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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	$2.24 \times 10^{-2} \text{ m}^3$
gravitational field strength at the Earth's surface in the UK	g	9.81 N kg^{-1}

Conversion factors

unified atomic mass unit	1u	$= 1.661 \times 10^{-27} \text{ kg}$
	1 day	$= 8.64 \times 10^4 \text{ s}$
	1 year	$\approx 3.16 \times 10^7 \text{ s}$
	1 light year	$\approx 10^{16} \text{ m}$

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 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	$P = IV = I^2 R, W = VIt$
e.m.f and potential difference	$V_{\text{load}} = \mathcal{E} - Ir$
conductors in series and parallel	$\frac{1}{G} = \frac{1}{G_1} + \frac{1}{G_2} + \dots \quad G = G_1 + G_2 + \dots$
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

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

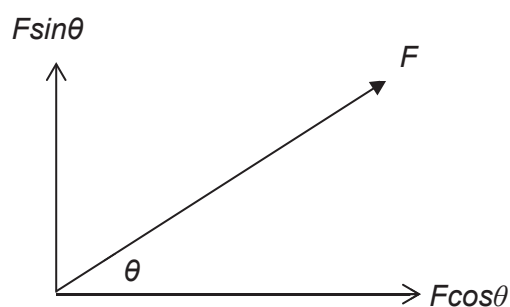
work done

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

power

$$P = Fv$$

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 $\sim kT$

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

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

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 $g = \frac{F}{m}$

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

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

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

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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