

The paper supplies a Data and Formulae sheet, and every year candidates memorise what is already printed on it and derive what is not. This booklet separates the two. Everything in the “you must know” sections is absent from that sheet and is examined as if it were obvious.

Printed on the exam formula sheet – do not memorise these

The uniform-acceleration (suvat) equations, and the equations of simple harmonic motion including $a = -\omega^2 x$ and $v = \pm\omega\sqrt{x_0^2 - x^2}$.

Gravitational and electric field and potential relationships: $g = GM/r^2$, $\phi = -GM/r$, $E = Q/4\pi\epsilon_0 r^2$, $V = Q/4\pi\epsilon_0 r$.

Capacitance in series and parallel, the stored energy $W = \frac{1}{2}QV$, and the exponential discharge $x = x_0 e^{-t/RC}$.

Ideal gas and kinetic theory: $pV = nRT$ and $pV = \frac{1}{3}Nm\langle c^2 \rangle$.

Radioactive decay $x = x_0 e^{-\lambda t}$ with $\lambda = 0.693/t_{1/2}$, and the mass-energy relation.

The de Broglie wavelength, the photon energy $E = hf$, and the Doppler shift for a moving source.

The data section: values of g , c , e , h , ϵ_0 , G , the Avogadro constant and the electron and proton masses.

You must know – mechanics

Density – $\rho = m/V$

Moment of a force – moment = force $\times$ perpendicular distance from the pivot. The word perpendicular carries the mark.

Work done – $W = Fs \cos \theta$, using the component of the force along the displacement

Kinetic and potential energy – $E_k = \frac{1}{2}mv^2$ and $\Delta E_p = mg\Delta h$ close to the Earth's surface

Power – $P = W/t$, and for a constant force $P = Fv$

Efficiency – useful output energy divided by total input energy, usually stated as a percentage

Momentum and impulse – $p = mv$ and $Ft = \Delta p$; momentum is conserved in every collision, kinetic energy only in an elastic one

Centripetal acceleration – $a = v^2/r = \omega^2 r$, directed towards the centre

Stress, strain and the Young modulus – $\sigma = F/A$, $\epsilon = \Delta L/L$, $E = \sigma/\epsilon$; strain energy is the area under the force-extension graph

You must know – electricity and circuits

Charge, potential difference, resistance , , – $Q = It$, $V = W/Q$, $R = V/I$

Resistivity – $R = \rho L/A$, where A is the cross-sectional area, not the surface area

Electrical power – $P = VI = I^2R = V^2/R$; choose the form using the quantity you actually know

Resistors in series and parallel – series $R = R_1 + R_2$; parallel $1/R = 1/R_1 + 1/R_2$

Electromotive force and internal resistance – $E = I(R + r)$, so the terminal potential difference is $V = E - Ir$

Potential divider – $V_{\text{out}} = V_{\text{in}} \times R_2/(R_1 + R_2)$

You must know – waves, thermal and fields

Wave equation – $v = f\lambda$, with the period $T = 1/f$

Double slit and diffraction grating – $\lambda = ax/D$ for the double slit; $d \sin \theta = n\lambda$ for the grating

Intensity – intensity is proportional to amplitude squared, and for a point source falls as $1/r^2$

Specific heat capacity and specific latent heat – $E = mc\Delta\theta$ for a temperature change; $E = mL$ for a change of state, where the temperature does not change

Transformer – $V_s/V_p = N_s/N_p$, and for an ideal transformer $V_p I_p = V_s I_s$

Force on a current and on a moving charge – $F = BIL \sin \theta$ and $F = BQv \sin \theta$; both are zero when the motion is parallel to the field

Magnetic flux and induced e.m.f. – $\Phi = BA \cos \theta$, and the induced e.m.f. equals the rate of change of flux linkage $N\Delta\Phi/\Delta t$

Constants worth knowing even though they are given

Knowing an order of magnitude catches an absurd answer in seconds: $g \approx 9.81 \text{ m s}^{-2}$, $c = 3.00 \times 10^8 \text{ m s}^{-1}$, $e = 1.60 \times 10^{-19} \text{ C}$, $h = 6.63 \times 10^{-34} \text{ J s}$, and one electronvolt is $1.60 \times 10^{-19} \text{ J}$.

Check every numerical answer against a magnitude you know. An electron mass of 10^{-19} kg , a speed above c , or an efficiency over 100 per cent all mean arithmetic went wrong, and spotting that costs nothing.