

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE (H157)

Advanced GCE (H557)

Physics B (Advancing Physics)

**DATA, FORMULAE AND
RELATIONSHIPS BOOKLET**

MODIFIED ENLARGED 24pt

**INSTRUCTIONS TO EXAMS OFFICER/
INVIGILATOR**

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READ INSTRUCTIONS OVERLEAF



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.

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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	$3.00 \times 10^8 \text{ m s}^{-1}$
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

$$V_m \quad 2.24 \times 10^{-2} \text{ m}^3$$

gravitational field
strength at the Earth's
surface in the UK

$$g \quad 9.81 \text{ N kg}^{-1}$$

CONVERSION FACTORS

unified atomic
mass unit

$$1 \text{ u} \quad = 1.661 \times 10^{-27} \text{ kg}$$

$$1 \text{ day} \quad = 8.64 \times 10^4 \text{ s}$$

$$1 \text{ year} \quad \approx 3.16 \times 10^7 \text{ s}$$

$$1 \text{ light} \\ \text{year} \quad \approx 10^{16} \text{ m}$$

MATHEMATICAL CONSTANTS AND EQUATIONS

$$e = 2.72$$

$$\pi = 3.14$$

$$1 \text{ radian} = 57.3^\circ$$

$$\text{arc} = r\theta$$

$$\text{circumference of circle} = 2\pi r$$

$$\sin \theta \approx \tan \theta \approx \theta$$

$$\text{and } \cos \theta \approx 1 \text{ for small } \theta$$

$$\text{area of circle} = \pi r^2$$

$$\text{surface area of cylinder} = 2\pi rh$$

$$\ln(x^n) = n \ln x$$

$$\text{volume of cylinder} = \pi r^2 h$$

$$\ln(e^{kx}) = kx$$

$$\text{surface area of sphere} = 4\pi r^2$$

$$\text{volume of sphere} = \frac{4}{3}\pi r^3$$

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

$$P = IV = I^2 R, W = VIt$$

e.m.f and potential difference

$$V = \varepsilon - Ir$$

conductors in series and parallel

$$\frac{1}{G} = \frac{1}{G_1} + \frac{1}{G_2} + \dots$$

$$G = G_1 + G_2 + \dots$$

resistors in series and parallel

$$R = R_1 + R_2 + \dots$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

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

$$\frac{dQ}{dt} = -\frac{Q}{RC}$$

$$Q = Q_0 e^{-t/RC} \quad \tau = RC$$

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

$$pV = \frac{1}{3}Nm\overline{c^2}$$

ideal gas equation

$$pV = nRT = NkT$$

MOTION AND FORCES

momentum

$$p = mv$$

impulse

$$F\Delta t$$

force

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

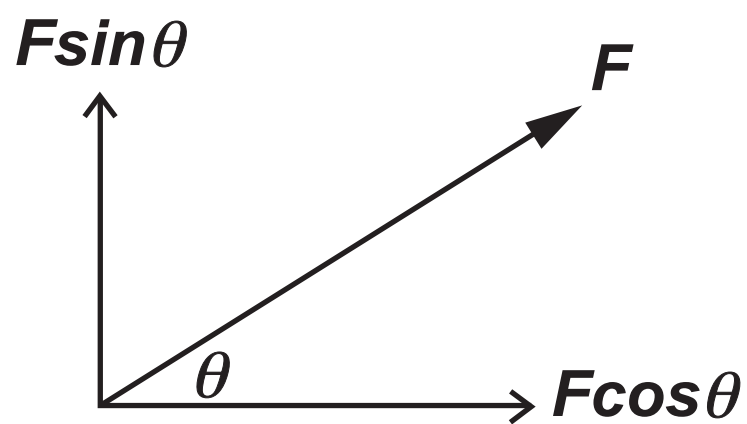
work done

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

power

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

components of a vector in two perpendicular directions



equations for uniformly accelerated motion

$$s = ut + at^2$$

$$v = u + at$$

$$v^2 = u^2 + 2as$$

for circular motion

$$a = \frac{v^2}{r}, F = \frac{mv^2}{r} = mr\omega^2$$

ENERGY AND THERMAL EFFECTS

energy

$$\Delta E = mc\Delta\theta$$

average energy approximation

$$\text{average energy} \sim kT$$

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

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

$$N = N_0 e^{-\lambda t}$$

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 x 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

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

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

$$E = \frac{F}{q} = \frac{V}{d},$$

$$\text{electrical potential energy} = \frac{kQq}{r}$$

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

ELECTROMAGNETISM

magnetic flux

$$\phi = BA$$

force on a current carrying conductor

$$F = ILB$$

force on a moving charge

$$F = qvB$$

Induced e.m.f

$$\varepsilon = - \frac{d(N\phi)}{dt}$$



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