

OCR

Oxford Cambridge and RSA

AS Level Physics B (H157) A Level Physics B (H557)

Data, Formulae and Relationships Booklet



INSTRUCTIONS

- Do **not** send this Booklet for marking. Keep it in the centre or recycle it.

INFORMATION

- This document has **8** pages.

Physics B

Data, Formulae and Relationships

Data

Values are given to three significant figures, except where more – or fewer – are useful.

Physical constants

| | | |
|------------------------------|--------------------------------|--|
| speed of light | c | $3.00 \times 10^8 \text{ m s}^{-1}$ |
| permittivity of free space | ϵ_0 | $8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$ (or F m^{-1}) |
| electric force constant | $k = \frac{1}{4\pi\epsilon_0}$ | $8.98 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$ ($\approx 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$) |
| permeability of free space | μ_0 | $4\pi \times 10^{-7} \text{ N A}^{-2}$ (or H m^{-1}) |
| charge on electron | e | $-1.60 \times 10^{-19} \text{ C}$ |
| mass of electron | m_e | $9.11 \times 10^{-31} \text{ kg} = 0.00055 \text{ u}$ |
| mass of proton | m_p | $1.673 \times 10^{-27} \text{ kg} = 1.0073 \text{ u}$ |
| mass of neutron | m_n | $1.675 \times 10^{-27} \text{ kg} = 1.0087 \text{ u}$ |
| mass of alpha particle | m_α | $6.646 \times 10^{-27} \text{ kg} = 4.0015 \text{ u}$ |
| Avogadro constant | L, N_A | $6.02 \times 10^{23} \text{ mol}^{-1}$ |
| Planck constant | h | $6.63 \times 10^{-34} \text{ J s}$ |
| Boltzmann constant | k | $1.38 \times 10^{-23} \text{ J K}^{-1}$ |
| molar gas constant | R | $8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ |
| gravitational force constant | G | $6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ |

Other data

| | | |
|---|-------|--|
| standard temperature and pressure (stp) | | 273 K (0 °C), 1.01×10^5 Pa (1 atmosphere) |
| molar volume of a gas at stp | V_m | 2.24×10^{-2} m ³ |
| gravitational field strength at the Earth's surface in the UK | g | 9.81 N kg ⁻¹ |

Conversion factors

| | | |
|--------------------------|--------------|------------------------------|
| unified atomic mass unit | 1u | = 1.661×10^{-27} kg |
| | 1 day | = 8.64×10^4 s |
| | 1 year | ≈ 3.16×10^7 s |
| | 1 light year | ≈ 10^{16} m |

Mathematical constants and equations

| | | |
|---|--------------|---|
| $e = 2.72$ | $\pi = 3.14$ | 1 radian = 57.3° |
| arc = $r\theta$ | | circumference of circle = $2\pi r$ |
| $\sin\theta \approx \tan\theta \approx \theta$ and $\cos\theta \approx 1$ for small θ | | area of circle = πr^2 |
| | | surface area of cylinder = $2\pi rh$ |
| $\ln(x^n) = n \ln x$ | | volume of cylinder = $\pi r^2 h$ |
| $\ln(e^{kx}) = kx$ | | surface area of sphere = $4\pi r^2$ |
| | | volume of sphere = $\frac{4}{3}\pi r^3$ |

Prefixes

| | | | | | | |
|------------|-----------|-----------|-----------|--------|--------|--------|
| 10^{-12} | 10^{-9} | 10^{-6} | 10^{-3} | 10^3 | 10^6 | 10^9 |
| p | n | μ | m | k | M | G |

Formulae and relationships**Imaging and signalling**

| | |
|---|---|
| focal length | $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$ |
| linear magnification | $m = \frac{v}{u}$ |
| refractive index | $n = \frac{\sin i}{\sin r} = \frac{c_{1\text{st medium}}}{c_{2\text{nd medium}}}$ |
| noise limitation on maximum bits per sample | $b = \log_2 \left(\frac{V_{\text{total}}}{V_{\text{noise}}} \right)$ |
| alternatives, N, provided by n bits | $N = 2^b, b = \log_2 N$ |

Electricity

| | |
|-----------------------------------|---|
| current | $I = \frac{\Delta Q}{\Delta t}$ |
| potential difference | $V = \frac{W}{Q}$ |
| power and energy | $P = IV = I^2 R, W = VIt$ |
| e.m.f and potential difference | $V = \mathcal{E} - Ir$ |
| conductors in series and parallel | $\frac{1}{G} = \frac{1}{G_1} + \frac{1}{G_2} + \dots \quad G = G_1 + G_2 + \dots$ |
| resistors in series and parallel | $R = R_1 + R_2 + \dots \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$ |
| potential divider | $V_{\text{out}} = \frac{R_2}{R_1 + R_2} V_{\text{in}}$ |
| conductivity and resistivity | $G = \frac{\sigma A}{L} \quad R = \frac{\rho L}{A}$ |
| capacitance | $C = \frac{Q}{V}$ |
| energy stored in a capacitor | $E = \frac{1}{2} QV = \frac{1}{2} CV^2$ |
| discharge of capacitor | $\frac{dQ}{dt} = -\frac{Q}{RC} \quad Q = Q_0 e^{-t/RC} \quad \tau = RC$ |

Materials

Hooke's law

$$F = kx$$

elastic strain energy

$$\frac{1}{2} kx^2$$

Young modulus

$$E = \frac{\text{stress}}{\text{strain}}, \text{ stress} = \frac{\text{tension}}{\text{cross-sectional area}},$$

$$\text{strain} = \frac{\text{extension}}{\text{original length}}$$

Gases

kinetic theory of gases

$$pV = \frac{1}{3} Nmc^2$$

ideal gas equation

$$pV = nRT = NkT$$

Motion and forces

momentum

$$p = mv$$

impulse

$$F\Delta t$$

force

$$F = \frac{\Delta(mv)}{\Delta t}$$

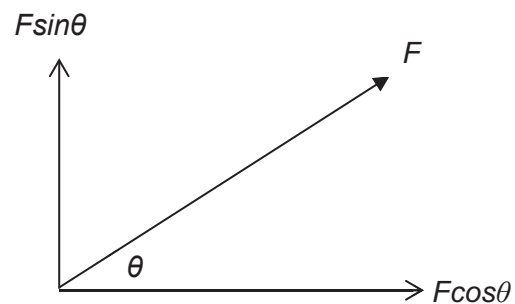
work done

$$W = Fx \quad \Delta E = F\Delta s$$

power

$$P = Fv, \quad P = \frac{\Delta E}{t}$$

components of a vector in two perpendicular directions



equations for uniformly accelerated motion

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

$$v = u + at$$

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

for circular motion

$$a = \frac{v^2}{r}, \quad F = \frac{mv^2}{r} = mr\omega^2$$

Energy and thermal effects

energy

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

average energy approximation

average energy $\sim kT$

Boltzmann factor

$$e^{-\frac{E}{kT}}$$

Waves

wave formula

$$v = f\lambda$$

frequency and period

$$f = \frac{1}{T}$$

diffraction grating

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

Oscillations

simple harmonic motion

$$\frac{d^2x}{dt^2} = a = -\left(\frac{k}{m}\right)x = -\omega^2x$$

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

$$x = A \sin(\omega t)$$

$$\omega = 2\pi f$$

Periodic time

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

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

total energy

$$E = \frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

Atomic and nuclear physics

radioactive decay

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

half life

$$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

radioactive dose and risk

absorbed dose = energy deposited per unit mass

effective dose = absorbed dose x quality factor

risk = probability \times consequence

mass–energy relationship

$$E_{\text{rest}} = mc^2$$

7

relativistic factor $\gamma = \frac{1}{\sqrt{1 - v^2 / c^2}}$

relativistic energy $E_{\text{total}} = \gamma E_{\text{rest}}$

energy–frequency relationship for photons $E = hf$

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

Field and potential

for all fields field strength $= -\frac{dV}{dr} \approx -\frac{\Delta V}{\Delta r}$

gravitational fields $g = \frac{F}{m}, E_{\text{grav}} = -\frac{GmM}{r}$

$$V_{\text{grav}} = -\frac{GM}{r}, F = -\frac{GmM}{r^2}$$

electric fields $E = \frac{F}{q} = \frac{V}{d},$ electrical potential energy $= \frac{kQq}{r}$

$$V_{\text{electric}} = \frac{kQ}{r}, F = \frac{kQq}{r^2}$$

Electromagnetism

magnetic flux $\Phi = BA$

force on a current carrying conductor $F = ILB$

force on a moving charge $F = qvB$

Induced e.m.f $\mathcal{E} = -\frac{d(N\Phi)}{dt}$

OCR
Oxford Cambridge and RSA

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact The OCR Copyright Team, The Triangle Building, Shaftesbury Road, Cambridge CB2 8EA.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.