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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.

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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}

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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 $\qquad \pi = 3.14$ $\qquad$ 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

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

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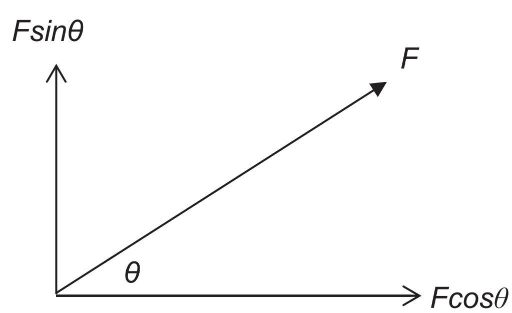
Materials

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	$pV = \frac{1}{3}Nm\overline{c^2}$
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	$s = ut + \frac{1}{2}at^2$ $v = u + at$ $v^2 = u^2 + 2as$
for circular motion	$a = \frac{v^2}{r}$, $F = \frac{mv^2}{r} = mr\omega^2$

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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	$E_{rest} = mc^2$

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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 $= -\frac{dV}{dr} \approx -\frac{\Delta V}{\Delta r}$

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

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