OCR (A) Physics A-level

Module 5 - Newtonian World and Astrophysics

Definitions and Concepts

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5.1: Thermal Physics

Absolute Temperature: A temperature value relative to absolute zero.

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

Avogadro Constant: The number of particles that make up one mole of any gas.

Boltzmann Constant: A constant relating the average kinetic energy of the particles in a gas, to the gas' temperature.

Boyle's Law: The pressure of an ideal gas is inversely proportional to its volume when held at constant temperature.

Brownian Motion: The random motion of particles.

Change of Phase: The transitions between solids, liquids and gases. During a change of phase, there is a change of internal energy but not temperature.

Equation of State of an Ideal Gas: An equation linking pressure, volume, number of moles, temperature and the ideal gas constant.

Gas: A phase of matter in which the particles are high energy and free to move. Gases will fill the space they are placed in.

Internal Energy: The sum of the randomly distributed kinetic and potential energies of the particles in a given system.

Kelvin: The unit of absolute temperature.

Liquid: A phase of matter in which the particles can slide over each other, but still have forces of attraction between each other.

Solid: A phase of matter in which the particles can only vibrate about fixed positions, due to strong intermolecular forces.

Specific Heat Capacity: The amount of energy required to increase the temperature of 1kg of a substance by 1 Kelvin.

Specific Latent Heat: The amount of energy required to change the state of 1kg of a substance without a change of temperature.

Thermal Equilibrium: A stable state in which there is no thermal heat transfer between two regions.

5.2: Circular Motion

Angular Velocity: An object's rate of change of angular position.

Centripetal Acceleration: The acceleration of an object moving in circular motion. Any object in circular motion must have an acceleration since the direction of the object, and therefore the velocity of the object, is constantly changing.

Centripetal Force: The resultant force responsible for an object moving in circular motion. Centripetal forces always act towards the centre of the object's rotation.

Frequency: The inverse of time period. The number of rotations per unit time.

Period: The time taken for one whole rotation.

Radian: A unit of angle, where 2π equal to one complete angular rotation.

5.3: Oscillations

Angular Frequency: A measure of an object's angular displacement per unit time.

Critical Damping: The form of damping that reduces the displacement of an oscillating object to its equilibrium position in the quickest time possible and without further oscillation.

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.

Forced Oscillations: Repeated up and down oscillations, at the frequency of a driver. The amplitude of oscillation is small at high frequencies and large at low frequencies.

Free Oscillations: Oscillations that are not caused by a driver. An object will naturally oscillate at its natural frequency.

Isochronous Oscillator: An oscillator whose frequency is independent to amplitude.

Natural Frequency: The frequency that a system naturally oscillates at when there is no driving force.

Overdamping: A type of damping where the system is damped more than required to stop the oscillations. It takes longer for the system to return to equilibrium than for critical damping.

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

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

Underdamping: A type of damping where energy is gradually removed from the system and the amplitude of oscillations slowly decreases.

5.4: Gravitational Fields

Escape Velocity: The minimum velocity required by an object to be able to escape a gravitational field of a mass when projected vertically from its surface.

Field Lines: A line representing the path that a mass would take when placed within the field.

Geostationary Satellite: A satellite that orbits above the equator with a 24 hour period, so it will always remain above the same position on the Earth. They orbit approximately 36,000km above the surface of the Earth.

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

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

Gravitational Potential Energy: The component of an object's energy due to its position in a gravitational field.

Gravitational Potential: The work done per unit mass required to move a small test mass from infinity to that point.

Kepler's First Law: All planets travel in elliptical orbits, centred around the sun.

Kepler's Second Law: All planets sweep out the same area in a given period of time.

Kepler's Third Law: The square of a planet's period is directly proportional to the cube of its mean distance to the sun.

Newton's Law of Gravitation: The force between two masses is proportional to the product of the masses involved and inversely proportional to the square of the separation of the masses.

5.5: Astrophysics and Cosmology

Absorption Line Spectrum: A spectrum consisting of dark lines at specific frequencies that have been absorbed by the gases present. Elements can only absorb certain energies, and therefore frequencies, of photons.

Astronomical Unit: The mean distance of the earth to the sun.

Big Bang Theory: The theory that the universe originated as a small, dense and hot region that expanded and cooled forming the structures in the universe we see today.

Black Hole: A law stating that the power output (luminosity) of a star is directly proportional to its surface area and its absolute temperature to the 4^{th} power.

Chandrasekhar Limit: The maximum mass that a white dwarf star can have whilst remaining stable.

Comets: Concentrated clusters of ice and dust that travel through space. When near the sun, they begin to melt and so leave a trail as they move.

Continuous Spectrum: A spectrum that covers a full range of frequencies without any gaps. The electromagnetic spectrum is an example of a continuous spectrum.

Cosmological Principle: A principle stating that the universe is isotropic (same in all directions to all observers) and homogenous (matter is distributed evenly).

Dark Energy: An energy that is responsible for the acceleration in the expansion of the universe which cannot be explained by any observable energy.

Doppler Effect: The apparent change in the wavelength of a wave as the source moves relative to an observer. For a source moving away the wavelength increases, for a source moving towards the observer the wavelength decreases.

Electron Degeneracy Pressure: The outwards force, resisting the inwards force of gravity, produced as a result of multiple electrons not being able to exist in identical states in an energy level.

Emission Line Spectrum: A series of bright lines at specific frequencies that have been emitted by the gases present. Elements can only release photons of certain energies, and therefore frequencies.

Galaxies: Collections of billions of stars, planets, gases and dust, held together by gravitational attraction.

Hertzsprung-Russell Diagram: A visual representation of the lifecycle of a star. It is a plot of luminosity against temperature.

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.

Light-Year: The distance travelled through space by a photon in a year.

Nebula: A cloud of dust and gas in space.

Neutron Star: An incredibly dense star that is formed when the core of a large star collapses. Protons and electrons are forced together under gravity to form neutrons.

Parsec: The distance at which the angle of parallax is 1 arcsecond.

Planet: A body that orbits around a star, in our case, the Sun.

Planetary Satellites: Bodies that orbit a planet. The gravitational force of the planet's mass provides the centripetal force of rotation.

Red-Giant: A stage in the life cycle of a star less than 3 solar masses, in which the hydrogen has run out and the temperature of the star increases. Helium nuclei fuse to form heavier elements.

Solar Systems: A collection of planets that orbit a common star.

Stefan's Law: A law stating that the power output (luminosity) of a star is directly proportional to its surface area and its absolute temperature to the 4^{th} power.

Stellar Parallax: The change in position of an object depending on the viewing angle. It can be used to estimate the distance of a star, based on how much it moves relative to the background of stars in the time it takes for the earth to move half an orbit.

Supernova: When a star greater than 1.4 solar masses dies, the core collapses rapidly inward and becomes rigid. The outer layers then fall inward and rebound off of the core in a shockwave, causing heavy elements to be fused and distributed into space in an explosion.

Universe: The name given to all space and matter.

White Dwarf: A dense star, similar mass to the sun, similar size to the earth. A final stage of a low mass star's life with low luminosity.

Wien's Displacement Law: A law stating that the peak wavelength of emitted radiation is inversely proportional to its absolute temperature.