Definitions

Kinematics, Dynamics, Work, Energy and Power

Displacement is the distance moved in a specific direction.

Velocity is the rate of change of displacement with respect to time.

Acceleration is the rate of change of velocity with respect to time.

Newton's First Law states that a body continues in its state of rest or uniform motion in a straight line unless an external resultant force acts on it.

Newton's Second Law states that the rate of change of momentum of a body is directly proportional to the resultant force acting upon it and takes place in the direction of the force.

Newton's Third Law states that if body A exerts a fore on body B, then body B exerts an equal and opposite force on body A.

A body is in equilibrium if the resultant force on the body and the resultant torque at any point are both zero.

Principle of Conservation of Linear Momentum states that the total momentum of a system stays constant when no net external force acts on it.

Principle of Conservation of Energy states that energy can neither be created nor destroyed, and can only be converted from one form to another.

Hooke's Law states that the force in a spring is proportional to its extension.

Upthrust is the upward force exerted by a fluid on an object submerged in it.

Archimedes' Principle states that the upthrust on an object is equal to the weight of fluid displaced.

Thermal Physics

Internal energy of a system is the sum of all the microscopic kinetic and potential energies of the atoms within the system due to random motion.

Zeroth Law of Thermodynamics states that if objects A and B are separately in thermal equilibrium with a third object C, then A and B are in thermal equilibrium with each other if placed in thermal contact.

First Law of Thermodynamics states that the increase in the internal energy of a system is the sum of the work done *on* the system and the heat supplied to the system.

An ideal gas is a gas which obeys the ideal gas law, $pV = nRT$.

An absolute temperature scale does not depend on the thermometric property of any substance.

Specific heat capacity is the quantity of heat required to raise the temperature of 1 kg of a substance by 1 K.

Specific latent heat of fusion/vaporisation is the energy required to change the state of 1 kg of a substance from solid to liquid/liquid to vapour without a change in temperature.

Gravitation

Newton's Law of Gravitation states that the force of attraction between two point masses is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Gravitational field strength is the gravitational force per unit mass experienced by a point mass at that point.

Gravitational potential energy is the work done by an external force in bringing a point mass from infinity to a point.

Gravitational potential is the work done per unit mass by an external force in bringing a mass from infinity to a point.

Geostationary orbit refers to a circular orbit around the Earth on which a satellite would appear stationary to an observer on the Earth's surface.

Electric Field

Coulomb's Law states that the force between two small charges is proportional to each of the charges and inversely proportional to the square of the distance between them.

Electric field strength is the electric force per unit positive charge acting on a small charge placed at that point.

Electric potential is the work done per unit positive charge by an external force in moving a small charge from infinity to that point.

Oscillations

Simple harmonic motion refers to a motion where acceleration is directly proportional to the displacement from a fixed point and is always directed towards that fixed point.

Free oscillations refer to oscillations made by an object of its own natural frequency, with no resistive forces acting on it.

Damped oscillations are oscillations in which the amplitude decreases with time.

Resonance occurs when a system responds with maximum amplitude to an external driving force.

Waves

The Principle of Superposition states that when two or more waves meet, the resultant displacement at any point is given by the vector sum of the displacements due to each of the waves at that point.

Diffraction refers to the spreading out of waves when they pass through a small opening or around a small obstacle.

Coherent sources are sources which have a constant phase difference.

Progressive waves transmit energy via propagating vibrations, without transmitting the wave particles.

Transverse waves are waves in which particles of the medium move in a direction perpendicular to the direction of travel of the wave.

Longitudinal waves are wave in which particles of the medium move in a direction parallel to the direction of travel of the wave.

Stationary waves are created when two similar waves of the same amplitude, frequency and wavelength travelling in opposite directions meet.

Phase difference is the difference in the stages of oscillation cycles between 2 waves at any point.

Polarisation is where transverse waves are made to oscillate in the same plane.

Circuits

Potential difference between two points is the amount of electric energy that is converted to other forms of energy when a unit charge passes from one point to the other.

E.m.f. of a source is the amount of non-electrical energy converted to electrical energy per unit charge in driving a unit charge round a complete circuit.

Resistance is the ratio of the p.d. across a device to the current through it.

One coulomb is the quantity of electric charge that passes a given point in a circuit in 1 s when there is a constant current of 1 A.

One volt is the potential difference between two points in a circuit in which one joule of energy is converted when one coulomb of charge passes from one point to the other.

One ohm is defined as the resistance of a conductor in which a current of 1 A passes through it when the p.d. across it is 1 V.

Electromagnetism & Electromagnetic Induction

Magnetic flux density of a magnetic field is the force per unit length per unit current that acts on a current-carrying conductor placed perpendicularly to the magnetic field.

One tesla is the magnetic flux density when the force on a 1 m wire carrying a current of 1 A and placed perpendicularly to the magnetic field is 1 N.

Magnetic flux through a surface is the product the magnetic flux density normal to the surface and the area of the surface.

One weber is the magnetic flux through an area of 1 m^2 when the magnetic flux density perpendicular to the plane of the area is 1 T.

Magnetic flux linkage in a coil is the product of the number of turns of the coil and the magnetic flux through the coil.

Faraday's Law states that the induced e.m.f. produced is proportional to the rate of change of magnetic flux linkage OR the rate of cutting of magnetic flux.

Lenz's Law states that the direction of the induced current will be such that it produces an effect to to oppose the change in magnetic flux that causes it.

Quantum Physics

Wave-particle duality states that matter has a dual nature which is both wave-like or particle-like.

Photoelectric effect refers to the phenomenon where electrons are emitted from a metal surface when light of sufficient frequency is incident on it.

Threshold frequency is the minimum frequency of light required for electrons to be emitted from a metal.

Work function is defined as the minimum amount of energy necessary to remove a free electron from the surface of the metal.

Wave function absolute squared ($|\Psi|^2$) gives the probability density of finding the particle at a particular point.

Quantum tunneling refers to the phenomenon where a particle without enough energy to pass over a potential barrier may still tunnel through it.

Lasers

Spontaneous emission refers to the emission of photons through the random de-excitation of excited atoms.

Stimulated emission refers to when the emission of photons from the de-excitation of an excited atom is triggered by an incoming photon whose energy is exactly equal to the energy difference between the excited state and a lower transition level.

Metastable state is where atoms remain in the excited state for a longer time compared to other excited states.

Nuclear Physics

Activity is the number of atoms decaying per second.

Decay constant is the probability of decay per nucleus per unit time.

Half-life is the time taken for a sample of atoms to decay to half their initial number.

Formula List

Kinematics, Dynamics, Work, Energy and Power

- $v = u + at,\ s = ut + \frac{1}{2}at^2,\ v^2 = u^2 + 2as$
- $p = mv,\ F = \frac{d(mv)}{dt} = ma$ (if no change in mass)
- $\text{Impulse} = \Delta p = F_{avg} \times t$
- Elastic collisions: Rel. speed of approach = Rel. speed of separation, $u_2 - u_1 = v_1 - v_2$
- $KE = \frac{1}{2}mv^2,\ GPE = mgh$
- $\text{Work Done} = Fs\cos\theta$
- $\text{Power} = Fv$
- Springs: $F = ke,\ EPE = \frac{1}{2}ke^2$
- Fluids: $\text{Upthrust} = \rho Vg,\ \text{Pressure} = \rho gh$

Circular Motion

- $v = r\omega$
- $\omega = 2\pi f = \frac{2\pi}{T}$
- $a = \frac{v^2}{r} = r\omega^2,\ F = m\frac{v^2}{r} = mr\omega^2$

Gravitation

- $F = \frac{GMm}{r^2} = -\frac{dU}{dr} = mg$
- $g = \frac{GM}{r^2} = -\frac{d\phi}{dr}$
- $U = -\frac{GMm}{r} = m\phi$
- $\phi = -\frac{GM}{r}$
- Escape velocity: $\frac{1}{2}mv^2 \geq mgh \Rightarrow v \geq \sqrt{2gR}$

Electric Field

- $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2} = -\frac{dU}{dr} = qE_{field}$
- $E_{field} = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r} = -\frac{dV}{dr}$
- $U = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r} = q\Delta V$
- $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$
- Parallel Plates: $E_{field} = \frac{V}{d}$

- Orbiting satellite: $\frac{GMm}{r^2} = m\frac{v^2}{r} \Rightarrow v = \sqrt{\frac{GM}{r}}$
- Energy of satellite: $KE = \frac{1}{2}mv^2 = \frac{GMm}{2r}$, $\text{Total E} = KE + GPE = -\frac{GMm}{2r}$
- Period of satellite: $\frac{GMm}{r^2} = mr(\frac{2\pi}{T})^2 \Rightarrow T^2 = \frac{4\pi^2R^3}{gR^2}$

Thermal Physics

- Kelvin = Celsius + 273.15
- $Q = mc\Delta\theta$
- $pV = nRT$
- W.D. = Area under *p*-*V* graph (+ve WD *by* gas for expansion; +ve WD *on* gas for compression)
- $\Delta U = Q + W$
- Average KE per gas molecule $= \frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$

Simple Harmonic Motion

- $a = -\omega^2 x$
- $x = x_0 \sin \omega t$
- $v = \omega x_0 \cos \omega t = \pm\omega\sqrt{{x_0}^2 - x^2}$
- $KE = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2({x_0}^2 - x^2),\ PE = \frac{1}{2}m\omega^2 x^2$
- Total E $= KE + PE = \frac{1}{2}m\omega^2 {x_0}^2$

Waves

- $v = f\lambda$
- Phase Difference $= \frac{\Delta x}{\lambda} \times 2\pi$ OR $\frac{\Delta t}{T} \times 2\pi$
- Intensity $= \frac{\text{P}}{\text{Area}}$
- Int. $\propto$ Amplitude, Int. $\propto \frac{1}{r^2}$, Amplitude $\propto \frac{1}{r}$
- Constructive Interference: Path diff. $= n\lambda$ OR Phase diff. $= 2n\pi$
- Destructive Interference: Path diff. $= (n + \frac{1}{2})\,\lambda$ OR Phase diff. $= (2n + 1)\,\pi$
- Double slit: $y_{bright} = n\frac{\lambda L}{d},\ y_{dark} = (n + \frac{1}{2})\frac{\lambda L}{d} \Rightarrow \Delta y = \frac{\lambda L}{d}$
- Diffraction grating: $d \sin\theta = n\lambda$

Electromagnetism

- Charge: $F = Bqv$
- Rod: $F = BIL$
- Coil: $F = NBIh$
- Circular Motion of charge: $Bqv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{Bq}$
- Velocity Selector: $Bqv = qE_{field} \Rightarrow v = \frac{E}{B} = \frac{V}{Bd}$

Electromagnetic Induction

- $\Phi = B_\perp A$ (for planes)
- $\Phi_{\text{linkage}} = NBA$ (for coils)
- $\varepsilon = -\frac{d\Phi}{dt} = \frac{N(\Delta BA)}{\Delta t}$
- Moving rod: $\varepsilon = BLv$
- Rotating disc: $\varepsilon = BAf$
- Generator: $\Phi = NBA\cos\omega t \Rightarrow \varepsilon = NBA\omega \sin\omega t$

Circuits

- $V = RI$
- $P = VI = \frac{V^2}{R} = I^2R$
- $I_{rms} = \frac{I_0}{\sqrt{2}},\ V_{rms} = \frac{V_0}{\sqrt{2}},\ P_{avg} = \frac{P_0}{2}$
- Transformers: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ $(= \frac{I_p}{I_s}$ if ideal transformer)

Quantum Physics

- $E = hf = \frac{hc}{\lambda}$
- $hf = \Phi + KE_{max}$ where $KE_{max} = eV_s$
- $I = \frac{Ne}{t}$, $P = \frac{NE}{t}$
- de Broglie's wavelength: $\lambda = \frac{h}{p} = \frac{h}{mv}$
- X-Ray: $\lambda_{min} = \frac{hc}{eV}$
- Heisenberg's Uncertainty Principle: $\Delta E \Delta t \geq \frac{h}{4\pi}$, $\Delta p \Delta x \geq \frac{h}{4\pi}$
- No. of possible transitions between *n* energy levels = ${}^{n}C_{2}$

Nuclear Physics

- $E = mc^2$
- $A = -\frac{dN}{dt} = \lambda N$
- $t_{½} = \frac{\ln 2}{\lambda}$
- $A = A_0 e^{-\lambda t}$, $N = N_0 e^{-\lambda t}$, $C = C_0 e^{-\lambda t}$
- $\frac{A}{A_0} = (\frac{1}{2})^{\text{no. of } t_{½}}$, $\frac{N}{N_0} = (\frac{1}{2})^{\text{no. of } t_{½}}$, $\frac{C}{C_0} = (\frac{1}{2})^{\text{no. of } t_{½}}$