PROBLEM SOLVING PHYSICS TOOLKIT

Most of this should be familiar to you from A level physics, but as the different A levels vary somewhat you may find one or two things here that you don't know. All the examples we use can be solved with just these equations (plus any others you may deduce from the problem itself, of course).

NEWTON'S LAWS AND MECHANICS

Newton's second law	$F = ma$	F = force, m = mass, a= acceleration
Impulse (integrated force applied over short time)	$F\Delta t = \Delta p$	F = force, Δt = time interval, Δp = change in momentum
Newton's law of gravity	$F = \frac{Gm_1 m_2}{r^2}$	F = force, G = gravitational constant, m_1, m_2 = masses, r = separation
Uniform circular motion	$a = \frac{v^2}{r} = \omega^2 r$	a = acceleration, v = speed of motion of object moving in a circle of radius r, ω = angular velocity of object = v/r
Friction	$F = \mu N$	F = force, μ = coefficient of friction, N = normal force; F is directed opposite to direction of motion of object
Hooke's law	$F = k\Delta x$	F = force, k = spring constant, Δx = change in spring length

ELECTROMAGNETISM

Coulomb's law	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	F = force, Q_1, Q_2 = charges, ε_0 = permittivity of free space (constant), r = separation
Magnetic force	$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$	**F** = force (vector), q = charge, **v** = velocity (vector), **B** = magnetic field (vector)
Speed of light	$c^2 = \frac{1}{\mu_0 \varepsilon_0}$	c = speed of light, μ_0 = permeability of free space (constant), ε_0 = permittivity of free space (constant)

The latter two equations will be used mostly in dimensional analysis problems.

THERMAL PHYSICS

Ideal gas law	$PV = Nk_B T$	P = pressure, V = volume, N = number of particles, k_B = Boltzmann's constant, T = absolute temperature
Blackbody radiation[1] (energy radiated by a body at temperature T, assuming perfect efficiency)	$f = \sigma T^4$	f = power radiated per unit area (flux), σ = Stefan's constant, T = absolute temperature

USEFUL MATHEMATICAL FORMULAE

Sum of N terms of an arithmetic series whose n^{th} term is $a_n = a_1 + (n-1)k$	$S_N = \sum_{i=0}^{N-1}(a_1 + ik) = \frac{N}{2}(a_1 + a_N)$
Sum of N terms of a geometric series whose n^{th} term is $a_n = a_1 f^{n-1}$	$S_N = a_1 \sum_{i=0}^{N-1} f^i = a_1 \frac{1-f^N}{1-f}$
Taylor series for $f(x)$ around $f(a)$ ($f' = \mathrm{d}f/\mathrm{d}x$ etc.)	$f(x) = f(a) + f'(a)(x-a) + \frac{1}{2!}f''(a)(x-a)^2 + \frac{1}{3!}f'''(a)(x-a)^3 + \cdots$
Commonly used series expansions:	$\sin\theta = \theta - \frac{1}{3!}\theta^3 + \frac{1}{5!}\theta^5 - \cdots$ (θ in radians) $\cos\theta = 1 - \frac{1}{2!}\theta^2 + \frac{1}{4!}\theta^4 - \cdots$ (θ in radians) $(1+x)^n = 1 + nx + \frac{1}{2}n(n-1)x^2 + \frac{1}{3!}n(n-1)(n-2)x^3 + \cdots$ $e^x = 1 + x + \frac{1}{2!}x^2 + \frac{1}{3!}x^3 + \cdots$ $\ln(1+x) = x - \frac{1}{2}x^2 + \frac{1}{3}x^3 - \cdots$ (for $\lvert x \rvert < 1$)

NUMERICAL CONSTANTS

$G = 6.67\times10^{-11}$ N m^2 kg^{-2}	$k_B = 1.38 \times 10^{-23}$ J K^{-1}	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
$g = 9.81$ m s^{-2}	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
Earth's mass = 6.0×10^{24} kg	$N_A = 6.02 \times 10^{23}$ (g-mol)$^{-1}$	$c = 2.998 \times 10^8$ m s^{-1}
Sun's mass = 2.0×10^{30} kg	1 mole of gas: 22.4 litres (STP)	$e = 1.6 \times 10^{-19}$ C
$h = 6.63 \times 10^{-34}$ J s	$m_e = 9.1 \times 10^{-31}$ kg	$m_p = 1.67 \times 10^{-27}$ kg

[1] This you probably didn't meet in A level, but it's useful, so we'll include it here.