

Appendix 7: Equations

Students need not memorise formulae for these qualifications.

The formulae below will be supplied in each examination. Any other formulae that are required will be provided in the question. Symbols used comply with the Association for Science Education (ASE) guidelines (which are based on International Union of Pure and Applied Physics (IUPAP) recommendations).

Unit 1: Mechanics and Materials

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$= Fx$$

Materials

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$$F = 6\pi\eta rv$$

Hooke's law

$$\Delta F = k\Delta x$$

Young modulus

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

$$\Delta E_{el} = \frac{1}{2} F \Delta x$$

Unit 2: Waves and Electricity

Waves and particle nature of light

Wave speed

$$v = f\lambda$$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Refractive index

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Diffraction grating

$$n\lambda = d \sin \theta$$

de Broglie wavelength

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

Photon model

$$E = hf$$

Einstein's photoelectric equation

$$hf = \phi + \frac{1}{2} m v_{\max}^2$$

Electricity

Current

$$I = \frac{\Delta Q}{\Delta t}$$

Potential difference

$$V = \frac{W}{Q}$$

Resistance

$$R = \frac{V}{I}$$

Electrical power, energy and efficiency

$$P = VI$$

$$P = I^2 R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

Resistivity

$$R = \frac{\rho l}{A}$$

$$I = nqvA$$

Unit 4: Further Mechanics, Fields and Particles

Further mechanics

Impulse

$$F\Delta t = \Delta p$$

Kinetic energy of a non-relativistic particle

$$E_k = \frac{p^2}{2m}$$

Motion in a circle

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

$$a = \frac{v^2}{r}$$

$$a = r\omega^2$$

Centripetal force

$$F = ma = \frac{mv^2}{r}$$

$$F = mr\omega^2$$

Electric and magnetic fields

Electric field

$$E = \frac{F}{Q}$$

Coulomb's law

$$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$$

$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$E = \frac{V}{d}$$

Electric potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

Capacitance

$$C = \frac{Q}{V}$$

Energy stored in capacitor

$$W = \frac{1}{2} QV$$

$$W = \frac{1}{2} CV^2$$

$$W = \frac{\frac{1}{2} Q^2}{C}$$

Capacitor discharge

$$Q = Q_0 e^{-t/RC}$$

Resistor-capacitor discharge

$$I = I_0 e^{-t/RC}$$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field

$$F = Bqv \sin \theta$$

$$F = BIl \sin \theta$$

Faraday and Lenz's laws

$$\mathcal{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$$

Nuclear and particle physics

In a magnetic field

$$r = \frac{p}{BQ}$$

Mass-energy

$$\Delta E = c^2 \Delta m$$

Unit 5: Thermodynamics, Radiation, Oscillations and Cosmology

Thermodynamics

Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

Ideal gas equation

$$pV = NkT$$

Molecular kinetic theory

$$\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$$

Nuclear decay

Mass-energy

$$\Delta E = c^2 \Delta m$$

Radioactive decay

$$A = \lambda N$$

$$\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$N = N_0 e^{-\lambda t}$$

$$A = A_0 e^{-\lambda t}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A \cos \omega t$$

$$v = -A\omega \sin \omega t$$

$$a = -A\omega^2 \cos \omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$T = 2\pi \sqrt{\frac{l}{g}}$$

Astrophysics and cosmology

Gravitational field strength

$$g = F/m$$

Gravitational force

$$F = \frac{Gm_1 m_2}{r^2}$$

Gravitational field

$$g = \frac{Gm}{r^2}$$

Gravitational potential

$$V_{\text{grav}} = \frac{-Gm}{r}$$

Stefan-Boltzmann law

$$L = \sigma T^4 A$$

Wien's law

$$\lambda_{\max} T = 2.898 \times 10^{-3} \text{ m K}$$

Intensity of radiation

$$I = \frac{L}{4\pi d^2}$$

Redshift of electromagnetic radiation

$$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

Cosmological expansion

$$v = H_0 d$$

Appendix 8: Data sheet

The value of the following constants will be provided in each examination paper.

Acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$	
Coulomb law constant	$k = 1/4\pi\epsilon_0 = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19} \text{ C}$	
Electron mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$	
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Proton mass	$m_p = 1.67 \times 10^{-27} \text{ kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27} \text{ kg}$	