

**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

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

**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 = $57.3^\circ$
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

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

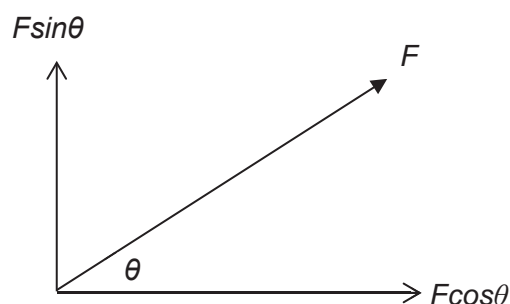
work done

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

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  $\times$  quality factorrisk = 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  $g = \frac{F}{m}, E_{\text{grav}} = -\frac{GmM}{r}$

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

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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