

Learn these by heart before the exam.

Mechanics and materials

$v = u + at$, $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$ constant acceleration only

$F = ma = \frac{\Delta p}{\Delta t}$, $p = mv$ resultant force = rate of change of momentum

$W = Fs \cos \theta$, $P = Fv$, $E_k = \frac{1}{2}mv^2$ power = force $\times$ velocity

stress $\sigma = \frac{F}{A}$, strain $\varepsilon = \frac{\Delta L}{L}$

$E = \frac{\sigma}{\varepsilon} = \frac{FL}{A \Delta L}$ Young modulus = gradient of the stress-strain graph

$E_{\text{elastic}} = \frac{1}{2}Fx = \frac{1}{2}kx^2$ area under a force-extension graph

Conservation of momentum in all collisions; kinetic energy conserved only when elastic.

Circular motion and gravitation

$\omega = \frac{2\pi}{T} = 2\pi f$, $v = r\omega$

$a = \frac{v^2}{r} = r\omega^2$, $F = \frac{mv^2}{r}$ centripetal – directed towards the centre

$F = \frac{GMm}{r^2}$, $g = \frac{GM}{r^2}$

$\phi = -\frac{GM}{r}$, $v = \sqrt{\frac{GM}{r}}$ gravitational potential; orbital speed

$T^2 = \frac{4\pi^2}{GM}r^3$ Kepler's third law (circular orbit)

Oscillations and waves

$a = -\omega^2 x$ defining condition of SHM

$x = x_0 \cos \omega t$, $v = \pm \omega \sqrt{x_0^2 - x^2}$ $v_{\text{max}} = \omega x_0$ at the centre

$E_{\text{total}} = \frac{1}{2}m\omega^2 x_0^2$

Resonance and damping: resonance = maximum amplitude when the driving frequency equals the natural frequency; damping reduces amplitude and lowers the resonant peak

$v = f\lambda$, intensity $\propto$ amplitude²

$d \sin \theta = n\lambda$ diffraction grating; two-source fringes $\lambda = \frac{ax}{D}$

Thermal and ideal gases

$pV = nRT = NkT$

$pV = \frac{1}{3}Nm\langle c^2 \rangle$, $\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$ mean kinetic energy $\propto$ absolute temperature

$Q = mc\Delta\theta$, $Q = mL$ L = specific latent heat

$\Delta U = q + w$ first law of thermodynamics; internal energy of an ideal gas depends only on T

Fields and electricity

$E = \frac{V}{d} = \frac{F}{q}$, $E = \frac{Q}{4\pi\epsilon_0 r^2}$

$V = \frac{Q}{4\pi\epsilon_0 r}$, $F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$ Coulomb's law

$C = \frac{Q}{V}$, $W = \frac{1}{2}QV = \frac{1}{2}CV^2$

decay: $V = V_0 e^{-t/RC}$ capacitor discharge; time constant $\tau = RC$

$V = IR$, $P = VI = I^2 R$, $R = \frac{\rho L}{A}$

$\varepsilon = I(R + r)$ e.m.f. = terminal p.d. + lost volts across internal resistance r

Magnetic fields and induction

$F = BIL \sin \theta$, $F = BQv$ force on a current / a moving charge

$\Phi = BA$, flux linkage = $N\Phi$

$\varepsilon = -\frac{d(N\Phi)}{dt}$ Faraday's law; the minus sign is Lenz's law

Fleming's left hand = motor (force); right hand = generator (induced current).

Quantum and nuclear

$E = hf = \frac{hc}{\lambda}$

$hf = \varphi + E_{k,\text{max}}$ photoelectric equation; φ = work function

$\lambda = \frac{h}{p} = \frac{h}{mv}$

$\Delta E = \Delta mc^2$ mass defect $\times c^2$ = binding energy

$A = \lambda N = A_0 e^{-\lambda t}$, $t_{1/2} = \frac{\ln 2}{\lambda}$

Binding energy per nucleon peaks at iron-56; fusion (light nuclei) and fission (heavy nuclei) both move towards it, releasing energy.