

Mathematical equations

Area of a triangle
 $A = \frac{1}{2}(bh)$
Area of a circle
 $A = \pi r^2$
Circumference of a circle
 $C = 2\pi r$
Volume of a cuboid
 $V = lwh$
Volume of a cylinder
 $V = \pi r^2 h$
Volume of a prism
 $V = Ah$
Volume of a sphere
 $V = \frac{4}{3}\pi r^3$
Area of the curved surface of a cylinder
 $A = 2\pi rh$

Vectors
 $A_H = A \cos \theta \quad A_V = A \sin \theta$
Trigonometric relationships
 $\tan \theta = \frac{\sin \theta}{\cos \theta} \quad \sin^2 \theta + \cos^2 \theta = 1$

Uncertainties

$y = a \pm b \Rightarrow \Delta y = \Delta a + \Delta b$
 $y = \frac{ab}{c} \Rightarrow \frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$
 $y = a^n \Rightarrow \frac{\Delta y}{y} = \left| n \frac{\Delta a}{a} \right|$

Fundamental constants

Acceleration g 9.8 m s⁻² (Earth's surface) of free fall
Gravitational constant G 6.67 × 10⁻¹¹ N m² kg⁻²
Avogadro constant N_A 6.02 × 10²³ mol⁻¹
Gas constant R 8.31 J K⁻¹ mol⁻¹
Boltzmann constant k_B 1.38 × 10⁻²³ J K⁻¹
Stefan–Boltzmann constant σ 5.67 × 10⁻⁸ W m⁻² K⁻⁴
Coulomb constant k 8.99 × 10⁹ N m² C⁻²
Permittivity of free space ϵ_0 8.85 × 10⁻¹² C² N⁻¹ m⁻²
Permeability of free space μ_0 4π × 10⁻⁷ T m A⁻¹
Speed of light in vacuum c 3.00 × 10⁸ m s⁻¹
Planck constant h 6.63 × 10⁻³⁴ J s
Elementary charge e 1.60 × 10⁻¹⁹ C
Electron rest mass m_e 9.110 × 10⁻³¹ kg = 0.000549 u = 0.511 MeV c⁻²
Proton rest mass m_p 1.673 × 10⁻²⁷ kg = 1.007276 u = 938 MeV c⁻²

Neutron rest mass m_n 1.675 × 10⁻²⁷ kg = 1.008665 u = 940 MeV c⁻²
(Unified) atomic mass unit 1.661 × 10⁻²⁷ kg = 931.5 MeV c⁻²
Solar constant S 1.36 × 10³ W m⁻²
Fermi radius R_0 1.20 × 10⁻¹⁵ m

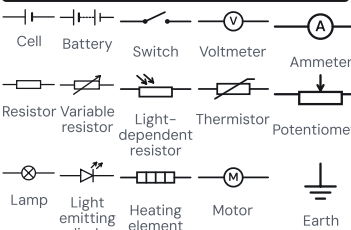
Metric (SI) multipliers

peta P 10¹⁵ · tera T 10¹² · giga G 10⁹ · mega M 10⁶ · kilo k 10³ · hecto h 10² · deca da 10¹ · deci d 10⁻¹ · centi c 10⁻² · milli m 10⁻³ · micro μ 10⁻⁶ · nano n 10⁻⁹ · pico p 10⁻¹² · femto f 10⁻¹⁵

Unit conversions

1 radian (rad) ≡ $\frac{180^\circ}{\pi}$
Temperature (K) = temperature (°C) + 273
1 light year (ly) = 9.46 × 10¹⁵ m
1 parsec (pc) = 3.26 ly
1 astronomical unit (AU) = 1.50 × 10¹¹ m
1 kilowatt-hour (kWh) = 3.60 × 10⁶ J
 $hc = 1.99 \times 10^{-25} \text{ J m} = 1.24 \times 10^{-6} \text{ eV m}$

Circuit symbols



Electromagnetic spectrum

γ rays · X-rays · UV · visible (400–700 nm) · IR · microwaves · radio, from short wavelength (high energy) to long. Scale 10⁻¹⁶ m to 10⁹ m.

A. Space, time and motion

A.1 Kinematics
 $s = \frac{u+v}{2}t$
 $v = u + at$
 $s = ut + \frac{1}{2}at^2$
 $v^2 = u^2 + 2as$

A.2 Forces and momentum
 $F_f \leq \mu_s F_N$
 $F_f = \mu_d F_N$
 $F_H = -kx$
 $F_d = 6\pi\eta rv$
 $F_b = \rho Vg$
 $F_g = mg$
 $p = mv$

$J = F\Delta t$
 $F = ma = \frac{\Delta p}{\Delta t}$
 $a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$

$v = \frac{2\pi r}{T} = \omega r$
A.3 Work, energy and power
 $W = F s \cos \theta$

$E_k = \frac{1}{2}mv^2 = \frac{p^2}{2m}$
 $\Delta E_p = mg\Delta h$
 $E_H = \frac{1}{2}k\Delta x^2$
 $P = \frac{\Delta W}{\Delta t} = Fv$
 $\eta = \frac{\text{useful work out}}{\text{total work in}} = \frac{\text{useful power out}}{\text{total power in}}$

B. The particulate nature of matter

B.1 Thermal energy transfers
 $\rho = \frac{m}{V}$
 $\overline{E_k} = \frac{3}{2}k_B T$
 $Q = mc\Delta T$
 $Q = mL$
 $\frac{\Delta Q}{\Delta t} = kA \frac{\Delta T}{\Delta x}$
 $L = \sigma AT^4$
 $b = \frac{L}{4\pi d^2}$
 $\lambda_{\max} T = 2.9 \times 10^{-3} \text{ m K}$

B.2 Greenhouse effect
emissivity = $\frac{\text{power radiated per unit area}}{\sigma T^4}$
albedo = $\frac{\text{total scattered power}}{\text{total incident power}}$

B.3 Gas laws
 $P = \frac{F}{A}$
 $n = \frac{N}{N_A}$
 $\frac{PV}{T} = \text{constant}$
 $PV = nRT = Nk_B T$
 $P = \frac{1}{3}\rho v^2$
 $U = \frac{3}{2}nRT = \frac{3}{2}Nk_B T$

B.5 Current and circuits
 $I = \frac{\Delta q}{\Delta t}$
 $V = \frac{W}{q}$
 $R = \frac{V}{I}$
 $\rho = \frac{RA}{L}$

$P = IV = I^2 R = \frac{V^2}{R}$
Series
 $I = I_1 = I_2 = \dots \quad V = V_1 + V_2 + \dots \quad R_s = R_1 + R_2 + \dots$
Parallel
 $I = I_1 + I_2 + \dots \quad V = V_1 = V_2 = \dots$
 $\dots \quad \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

$\varepsilon = I(R + r)$

C. Wave behaviour

C.1 Simple harmonic motion
 $a = -\omega^2 x$
 $T = \frac{1}{f} = \frac{2\pi}{\omega}$
 $T = 2\pi\sqrt{\frac{m}{k}}$
 $T = 2\pi\sqrt{\frac{l}{g}}$

C.2 Wave model
 $v = f\lambda = \frac{\lambda}{T}$

C.3 Wave phenomena
 $\frac{n_1}{n_2} = \frac{\sin \theta_2}{\sin \theta_1} = \frac{v_2}{v_1}$
Constructive interference
path difference = $n\lambda$
Destructive interference
path difference = $(n + \frac{1}{2})\lambda$
 $s = \frac{\lambda D}{d}$

C.4 Standing waves and resonance
No equations in the booklet.

C.5 Doppler effect
 $\frac{\Delta f}{f} = \frac{\Delta \lambda}{\lambda} \approx \frac{v}{c}$

D. Fields

D.1 Gravitational fields
 $F = G \frac{m_1 m_2}{r^2}$
 $g = \frac{F}{m} = G \frac{M}{r^2}$

D.2 Electric and magnetic fields
 $F = k \frac{q_1 q_2}{r^2}$ where $k = \frac{1}{4\pi\epsilon_0}$
 $E = \frac{F}{q}$
 $E = \frac{V}{d}$

D.3 Motion in electromagnetic fields
 $F = qvB \sin \theta$
 $F = BIL \sin \theta$
 $\frac{F}{L} = \mu_0 \frac{I_1 I_2}{2\pi r}$

E. Nuclear and quantum physics

E.1 Structure of the atom
 $E = hf$
E.3 Radioactive decay
 $E = mc^2$
E.5 Fusion and stars
 $d \text{ (parsec)} = \frac{1}{p \text{ (arc-second)}}$