

A Level Physics Formulae

10. Creating models

Radioactivity

Probability p of decay in time Δt : $p = \lambda \Delta t$

Activity: $\frac{dN}{dt} = -\lambda N$

Number of atoms: $N = N_0 e^{-\lambda t}$

Half-life: $t_{1/2} = \frac{\ln 2}{\lambda}$

Exponential decay of charge

Change in discharge: $\frac{dQ}{dt} = -\frac{Q}{RC}$

Discharge of capacitor: $Q = Q_0 e^{-t/RC}$

Time constant (charge reduced by 1/e): $\tau = RC$

Charge, capacitance and voltage: $Q = CV$

Energy stored on capacitor: $E = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} \cdot \frac{Q^2}{C}$

Harmonic oscillators

Period of harmonic oscillator: $T = \frac{2\pi}{\omega} = 2\pi \sqrt{\frac{m}{k}}$

Period of pendulum of length l : $T = 2\pi \sqrt{\frac{l}{g}}$

Acceleration \propto displacement: $\frac{d^2 s}{dt^2} = -\frac{k}{m} s = -(2\pi f)^2 s$

Displacement, where ϕ is phase angle: $s = A \sin(2\pi ft + \phi)$, i.e. $\omega = 2\pi f$

Energy stored in mechanical oscillator: $E = \frac{1}{2} kx^2 + \frac{1}{2} mv^2$

11. Out into space

Centripetal force: $F = \frac{mv^2}{r} = m\omega^2 r$

Gravitational force between two masses: $F = -\frac{Gm_1 m_2}{r^2}$

Gravitational field strength: $g = -\frac{GM}{r^2}$

G.P.E. difference in uniform field: $E = mg\Delta h$

Gravitational potential: $V_{grav} = -\frac{GM}{r}$

Force, momentum and acceleration: $F = \frac{\Delta p}{\Delta t} = m \frac{\Delta v}{\Delta t} = ma$

12. Our place in the Universe

Relative velocity from radar: $\frac{v}{c} = \frac{\Delta t_{back} - \Delta t_{out}}{\Delta t_{back} + \Delta t_{out}}$

Doppler shift (two-way): $\frac{v}{c} = \frac{\lambda_{back} - \lambda_{out}}{\lambda_{back} + \lambda_{out}} \Rightarrow \frac{\Delta\lambda}{2\lambda} \approx \frac{v}{c}$

Doppler shift (one-way): $\frac{\Delta\lambda}{\lambda} \approx \frac{v}{c}$

Recession velocity: $v = H_0 r$

Red-shift: $\frac{R_{observed}}{R_{emitted}} = 1 + \frac{\Delta\lambda}{\lambda_{emitted}} = 1 + z$

13. Matter: very simple

Ideal gas law: $pV = nRT = NkT \Rightarrow \frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

Kinetic model of a gas: $pV = \frac{1}{3} N m \overline{c^2}$

Average kinetic energy of molecule: $\frac{1}{2} m \overline{v^2} = \frac{3}{2} kT$

Internal energy of monatomic gas: $U = \frac{3}{2} NkT = \frac{3}{2} nRT$

Internal energy, work, thermal transfer: $\Delta U = W + Q$

Change in energy: $\Delta E = m c \Delta\theta$

Approximate energy of particle: kT

14. Matter: very hot and very cold

Boltzmann factor: $\exp(-\varepsilon / kT)$

Rate of reaction: $\text{rate} \propto \exp(-\varepsilon / kT)$

15. Electromagnetic machines

Flux

Flux linkage: $\text{flux linkage} = N\phi$

Permeance, magnetic flux, current-turns: $\Lambda = \frac{\phi}{NI}$

Permeance, area, length: $\Lambda = \frac{\mu A}{L}$

Electromotive force: $\text{e.m.f.} = -N \frac{d\phi}{dt}$

Flux density: $B = \frac{\phi}{A}$

Flux density, where $n = \text{turns/metre}$: $B = \mu nI$

Transformers

Transformer, voltage & turns: $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

Transformer, current & turns: $\frac{I_S}{I_P} = \frac{N_P}{N_S}$

Force on conductor: $F = ILB$

16. Charge and field

Work done: $W = q\Delta V$

Speed of particle: $v = \sqrt{\frac{2qV}{m}}$

Electric field strength (NC^{-1} or Vm^{-1}): $E = \frac{F}{q} = -\frac{\Delta V}{\Delta x}$

Electric potential at point in field: $V = \frac{E}{q}$

Magnetic force on moving charge: $F = qvB$

Radius of circular path in magnetic field: $r = \frac{p}{qB}$

Electric potential: $V_{elec} = \frac{q}{4\pi\epsilon_0 r}$

Electric field strength: $E = \frac{q}{4\pi\epsilon_0 r^2}$

Force between two point charges: $F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$

17. Probing deep into matter

De Broglie wavelength: $\lambda = \frac{h}{p}$

Energy-frequency relationship for photons: $E = hf = E_{initial} - E_{final}$

Energy level spacings in hydrogen: $E_n = \frac{-13.6\text{eV}}{n^2}$

18. Ionising radiation and risk

Exponential attenuation of γ radiation: $I = I_0 e^{-\mu x}$

Risk: risk = probability x consequences

Absorbed dose (measured in gray): $\text{dose} = \frac{E}{m}$

Dose (measured in sievert): $\text{dose} = \frac{E}{m} \times \text{quality factor}$

Rest energy: $E_{rest} = mc^2$

Binding energy of nucleus: $E = (m_{\text{nucleus}} - m_{\text{nucleons}})c^2$

General / AS formulae

Density, mass and volume: $\rho = \frac{m}{V}$

Momentum (for slow particles): $p = mv$

Energy transfer in circuit: $E = VIt = Pt = qV$

Force, mass and acceleration: $F = ma$

Weight:	$W = mg$
Kinetic energy:	$\text{K.E.} = \frac{1}{2}mv^2$
Change in potential energy:	$\Delta\text{P.E.} = mg\Delta h$
Work done:	$\text{Work done} = Fs$
Charge:	$\Delta Q = I\Delta t$
Potential difference:	$V = IR$
Electrical power:	$P = IV = I^2R = \frac{V^2}{R}$
Resistance:	$R = \frac{V}{I} = \frac{\rho L}{A}$
Conductance:	$G = \frac{I}{V} = \frac{\sigma A}{L}$
Internal resistance:	$V_{\text{load}} = E - IR_{\text{internal}}$
Pressure:	$P = \frac{F}{A}$
Wave speed:	$v = f\lambda$
Frequency:	$f = \frac{1}{T}$
Impulse:	$\text{Impulse} = F\Delta t = mv - mu$
Power:	$P = \frac{Fs}{t} = Fv$
Efficiency:	$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy output}}$
Speed, distance, time:	$v = \frac{s}{t}$
Constant acceleration formulae:	$s = ut + \frac{1}{2}at^2$ $v = u + at$ $v^2 = u^2 + 2as$
Optics:	$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}; n = \frac{\sin i}{\sin r} = \frac{c_{\text{vacuum}}}{c_{\text{medium}}}$