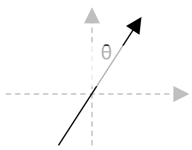
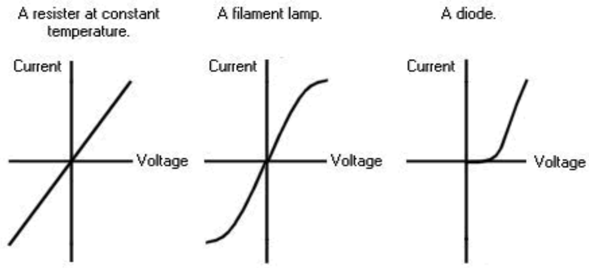
Topic 2: Kinematics			
Distance	Total length covered by a moving object irrespective of the direction of motion.		
Displacement	Linear distance of the position of the moving object from a given reference point.		
Speed	Distance travelled by the body per unit time.		
Velocity	Speed in a specific direction.		
Acceleration	Rate of change of velocity.		
Terminal velocity	Constant velocity that is reached by a falling object when the drag force equals in magnitude to the force that is accelerating the object.		
Drag force	Retarding force that is due to air resistance. (Drag force proportional to speed of object provided density of air constant)		
Force	Push or pull.		
Inertia	Resistance to a change in the state of rest or motion of the body, when a force is applied.		
Newton's laws of motion	1. An object will remain at rest or an object in motion will continue in motion at constant speed in a straight line in the absence of a net force acting on it (when the net force acting on it is zero). 2. The rate of change of momentum of a body is directly proportional to the net force acting on it and takes place in the direction of the force. 3. When two bodies A and B interact, the force that A exerts on B is equal and opposite to the force that B exerts on A.		
Friction	Force that opposes the relative motion of two surfaces.		
Static friction	Surfaces prevented from relative motion (they are at rest).		
Dynamic/kinetic friction	Surfaces are moving relative to each other.		
Work	Force multiplied by displacement in the direction of the force.		
Energy	Capacity to do work.		
KE	Energy by virtue of motion.		
PE	Energy stored in a body as a consequence of: i) Position (raised object has GPE) ii) Condition (stretched elastic band has EPE) iii) Shape		
Principle of conservation of energy	Energy cannot be created or destroyed but may be converted from one form to another but the total amount remains constant in the system.		
Efficiency	Ratio of the useful energy output to the energy input.		
Power	Rate of doing work.		
Linear momentum	(Of an object) is defined as the product of its mass and velocity		

Impulse	Change in momentum caused by a force.		
Law of conservation of momentum	The total momentum of a closed system is constant, provided no external resultant force act on it.		
Topic 3: Thermal Physics			
Thermal Equilibrium	Two objects placed in thermal contact will eventually come to the same temperature.		
Absolute temperature	Zero kelvin at absolute zero (temperature at which all matter has minimum KE) and 273.16 K at the triple point of water.	$T = \theta + 273$	K
Internal Energy (for ideal gases, only dependent on temp)	Total of the PE (arising from the forces between molecules) and random KE of all the particles in the substance.	$U = \frac{3}{2}nRT$	J
Specific heat capacity	Energy required to raise a unit mass of substance by 1K.	$c = \frac{Q}{m\Delta T}$	J kg^{-1} K^{-1}
Thermal capacity	Energy required to raise an object's temperature by 1K.	$C = \frac{Q}{\Delta T}$	J K^{-1}
KMT	$PV = nRT$ - Extremely small particles - Constant motion - Elastic collisions (KE conserved) - No intermolecular attractive forces	Solids are better thermal conductors than fluids: particles are closely packed in solids KE increases with temp, no change in PE. After phase change complete, intermolecular PE increases to break bonds.	
Solids	- Fixed volume and fixed shape - Held together in position by bonds - Vibrate in fixed positions		
Liquids	- Fixed volume and indefinite shape - Not completely in fixed positions - Close to each other but free to move around		
Gases	- Expand to fill container - Not fixed in position - Forces weak		
Latent heat	Energy required for a material to change phase.		
Specific latent heat	Amount of energy per unit mass absorbed or released during a change in phase.	$L = \frac{Q}{m}$	J kg^{-1}
" of fusion	Heat required to change unit of mass of material from solid to liquid without a change in temperature.		
" of vaporisation	Heat required to change unit mass of material from liquid to vapour without a change in temperature.		
Temperature	Measure of the average KE of the molecules in a substance.		
Pressure	(Of a gas) is defined as the force exerted over an area.	$P = \frac{F}{A} = \frac{1}{3}\frac{Nm}{V}\overline{c^2} = \frac{1}{3}\rho\overline{c^2}$	N m^{-2}
Pressure Law	P/T = constant V - Temp increase, molecules higher avg KE - Fast moving molecules ➔ greater change in momentum ➔ force greater		

	- Fast moving molecules ➔ hit walls more often per second ➔ Total force on wall increases ➔ Pressure increase		
Charles' Law	V/T = constant P - Temp increase, faster moving molecules, greater force - Vol increase, rate of collisions on a unit area decreases ➔ Avg force per unit area same ➔ pressure same		
Boyle's Law	pV = constant T - Constant temp, constant avg speed, constant force - Vol increase, rate decreases, avg total force decreases ➔ Avg total force decreases ➔ Pressure decreases	$P_1V_1 = P_2V_2$	
Topic 4: Waves			
Displacement	Distance that the object has moved from its rest position in a stated direction.	$x = x_o sin\omega t$ OR $x = x_o cos\omega t$	
Amplitude	Maximum magnitude of displacement from the equilibrium position.		
Wavelength	Distance between any two successive points which are in phase.		
Frequency	Number of complete oscillations per unit time. Number of wave crests per unit time.		Hz
Period	Time taken from one complete oscillation.		
Wave speed	Distance the wave profile moves per unit time. <u>Derivation:</u> $$v = \frac{s}{t}$$ For one cycle, time taken is T and distance covered is one wavelength, thus $$v = \frac{\lambda}{T}$$ Since T = 1/f, $$v = f\lambda$$		
Angular frequency		$\omega = 2\pi f$	
Simple harmonic motion	Oscillatory motion of a particle whose acceleration is directly proportional to its displacement from the equilibrium position and this acceleration is always directed towards that position.	$a = -\omega x^2$	
Energy changes in SHM	Total energy: constant $$TE = \frac{1}{2}m\omega^2 {x_o}^2$$ KE: max at x = 0 (v is max), min at x = x_o (v is min)		J

	$$KE = \frac{1}{2}m\omega^2({x_o}^2 - x^2)$$ PE: max at x = x_o, min at x = 0 $$PE = \frac{1}{2}m\omega^2 x^2$$		
Wave pulse	An isolated disturbance, traveling through an otherwise undisturbed medium.		
Continuous wave	Produced when a medium is disturbed in a regular periodic way.		
Progressive/travellin g waves	Movement of a disturbance from a source which transfer energy but not material to places around it. E.g. EM waves and mechanical waves		
Transverse wave	Displacement of the particles in a medium is perpendicular to the direction of the wave motion.		
Longitudinal wave	Displacement of the particles in a medium is parallel to the direction of the propagation of the wave.		
Sound	A form of energy produced by vibrating sources placed in a medium. The vibrating source in air causes the shifting of layer of air particles, producing sound waves. **Compression carries energy*		
Wavefront	A line or surface joining points of a wave that are in phase.		
Ray	Path taken by the wave and is used to indicated the direction of the wave propagation. Right angles to wavefront.		
Intensity	Rate of energy flow per unit cross-sectional area perpendicular to the direction of wave propagation.		
Principle of superposition	When two or more waves of the same kind exist simultaneously at a point in a medium, the resultant displacement of waves at a given point in time and space is the vector sum of the displacement due to each wave acting independently.		
Unpolarised light	Light in which the plane of vibration of the electric vector is continually changing.		
Polarised light	Electric fields of light oscillates in a single plane. 	$I = I_o \cos^2 \theta$	
Snell's Law	$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$		
Critical angle	Angle of incidence in the optically denser medium for which the angle in the optically less dense medium is 90° to the normal.		
TIR	Takes place when:		

	1. Ray of light travels from optically denser medium to a less dense medium 2. Angle *i* > angle c		
Diffraction	Refers to the phenomenon of bending or spreading of waves when they pass an obstacle, or pass through an aperture. More impt when wavelength is comparable to the size of the aperture or obstacle i.e. λ = b		
Interference	Waves from two or more coherent sources superpose with one another producing a resultant wave. If slits are sufficiently narrow, bright fringes are equally bright.		
Standing waves	Formed by the superposition of two waves that are: - Same type of wave - Of the same amplitude - Of the same frequency - Travelling in opposite direction Distinct features of standing waves include: - No transmission of energy - All points have different amplitude - All points have the same phase		
Topic 5: Electric force and field			
Electrical conductor	One that allows the flow of charge through it.		
Electrical insulator	Does not allow the flow of charge through it.		
Conservation of electric charge	The total charge of an isolated system cannot change.		
Coulomb's Law	The electrostatic force between 2 point charges is directly proportional to the product of the two charges and inversely proportional to the square of the distance between them.	$F = \frac{kQq}{r^2}$	N
Electric field strength	(At a point) is defined as the force per unit charge experienced by a small positive test charge.	$E = \frac{kQ}{r^2}$ $= \frac{F}{q}$	NC^{-1}
Electric potential difference	Work done per unit charge to move a small positive test charge between 2 points.	$W = q\Delta V$	V JC^{-1}
Electronvolt	Work done when a charge equals to one electron charge is taken across a pd of 1V.		
Electric current	Rate of flow of electric charge.	$I = \frac{\Delta q}{\Delta t}$ $Q = ALnq$ $I = Anvq$	A
Resistance	Ratio of potential difference to the current.	$R = \frac{V}{I}$ $R = \frac{\rho L}{A}$	
Ohm's Law	The current through the conductor is directly proportional to the pd across it, provided the temperature (and other physical conditions) remains constant.		

			
Power		P = VI = I^2R = V^2/R	W
Emf	Electrical power supplied by the source per unit current delivered by the source.	$V = \varepsilon - Ir$	
Other little stuff	Ideal Ammeter: ZERO resistance Ideal Voltmeter: Infinite resistance $$V_{out}=V_{in}\left(\frac{R_2}{R_1+R_2}\right)$$ LDR: Increase in light intensity, decrease in resistance of LDR Thermistor: Increase in temperature, decrease in resistance of thermistor Strain gauge: Increase in length, increase in resistance In a magnetic field: F on moving charge always at right angle to velocity ➔ circular motion $F_c = F_{magnetic}$ If charge enters field at an angle, the path will be a spiral one.		
Topic 6: Circular Motion			
Uniform circular motion	Motion in a circle of constant radius at constant speed.		
Angular displacement	Angle through which the object moves (when in circular motion).	$\theta = \frac{s}{r}$	rad
Angular speed	Rate of change of angular displacement.	$\omega = \frac{\theta}{t}$ $v = r\omega$	rad s^{-1}
Centripetal acceleration		$a_c = \frac{v^2}{r}$	
Centripetal force	Net force acting on an object experiencing a_c. Provided by friction, gravity, tension, normal force or others.	$F_c = \frac{mv^2}{r}$	N
Newton's Law of Universal Gravitation	Every point particle in the universe attracts every other point particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. - Point masses - Equal and opposite forces	$F = \frac{GMm}{r^2}$	N

	- Always attractive - Act between all objects in universe		
Gravitational field strength	(At a point) is defined as the force per unit mass exerted on a test mass placed at that point. *Assumpn for eqn: all mass concentrated at its centre.*	$g = \frac{GM}{r^2} = \frac{F}{m}$	N kg^{-1}
Acc due to gravity	Varies due to altitude, local geology, and shape of the earth (not quite spherical).		ms^{-2}
Neutral point	Point between two masses which net gravity is zero.		
Topic 7: Nuclear and Particle Physics			
Nucleons	Protons or neutrons.		
Mass/Neutron no.	No. of protons and neutrons.		
Atomic/proton no.	No. of protons.		
Isotopes	Nuclides of the same element with the same proton number but different neutron number.		
Coulomb interaction (weak interaction)	Repulsive force arising from the protons with the atom being all positive in charge. (long-ranged)	Interaction within nucleus	
Strong nuclear force/strong interaction	Strong FOA between hadrons that can overcome coulomb interaction. (Experienced by both protons and neutrons.) (short ranged)		
Radioactive half-life	Time taken for half the unstable nuclei in a given sample to decay.		
Unified atomic mass	1/12 the mass of a C-12 atom.		
Mass defect	Difference between the total mass of the constituents of a nucleus and the mass of the nucleus.		
Binding energy	Amount of energy that is released when a nucleus is assembled from its component nucleons.		
Binding energy per nucleon	Amount of energy that is released when a nucleus is assembled from its component nucleons divided by the number of nucleons making up the nucleus.		
Topic 8: Energy production			
Primary source of energy	One that has not been transformed or converted before use by the consumer.		
Secondary source	One that results from the transformation of a primary source.		
Renewable sources	Can be replenished in relatively short time. - Sun (solar) - Water (kinetic/potential) - Wind (kinetic)		
Non-renewable	Can be replaced but only over very long geological times. - Nuclear fuels – Uranium-235 (Nuclear) - Fossil fuels (Chemical potential)		
Specific energy	Indicate the number of joules of energy that can be released per unit mass of fuel consumed.		J kg^{-1}

	$Specific\ energy = \frac{Amt\ of\ energy\ liberated}{Mass\ of\ fuel\ consumed}$		
Energy density	Energy liberated per unit volume of fuel consumption. $Energy\ density = \frac{Amt\ of\ energy\ liberated}{Volume\ of\ fuel\ consumed}$		J m^{-3}
Nuclear power	Production of energy through a nuclear fission.		
Critical mass	The minimum mass required to sustain a chain reaction. Depends on nature of fuel used and shape of assembly.		
Moderator	Slow neutrons down to allow further reactions to take place.		
Control rods	Movable rods that absorb neutrons readily in the reaction chamber as necessary to control the chain reaction.		
Heat exchangers	Allow nuclear reactions to take place in a sealed environment. The reactions increase the core temperature so that water and steam transfer thermal energy away to turn the turbines.		
Fuel enrichment	Process in which the percentage composition of Uranium-235 in the fuel rods is increased.		
Reprocessing	Involves treating depleted fuel rods to recover uranium and plutonium.		
Wind power	Solar energy → KE of wind → KE of turbines → Electric energy	$KE = \frac{1}{2}A\rho v^3$	J
Pumped storage system	GPE of water → KE of water → KE of water turbines → electrical energy	$P = \frac{mg\Delta h}{t}$	W
Solar power	Solar energy → electric energy		
Solar heating panels	Solar energy → internal energy of the fluid		
Photovoltaic Cell	Solar energy → Electrical energy		
Thermal energy	- Transferred only when there is a difference in temp - Always flow from a region of higher temp to a region of lower temp		
Conduction	Transfer of thermal energy through atomic vibrations.		
Free electron diffusion	Apply for metals/good conductors only.		
Convection			
Thermal radiation	Continual emission of IR waves from the surface of bodies, transmitted without the aid of a medium.		
Black body	Perfect emitter (radiator) or absorber of EM radiation of all wavelengths.		
Wien's displacement law	Relates the wavelength at which the radiation intensity is a maximum to the temp of the black body.	$\lambda_{max}T = k$	2.9x10^{-3} m K
Stefan-Boltzmann Law	Links the total power radiated by a black body (per unit area) to the temp of the black body.	$P = \varepsilon\sigma AT^4$	W

Emissivity	Ratio of power radiated by an object to the power radiated by a black body of <u>same dimensions</u> at the <u>same temperature</u>. Black body = 1 Objects that completely reflect radiation without any absorption at all = 0	Check data booklet	
Solar constant	Amount of solar radiation across all wavelength that is incident in one second on one square metre, at the <u>mean distance</u> of the Earth from the Sun on a plane perpendicular to the line joining the centre of the Sun and the centre of the Earth. Loss of solar energy through: - Scattering - Absorption Amount of energy dependent on: - Output of the sun - Weather conditions on earth - Distance between the Sun and the Earth (elliptical orbit)		1400 W m^{-2}
Albedo	Fraction of radiation received by a planet that is reflected straight back into space. Varies from 0 to 1. Varies daily, could be due to: - Season (cloud formations) - Latitude - Surface type (oceans low α, snow high α)	Check data booklet	0.30 – 0.35
Greenhouse effect	- Short wavelength radiation is received from the sun and causes the surface of the Earth to warm up. - The Earth will emit IR radiation (long wavelength radiation) because the Earth is cooler than the Sun. - Some of the IR radiation is absorbed by the greenhouse gases in the atmosphere and re-radiated in all directions.		
Thermal Equilibrium	$S(1-\alpha)\pi r^2 = e\sigma 4\pi r^2 T^4$ Simplifications: - Treats whole planet as a single body - Ignores any processes that involve feedback		
Enhanced greenhouse effect	Increase in the greenhouse effect caused by human activities. <u>Causes of Global Warming</u> - Changes in composition of greenhouse gases in atmosphere. - Changes in the intensity of the radiation emitted by the Sun.		

	- Cyclical changes in the Earth's orbit and volcanic activities. Mechanisms that increase the rate of global warming - Reduction in snow cover, reduce albedo, increase overall rate of heat absorption - Reduces solubility of gases in sae, increase atmospheric concentrations - Increase both evaporation and atmosphere's ability to hold water vapour		
Topic 9: Wave Phenomena			
Modulation	Intensities of the maxima of the double slit pattern is enveloped and 'bounded' by the intensity distribution of the single slit pattern.		
Resolution	Minimum distance between distinguishable objects in an image.		
Angular resolution	Smallest angular distance between two light sources that can be resolved.		
Rayleigh criterion	Two sources are just resolvable when the first minimum of the diffraction pattern of one of the sources falls on the central maximum of the diffraction pattern of the other source.	$\theta = \frac{1.22\lambda}{b}$	
Resolvance (diffraction grating)	Ratio of the wavelength λ of the light to the smallest difference in wavelength that can be resolved by the diffraction grating Δλ.	$R = \frac{\lambda}{\Delta\lambda} = Nm$	
Doppler effect	Change in the measured frequency of a wave that results from the relative motion of a source and/or an observer relative to the medium in which the wave is propagated.		
Topic 10: Fields (Electric and Gravitational)			
GPE	Work done by an external force in moving it from infinity to that point. ΔGPE = KE → v_{esc}	$E_p = \frac{-GMm}{r} = mV_g$	J
Gravitational potential	Work done per unit mass by an external fore to bring a test mass from infinity to that point.	$V_g = \frac{W}{m} = -\frac{GM}{r}$	J kg^{-1}
Electric potential	Work done per unit charge in moving a small positive test charge from infinity to that point.	$V_e = \frac{W}{q} = \frac{kQ}{r}$	J C^{-1}
EPE		$\Delta E_p = \Delta Vq$	
Electric potential		E=V/d	
Topic 11: Electromagnetic induction, power generation and transformers, capacitors			
Magnetic flux	The product of the magnetic field strength and the area in which the magnetic field passes through. Magnetic flux density (B) passing through an area (A) normal to the direction of the magnetic field.	ϕ = BA cos(θ)	Weber (Wb) or Tesla meter sq (T m^2)

	- B = magnetic field strength - A = plane area which field lines pass through - θ= Angle between direction of B and plane normal		
Magnetic flux density / magnetic field strength	A measure of the magnetic field strength (numerically equal); Number of magnetic field lines (passing through an area); flux per unit area	ϕ /A = B	Tesla
Magnetic flux linkage	The magnetic flux passing through (linked with) a coil - N = Number of turns of the coil	NΔϕ	
Lenz's law	The direction of the induced emf is such as to create a force that opposes the change in magnetic flux that causes it (the induced emf)		
Faraday's law	The magnitude of the induced emf is directly proportional to the rate of change of magnetic flux linkage		
Induced EMF	The emf produced due to a change in magnetic flux over time, due to: - Wire or coil cutting through a magnetic field - A change in magnetic field strength as a conductor passes through a field - Change in coil size or orientation where - B = magnetic field strength - x = distance travelled by rod - l = length of wire/rod passing through field - v = velocity in which rod is travelling	Ɛ (for coil) = $-(N)\frac{\Delta \phi}{\Delta t}$ Ɛ(for rod) $=\frac{\Delta \phi}{\Delta t}$ $=\frac{Bl\Delta x}{\Delta t}$ $= Blv$	Volts (V)
Slip rings	Used in an AC generator, ensures a closed circuit is maintained whereby the coil is still connected with the rest of the circuit despite rotation		
Root-Mean square (RMS)	The RMS value of any alternating electrical quantity is equal to the constant DC value that would give the same average power output / The RMS value current/voltage = current/voltage in a direct circuit required to provide the mean power supplied by an AC	V_{rms} = $\frac{Vmax}{\sqrt{2}}$	
Max/ Average AC power	½ $V_{max}I_{max}$ = Avg AC power $V_{max}I_{max}$ = Max AC power		
Transformers	An apparatus that increases or decreases the voltage of an alternating current. Used in power transmission, usually a step-up transformer is used to increase voltage and reduce current, thus reducing energy loss through current transmission in the wires. The power is then put through a step-down transformer to convert the voltage to a more usable value.		

	- Must use AC to create a changing magnetic flux		
Transformer rule	$$\frac{\mathcal{E}(pri)}{\mathcal{E}(sec)}=\frac{V(pri)}{V(sec)}=\frac{I(sec)}{I(pri)}$$		
Lamina / laminated core	Layers of insulating material (lamina) placed between sheets of iron in the core, to direct the flow of magnetic flux. Reduces eddy currents flowing inside the core.		
Eddy currents	Currents that flow within the iron core of a transformer, leads to energy loss and a loss of efficiency of the transformer.		
Rectification	The process of converting an AC supply into a DC supply. Usually done so with diode bridges, can be half-wave or full-wave.		
Capacitor	The arrangement in which two parallel plates are separated by an insulator (air, vacuum, material). Has the ability to store charge and thus energy.		
Capacitance (C)	The ratio between the charge stored in a capacitor(in one plate) and the potential difference between the two charged plates. The factors affecting capacitance are also - Permittivity (Ɛ) ($\mathcal{E}_0$ is the permittivity of vacuum) - Overlap Area (A) - Distance between parallel plates (d)	$C = QV$ $C = \mathcal{E}\frac{A}{d}$	Coulomb/Volt ; Farad (F)
Energy stored in a capacitor	It is the area under the graph of charge against potential difference between the capacitor. Therefore it is = $\frac{1}{2}QV$=$\frac{1}{2}CV^2$		Joules (J)
Time constant (of a capacitor when it discharges)	The time required for 0.37 (1/e = approx 0.37) of the capacitor's initial charge/voltage to be remaining in the capacitor. Where: - R = total resistance in the circuit that it is discharging to - C = capacitance of capacitor	τ = RC	s^{-1}
Topic 12: Quantum physics			
Photoelectric Effect	Emission of electrons from the surface of a metal when EM radiation of sufficiently high frequency is shone on it. 1. Existence of threshold frequency 2. Emission of photoelectrons is almost instantaneous 3. Max KE of ejected electrons is independent of the intensity of the light but dependent on the frequency of the light used. E = hf		

	I = nhf 4. Rate at which electrons were ejected (so photocurrent produced) proportional to intensity (brightness of light)		
Work function	Minimum amount of energy required for an electron to escape from the surface of a metal. *Note: Rest of energy is converted to KE for electron to make its way to the surface and escape from the metal.* WD by stopping potential = Loss in KE of electrons	$hf = \emptyset + KE$ $eV = KE = hf - \emptyset$	
De Broglie hypothesis	All moving particles have a "matter wave" associated with them. KE = EPE $\frac{1}{2} mv^2 = eV \rightarrow v = (2eV/m)^{1/2}$ $\lambda = \frac{h}{\sqrt{2eVm}}$ Experiment: Diffraction (electron 'wave' wavelength ~ gap) Atomic spacing in crystal atoms (e.g. powdered graphite) Electrons accelerated towards thin layer of graphite	$p = \frac{h}{\lambda}$	
Wave function	Square of the amplitude of the wave function gives the probability of finding the electron at a particular point.		
Beta decay	3 pdts → infinite number of directions and velocities the beta and neutrino can take → KE can take on any value → continuous spectrum		
Decay constant	Probability of decay of a nucleus per unit time.		
Activity	Number of nuclei decaying per unit time.		
Half life	Time taken for half the nuclei in a given sample to decay.		

Nuclear Radius:

- Rutherford scattering (determined by distance of closest approach, KE = (kQq)/r, where r is the radius of the nucleus)
- Electron diffraction (determined diameter of obstacle i.e. diameter of nucleus; make use of wave property, d sinx = lambda)

Nuclear energy levels:

- Alpha decay
- Gamma ray spectra

Quantised energy levels/atomic energy levels (outside of nucleus):

- Emission spectra
- Absorption spectra
- Note: both involve electrons