Oxford Cambridge and RSA

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

Data, Formulae and Relationships Booklet

Physics B

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

INFORMATION
- This document has **8** pages.

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	3.00×10^{8} m s^{-1}
permittivity of free space	ε_0	8.85×10^{-12} C^{2} N^{-1} m^{-2} (or F m^{-1})
electric force constant	$k = \frac{1}{4\pi\varepsilon_0}$	8.98×10^{9} N m^{2} C^{-2} ($\approx 9 \times 10^{9}$ N m^{2} C^{-2})
permeability of free space	μ_0	$4\pi \times 10^{-7}$ N A^{-2} (or H m^{-1})
charge on electron	$-e$	-1.60×10^{-19} C
mass of electron	m_e	9.11×10^{-31} kg = 0.000 55 u
mass of proton	m_p	1.673×10^{-27} kg = 1.007 3 u
mass of neutron	m_n	1.675×10^{-27} kg = 1.008 7 u
mass of alpha particle	m_α	6.646×10^{-27} kg = 4.001 5 u
Avogadro constant	L, N_A	6.02×10^{23} mol^{-1}
Planck constant	h	6.63×10^{-34} J s
Boltzmann constant	k	1.38×10^{-23} J K^{-1}
molar gas constant	R	8.31 J mol^{-1} K^{-1}
gravitational force constant	G	6.67×10^{-11} N m^{2} 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	$= 1.661 \times 10^{-27}$ kg
	1 day	$= 8.64 \times 10^4$ s
	1 year	$\approx 3.16 \times 10^7$ s
	1 light year	$\approx 10^{16}$ m

Mathematical constants and equations

$e = 2.72$ $\quad$ $\pi = 3.14$ $\quad$ 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 $n = \frac{\sin i}{\sin r} = \frac{c_{\text{1st medium}}}{c_{\text{2nd medium}}}$

noise limitation on maximum bits per sample $b = \log_2\left(\frac{V_{\text{total}}}{V_{\text{noise}}}\right)$

alternatives, N, provided by b 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 $P = IV = I^2R,\ \ W = VIt$

e.m.f and potential difference $V_{\text{load}} = \mathcal{E} - Ir$

conductors in series and parallel $\frac{1}{G} = \frac{1}{G_1} + \frac{1}{G_2} + \ldots \qquad G = G_1 + G_2 + \ldots$

resistors in series and parallel $R = R_1 + R_2 + \ldots \qquad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

potential divider $V_{\text{out}} = \frac{R_2}{R_1 + R_2} V_{\text{in}}$

conductivity and resistivity $G = \frac{\sigma A}{L} \qquad R = \frac{\rho L}{A}$

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

energy stored in a capacitor $E = \frac{1}{2} QV = \frac{1}{2} CV^2$

discharge of capacitor $\frac{\mathrm{d}Q}{\mathrm{d}t} = -\frac{Q}{RC} \qquad Q = Q_0\, \mathrm{e}^{-t/RC} \qquad \tau = RC$

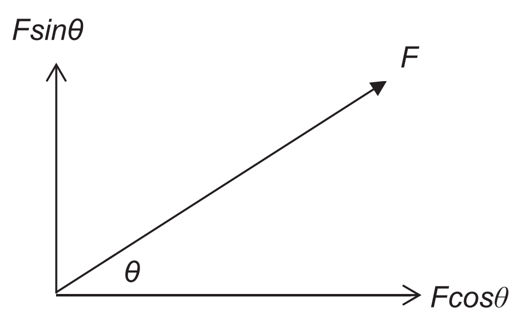
Materials

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	$pV = \frac{1}{3}N m\overline{c^2}$
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	$P = Fv$
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	$a = \frac{v^2}{r}$, $F = \frac{mv^2}{r}$

Energy and thermal effects

energy	$\Delta E = mc\Delta\theta$
average energy approximation	average energy ~ 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	$\frac{d^2x}{dt^2} = a = -\left(\frac{k}{m}\right)x = -\omega^2 x$
	$x = A\cos(\omega t)$
	$x = A\sin(\omega t)$
	$\omega = 2\pi f$
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	$\frac{\Delta N}{\Delta t} = -\lambda N$ $N = N_0 e^{-\lambda t}$
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 × consequence
mass–energy relationship	$E_{rest} = mc^2$

relativistic factor	$\gamma = \dfrac{1}{\sqrt{1 - v^2 / c^2}}$
relativistic energy	$E_{\text{total}} = \gamma E_{\text{rest}}$
energy–frequency relationship for photons	$E = hf$
de Broglie	$\lambda = \dfrac{h}{p}$

Field and potential

for all fields	$\text{field strength} = -\dfrac{\mathrm{d}V}{\mathrm{d}r} \approx -\dfrac{\Delta V}{\Delta r}$
gravitational fields	$g = \dfrac{F}{m}$
	$V_{grav} = -\dfrac{GM}{r}$, $F = -\dfrac{GmM}{r^2}$
electric fields	$E = \dfrac{F}{q} = \dfrac{V}{d}$, electrical potential energy $= \dfrac{kQq}{r}$
	$V_{elec} = \dfrac{kQ}{r}$, $F = \dfrac{kQq}{r^2}$

Electromagnetism

magnetic flux	$\Phi = BA$
force on a current carrying conductor	$F = ILB$
force on a moving charge	$F = qvB$
Induced e.m.f	$\mathcal{E} = -\dfrac{\mathrm{d}(N\Phi)}{dt}$