

# 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

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### 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	$\epsilon_0$	$8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$ (or $\text{F m}^{-1}$ )
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	$\mu_0$	$4\pi \times 10^{-7} \text{ N A}^{-2}$ (or $\text{H m}^{-1}$ )
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	$m_\alpha$	$6.646 \times 10^{-27} \text{ kg} = 4.0015 \text{ u}$
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), $1.01 \times 10^5$ Pa (1 atmosphere)
molar volume of a gas at stp	$V_m$	$2.24 \times 10^{-2}$ m <sup>3</sup>
gravitational field strength at the Earth's surface in the UK	$g$	9.81 N kg <sup>-1</sup>

**Conversion factors**

unified atomic mass unit	1u	= $1.661 \times 10^{-27}$ kg
	1 day	= $8.64 \times 10^4$ s
	1 year	≈ $3.16 \times 10^7$ 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 $\theta$		area of circle = $\pi r^2$
		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	$\mu$	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

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

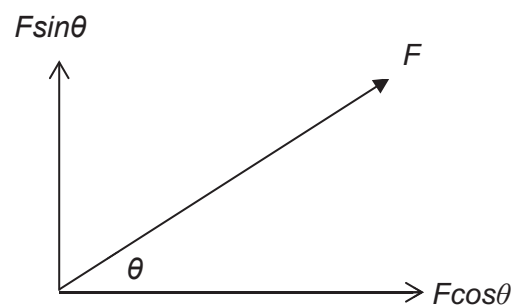
work done

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

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

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

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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  $\mathcal{E} = -\frac{d(N\Phi)}{dt}$

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