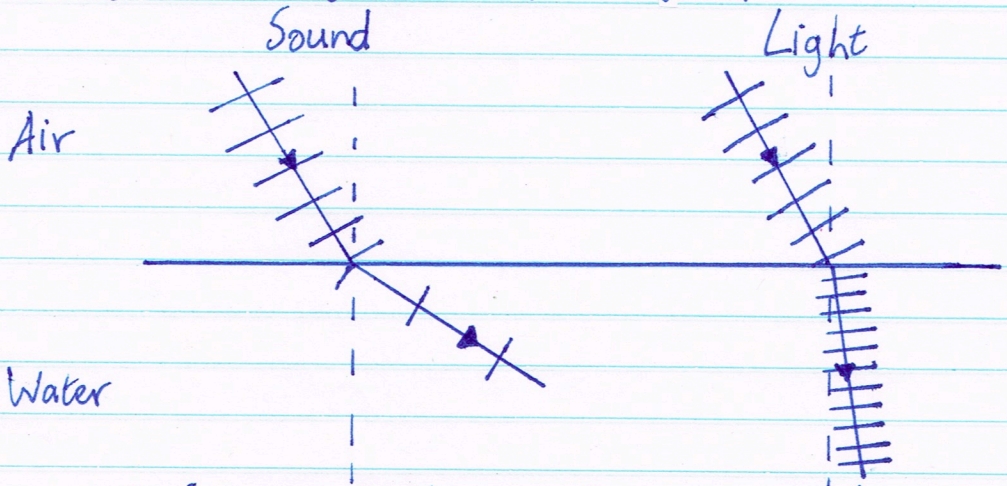
Reflection :	Changed	Unchanged	Application
	Direction	v, λ, f	Echoes + Reverberation



Echos are heard when reflected sound takes more than 0.1 sec after original sound.

Refraction:	Changed	Unchanged	Application
	Direction, λ, v	f	zones of silence

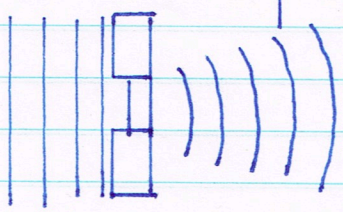
If a wave travels faster in a new medium, it bends away from the normal.
If a wave travels slower in a new medium, it bends towards the normal
} Snell's Law



v increases in denser medium so must λ.

v decreases in denser medium so must λ.

Diffraction:	Changed	Unchanged	Application
	Direction	v, f, λ	Hearing around objects



Note - Larger wavelengths are more easily diffracted.
-Greatest diffraction occurs when the wavelength is equal to or larger than the opening

Wave Behavior

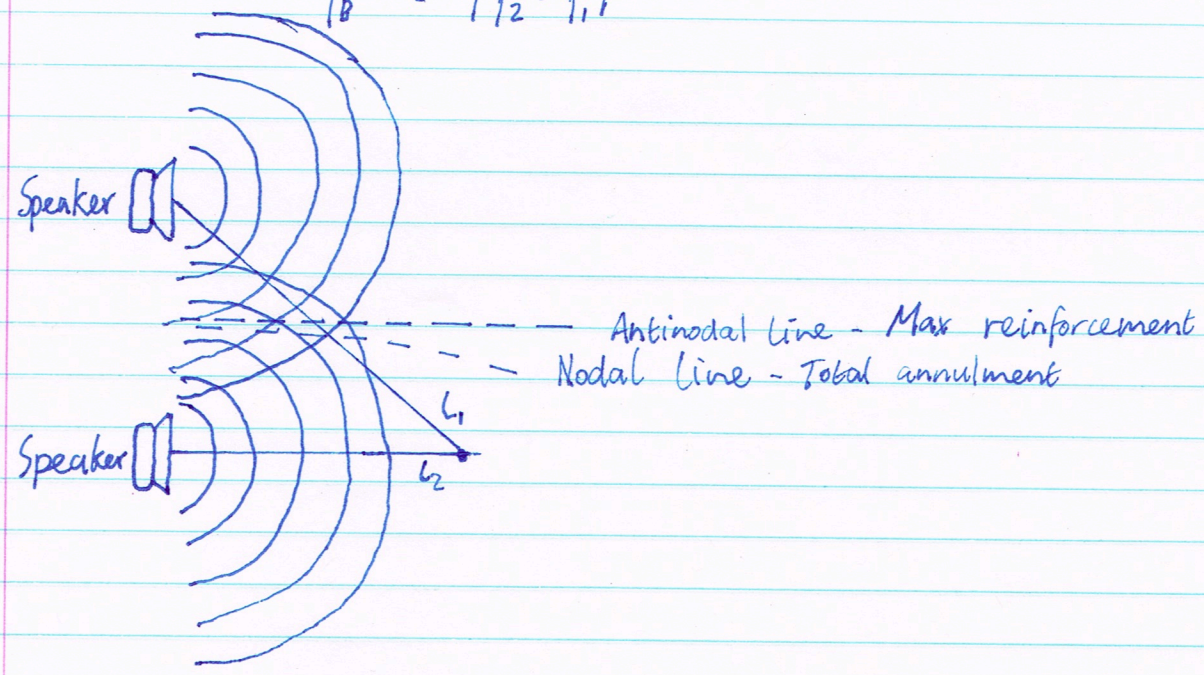
$v = f\lambda$

Interference - Adding Waves (Superposition)

- Constructive - when both waves are in phase
- Destructive - when the waves are out of phase
  max destruction at 180° out of phase

Beating - occurs when two waves of very similar frequency interfere with each other.

$f_B = |f_2 - f_1|$



Interference is constructive when $L_1 - L_2 = n\lambda$

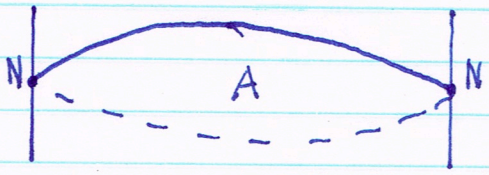
" destructive when $L_1 - L_2 =$ odd $\times \frac{1}{2}\lambda$

Resonance

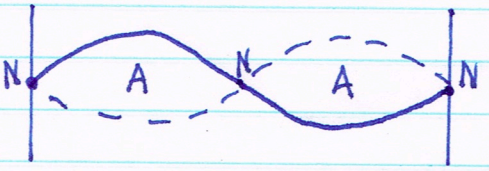
Resonance occurs whenever the frequency of a forcing vibration is equal to the natural frequency of the vibrating object. The amplitude of vibrations is greatly increased.

Standing Waves

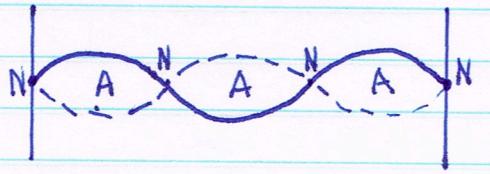
Produced when a wave is reflected back opposite to the incident and constructive reinforcement occurs. Called standing waves as they appear not to move.



First Harmonic ~Fundamental $\lambda = 2L$



Second Harmonic First overtone $\lambda = L$

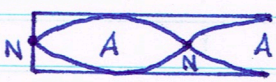
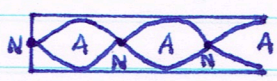


Third Harmonic Second overtone $\lambda = \frac{2}{3}L$

Nodes are $\frac{\lambda}{2}$ apart.

Antinodes are $\frac{\lambda}{2}$ apart.

Standing Waves in Air Columns.

	Open	Closed	
First Harmonic			First Harmonic
Second Harmonic			Third Harmonic
Third Harmonic			Fifth Harmonic

Noise and Music

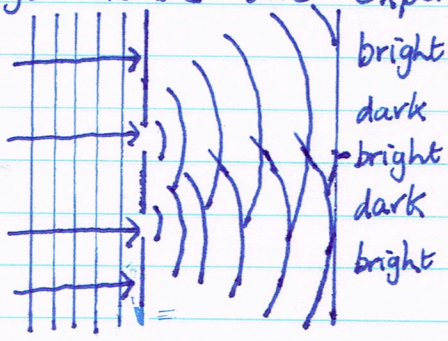
High frequency = High pitch + visa-versa
Loudness is from the amplitude

Music - Regular f and definite pitch. Pleasant to hear
Noise - Irregular f. Usually unpleasant to hear

Emr (Electromagnetic Radiation)

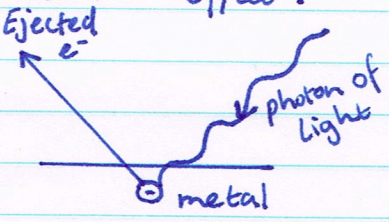
Light is both wave like and particle like.

1801 Young's double slit experiment:



Demonstrated diffraction and interference like a wave.

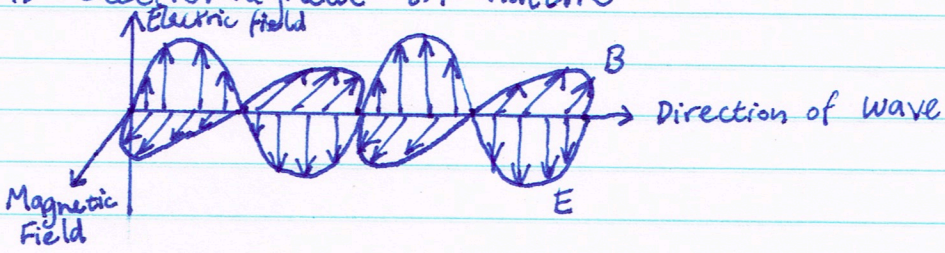
The photoelectric effect:



Electrons would not be removed by low frequency light, no matter how bright. This cannot be explained by the wave theory of light.

$E_{k(e^-)} = hf - \phi$ where ϕ is the energy to remove the e^-

Light is electromagnetic in nature



E_k Light $= hf$

All Emr is light, photons, in true sense.
However low energy radiation is more wave like.
eg. radio waves
And high energy radiation is more particle like.
eg. gamma rays.

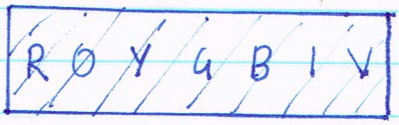
All Emr travels at the speed of light in a vacuum
- 3×10^8 m/s

$\therefore \quad c = f\lambda$

Spectra

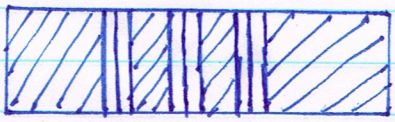
When light passes through a prism a continuous spectrum is formed. A hot blackbody emits all wavelengths of Emr.

Continuous :



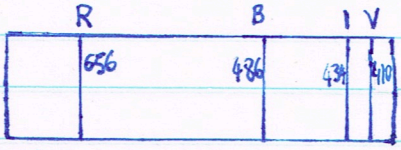
Visible light → 400-700nm

Absorbtion spectrums are created from light from a hot blackbody passing through a cloud of gas, whos particles absorb certain frequencies, leaving a unique 'fingerprint' of the gas.



Note: this band absorbtion which is caused from excited molecules not atoms

Emission spectrums are created from the gas which absorbed the light.



This is the H emission spectrum

Note: this is a line emission spectrum

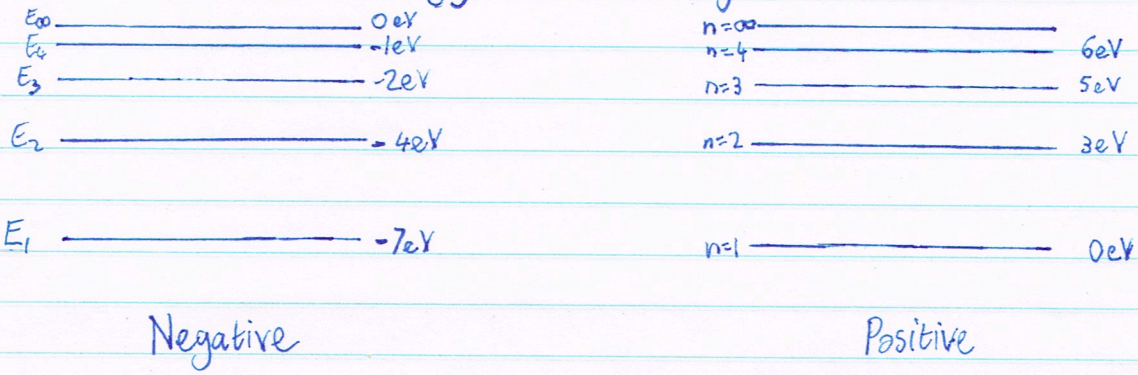
When light is absorbed, electrons in the atoms of the gas are excited to higher energy levels

$\Delta E = E_2 - E_1 = hf$

Where E_2 and E_1 is the energy at the respective levels.

Electrons can also be excited by: - thermal excitement
- bombardment of e^-

Energy Level Diagrams ~ From Bohrs model of atom.



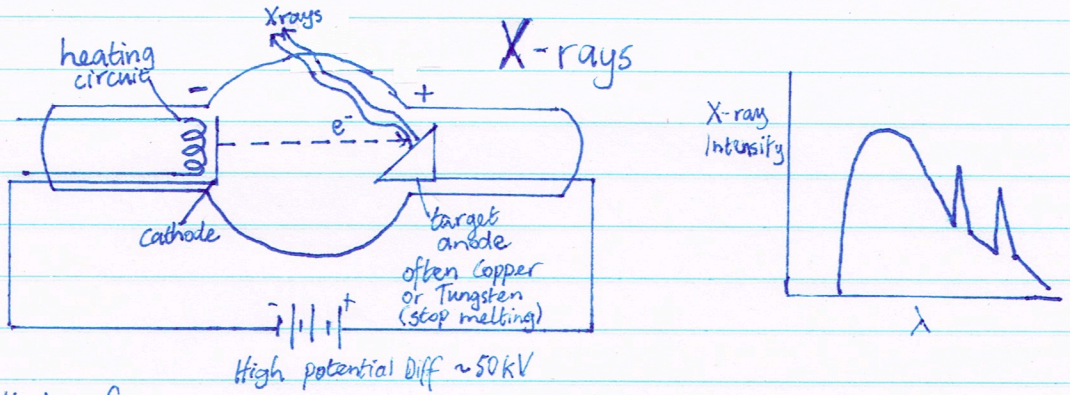
Negative

Positive

Fluorescence

Fluorescent materials have the ability to absorb UV light and re-emit it as visible light. This is due to electrons returning to ground state in a series of smaller jumps.

Fluorescent minerals glow under UV light.
Eg. Fluorite, Calcite
Fluorescent Tubes: excited electrons emits UV Emr.



- High f
- High E_K
- Strong penetrating powers
- Xrays are repelled by electron shells, accounting for varying wavelengths
- Characteristic peaks are due to X-rays knocking out electrons from lower shells. Electrons from higher levels within the atom quickly fall to the vacated orbital and consequently release high energy photons (X-rays) of a specific frequency.

Particles

Quarks - fundamental matter particles.
Two main types - Leptons - particles not influenced by the strong nuclear force. Ie Neutrino
Hadrons - particles affected by the strong nuclear force.

The quark model was developed from particle accelerators. There are 6 'flavours' of quarks: up, down, charm, strange, top and bottom. All are characterised by a mass, charge and spin. up, charm and top have $+\frac{2}{3}$ charge
down, strange and bottom have $-\frac{1}{3}$ charge

Neutrino

Similar to electrons but carry no charge.
They account for the discrepancy in unaccountable energy loss during beta decay.

Beta Negative decay:

$^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu}$ (antineutrino in this case)

Beta positive decay leads to the formation of neutrinos rather than antineutrinos.

Beta positive particles: $^{0}_{+1}e$ is called a positron and is the opposite of an electron.

$^{27}_{13}Al + {}^{4}_{2}\alpha \rightarrow {}^{30}_{15}P + {}^{1}_{0}n$

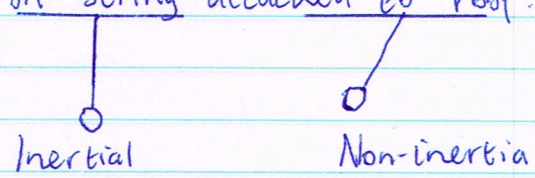
$^{30}_{15}P \rightarrow {}^{30}_{14}Si + {}^{0}_{+1}e + {}^{0}_{0}\nu$ (neutrino)

Classical Relativity

The transformation between a moving object and an observer in another inertial frame of reference.

Inertial frame of reference - non-accelerating, thus Newtons Laws apply

Ball on string attached to roof:



Inertial Non-inertial

Special Relativity.

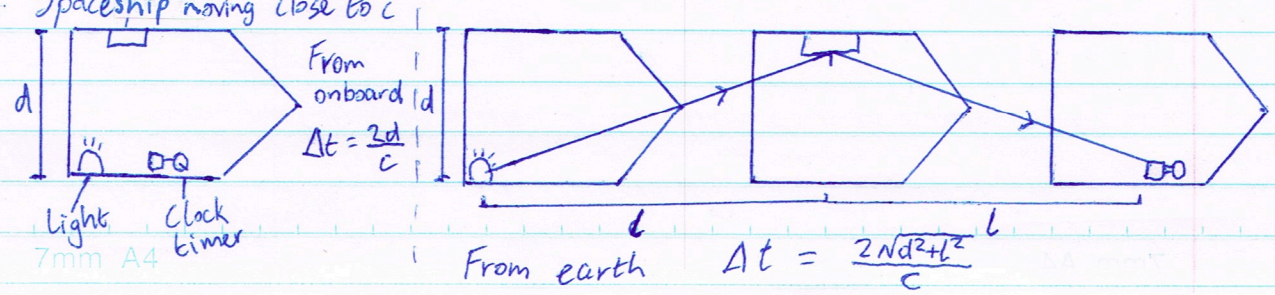
First postulate - Different observations from different frames of references can all be correct, there is no one definite answer. This comes from the fact the laws of physics are the same in all frames.

Second postulate - The speed of light relative to any inertial frame is always 3×10^8

Consequences of Special Relativity from Lorentz transformations

Time dialation - time lapse between 2 events can change from one observer to another in a different frame of reference. Eg:

Spaceship moving close to c



Length contraction - The dimensions parallel to the relative velocity of an object moving close to the speed of light appears 'contracted.'

Relativity of simultaneity - Two events happening in two different locations that occur simultaneously in one inertial frame of reference, may not occur simultaneously in another. Thus there is a lack of absolute simultaneity.

Mass Energy Equivalence - From Einstein's famous $E = mc^2$ we can think of mass simply as a form of energy. Einstein proved this through showing that as the speed of a body approaches the speed of light it's energy approaches infinity. Similarly, the relativistic mass of a body increases with velocity and would be infinite if it could achieve the speed of light. Hence it is not possible to travel at the speed of light.

Astronomical Measurements

1 Au is the distance from the Earth to the sun

$1 \text{ Au} = 1.496 \times 10^8 \text{ km}$

1 Light year is the distance light travels in a year

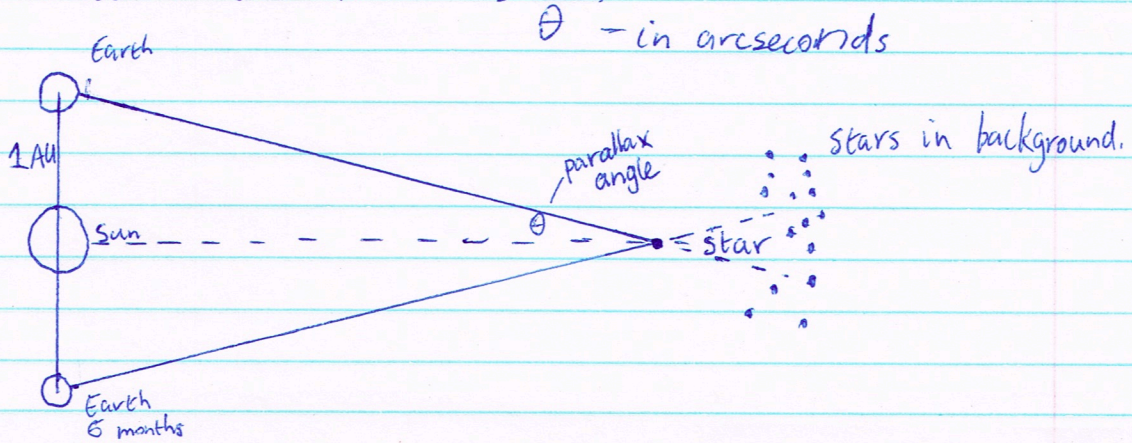
$1 \text{ L.Y.} = 9.46 \times 10^{12} \text{ km}$

1 parsec is the distance to a star that has a parralax angle of 1 arcseconds

$1 \text{ pc} = 3.086 \times 10^{13} \text{ km}$ or 3.26 Light years.

$\text{Arcseconds} = \frac{\text{Degrees}}{3600}$

$\text{Distance to a star (pc)} = \frac{1}{\theta}$ - in arcseconds



Doppler Effect

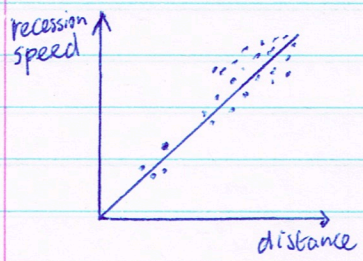
When a sound source is moving towards the observer the apparent frequency is higher as the wavelength is compressed. A lower frequency is heard when the sound source is receeding.

$$\frac{f_{observed}}{V_{sound} - V_{obs}} = \frac{f_{source}}{V_{sound} - V_{source}}$$

Red Shift

The doppler effect can also be observed with light. When a light source is moving away from us then there is a decrease in the frequency and a consequent 'Red Shift' on the spectra. The absorbtion spectra lines due to certain gasses are all shifted towards Red on the spectrum.

Hubbles Law



Hubble graphed the recession speed, found from different planets red shift spectra, and plotted it against the distance of the planet from earth.

He found $v \propto d$ and created a constant H so that $v = Hd$.

$\frac{1}{H}$ gives an indication of the age of the universe.

Hubbles law proves and shows the rate at which the universe is expanding.

Big Bang Theory + Models of The Universe

The theory that the universe expanded from an infinitely dense single point between 12 and 20 billion years ago. This is supported by the expansion of the universe as in Hubbles Law.

Closed Universe - ○ Universe is finite, All planets would return to same position eventually, it is sufficiently dense to reverse the Big Bang (Big Crunch)

Open Universe - ⧖ Universe is infinite, all planets continue to move away. Universe will never end but will eventually become very cold and dark.