Definitions and Concepts for OCR (B) Physics A-level

Module 5: Rise and Fall of the Clockwork Universe

5.1: Models and Rules

5.1.1: Creating Models

Activity: The number of nuclei that decay per second for a given radioactive source, measured in Becquerels (Bq).

Capacitance: The charge per unit potential difference between the two sides of the capacitor.

Capacitor: An electrical component that stores charge. A parallel-plate capacitor is made of two parallel conducting plates with an insulator between them (dielectric).

Conservation of Energy: Energy cannot be created or destroyed - it can only be transferred into different forms.

Damping: The dissipation of energy from an oscillating system. The consequence is that the amplitude of oscillation will decrease. Damping occurs when a force opposes the system's motion.

Decay Constant, λ: The probability of a nucleus decaying per unit time.

Driving Frequency: The frequency at which driving force is acting.

Electrical Charge: A property of matter which causes things to feel a force when placed in an electric field. Charge is current times time but you can think of -1 C as a discrete number, $1/(1.6 \times 10^{-19})$, of electrons.

Energy Stored by a Capacitor: Equal to half the product of the charge stored and the capacitance. This can be found from the area under a charge-voltage graph.

Exponential Relationship: For regular intervals of x, the percentage change in y is constant. For an increase of 1 in x, the number that y is multiplied by is called the constant ratio. For example, take the graph of $y = 2^x$. When $x = 1$, $y = 2$, and when $x = 2$, $y = 4$, so when x increases by 1, the value of y is multiplied by 2. This is true for all points in the graph if the function is exponential, so when $x = 3$, $y = 4 \times 2 = 8$, which is true. The function $y = 2^x$ is exponential with a constant ratio of 2.

Forced Vibrations/Oscillations: Repeated up and down oscillations, at the frequency of a driving force.

Free Vibrations/Oscillations: Oscillations that are not caused by a driving force. An object will naturally oscillate at its natural frequency.

Frequency: Of a wave, how many wavelengths pass a fixed point per second. It is the reciprocal of time period.

Graphs of SHM: If the x-t graph of the motion of an object in SHM appears as a sine wave, the gradient of that graph will form the v-t graph of the motion (which in this case shows a cosine wave). Since the acceleration of an object in SHM is directly proportional to the negative of the displacement, the a-t graph will appear as a sine wave reflected in the x-axis.

Half-life, $T_{1/2}$: The time taken for half of the radioactive nuclei in a given sample to decay.

Kinetic Energy: Energy due to motion. It is the amount of energy that would be transferred from an object when it decelerates to rest.

Logarithmic Scale: A scale that is based on the change of exponents (e.g. 10^1, 10^2, 10^3,…). An exponential curve plotted with a logarithmic scale will appear as a straight line.

Period: Also known as time period. The time required for one complete cycle of a vibration to occur. Of a wave, it is the time taken for one wavelength to pass. It is the reciprocal of frequency.

Potential Energy: Energy due to arrangement or position (in a field). Examples are gravitational potential energy and elastic potential energy. An object at rest still has the potential to do work because of potential energy.

Probability: How likely it is for something to happen.

Qualitative Observations: Non-numerical observations (e.g. colour).

Radioactive Decay: The process of unstable nuclei releasing energy, and sometimes particles, by radiation.

Randomness: The nature of something occurring being unpredictable.

Resonance: Resonance occurs when the frequency of forced oscillations is equal to the natural frequency of the oscillating system. The rate of energy transfer is at a maximum during resonance.

Resonator: A device that oscillates to cause resonance. Its amplitude is highest when its driving frequency is equal to the natural frequency of the object it is causing resonance with.

Restoring Force: The force that acts to bring an object back to its equilibrium position.

Simple Harmonic Motion: Motion where the acceleration of an object is directly proportional, and in the opposite direction, to its displacement.

Time Constant, τ: The product of the circuit resistance and capacitance for a given capacitor. It is the time taken for the capacitor to discharge to 1/e (or 36.8%) of its initial charge.

5.1.2: Out into Space

Angular Velocity: A measure of how fast an object is rotating or revolving. Measured in radians per second, rad s^{-1}.

Equipotential Surface: A surface of constant potential. No work is done by the field when an object moves along an equipotential.

Field Line / Line of Force: A line representing the path that a north pole (magnetic field), positive charge (electric field) or mass (gravitational field) would take when placed within the field.

Gravitational Field: A region surrounding a mass in which any other object with mass will experience an attractive force.

Gravitational Field Strength: The force per unit mass exerted on a small test mass placed within the field.

Gravitational Potential, V_{grav} (at a point in the field): The work done per unit mass required to move a small test mass from infinity to that point.

Gravitational Potential Energy: Energy due to being in a gravitational field. It is the type of energy gained by an object when it is raised by a height in a gravitational field.

Kinetic Energy: Energy due to motion. It is the amount of energy that would be transferred from an object when it decelerates to rest.

Point Mass: You can model the mass of a spherical object as a point mass at its centre.

Potential Energy: Energy due to arrangement or position (in a field). Examples are gravitational potential energy and elastic potential energy. An object at rest still has the potential to do work because of potential energy.

Radial Field: A field in which the field lines are all directed towards a single point (e.g. the centre of a planet or a point charge).

Uniform Field: A field in which all of the field lines are parallel and equally spaced – field strength is equal in all areas of the field.

5.1.3: Our Place in the Universe

Big Bang Theory: Also known as the 'hot big bang theory'. This model describes the universe as having expanded from the initial state of an extremely hot and dense singularity.

Cosmic Microwave Background Radiation (CMB or CMBR): Microwave radiation found in all directions, everywhere. Believed to have originated as gamma rays in the Big Bang which over time have lost energy as the universe expanded and cooled.

Hubble's Law: The speed of a galaxy moving away from ours is proportional to its distance away from us. The constant of proportionality is Hubble's constant. This is seen in cosmological red-shifts (due to the Doppler effect).

Light Year: The distance covered by light travelling in a vacuum for one year.

Logarithmic Scale: A scale that is based on the change of exponents (e.g. 10^1, 10^2, 10^3,…). An exponential curve plotted with a logarithmic scale will appear as a straight line.

Radar: Used to measure distances in the solar system and relative speeds. A pulse is transmitted and detected from the same place, after reflecting off a body. This pulse travels at the speed of light which allows the calculation of what distance is covered in its path.

Red-shift: The effect of an object appearing as red due to it moving away from the observer. The opposite would be seen (blue-shift) if the object was moving towards the observer. This is caused by the Doppler effect, an apparent change in wavelength due to movement of the source relative to the observer.

Relativistic Factor: Also known as the 'Lorentz Factor'. The factor by which time, length, and relativistic mass changes for objects moving at relative velocities.

Time Dilation: When two observers with different relative velocities record a different time taken for an event to occur.

5.2: Matter

5.2.1: Matter: Very Simple

Absolute Temperature: A temperature value relative to absolute zero. Measured in Kelvin (K).

Absolute Zero: The theoretical lowest possible temperature of a system, where no heat remains and the particles in the system have no kinetic energy.
Equal to 0 K.

Avogadro's Constant, N_A: The number of units of a given substance in a mole.
To 3 significant figures, it's equal to 6.02×10^{23} mol^{-1}.

Ideal Gas: A hypothetical gas that obeys the ideal gas laws exactly.

Internal Energy: The total energy contained within a closed system. It includes the sum of the potential energies (due to intermolecular forces) and kinetic energies of each particle.

Impulse: The change of momentum of an object when a force acts on it. Equal to the area underneath a force-time graph.

Kinetic Theory of Ideal Gases: The assumptions that ideal gas particles move randomly (brownian motion), that the particles (atoms or molecules) occupy negligible volume, that all collisions are perfectly elastic, and that there are negligible forces between particles except during collision. The average energy per particle is directly proportional to temperature.

Random Walk of Molecules: A model of the random motion of gas molecules (brownian motion).

Root Mean Square Speed: A measure of the speed of molecules in a gas. It is determined by squaring the velocity of each particle and determining an average velocity-squared, and then finding the square root of that average velocity-squared.

Specific Thermal Capacity, c: Also known as specific heat capacity. The amount of energy required to increase the temperature of 1kg of a substance by 1 Kelvin.

5.2.2: Matter: Hot or Cold

Activation Energy: The minimum energy required for a reaction or physical phenomena to occur.

Boltzmann Factor: The probability of molecules occupying a given energy state relative to the probability of the molecule occupying a state with zero energy. This changes with which energy state you're referring to and the temperature of the system.

Ionisation: The process of an atom or molecule gaining/losing electrons to acquire a charge.

Thermionic Emission: The emission of electrons from a metal plate due to heating it.