OCR
Oxford Cambridge and RSA

Physics B

Advanced Subsidiary GCE (H157)
Advanced GCE (H557)

Physics B (Advancing Physics)

Data, Formulae and Relationships Booklet

The information in this booklet is for the use of candidates following the Advanced Subsidiary GCE in Physics B (Advancing Physics) (H157) or the Advanced GCE in Physics B (Advancing Physics) (H557) course.

The data, formulae and relationships in this datasheet will be printed for distribution with the examination papers.

Copies of this booklet may be used for teaching.

This document consists of **8** pages.

Instructions to Exams Officer/Invigilator

- **Do not send this Data Sheet for marking; it should be retained in the centre or destroyed.**

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 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	$P = IV = I^2R,\quad W = VIt$
e.m.f and potential difference	$V = \mathcal{E} - Ir$
conductors in series and parallel	$\frac{1}{G} = \frac{1}{G_1} + \frac{1}{G_2} + \ldots \qquad G = G_1 + G_2 + \ldots$
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	$\frac{dQ}{dt} = -\frac{Q}{RC} \qquad Q = Q_0\, e^{-t/RC} \qquad \tau = RC$

Materials

Hooke's law	$F = kx$
elastic strain energy	$\frac{1}{2}kx^2$
Young modulus	$E = \frac{\text{stress}}{\text{strain}}$, $\text{stress} = \frac{\text{tension}}{\text{cross-sectional area}}$, $\text{strain} = \frac{\text{extension}}{\text{original length}}$

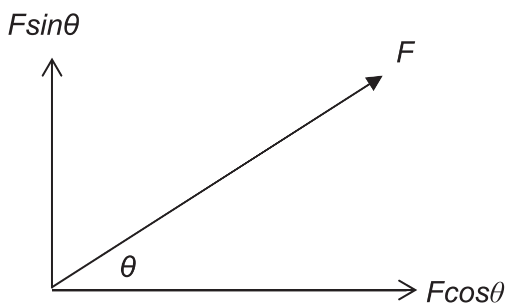
Gases

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

components of a vector in two perpendicular directions



equations for uniformly accelerated motion

$$s = ut + \tfrac{1}{2}at^2$$
$$v = u + at$$
$$v^2 = u^2 + 2as$$

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

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

energy–frequency relationship for photons $E = hf$

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

Field and potential

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

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

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

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

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

Electromagnetism

magnetic flux $\Phi = BA$

force on a current carrying conductor $F = ILB$

force on a moving charge $F = qvB$

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