

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced Subsidiary GCE (H157)**

**Advanced GCE (H557)**

**Physics B (Advancing Physics)**

**DATA, FORMULAE AND  
RELATIONSHIPS BOOKLET**

**MODIFIED ENLARGED**

**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.**

**INSTRUCTIONS TO EXAMS OFFICER/INVIGILATOR**

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## 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)		$273 \text{ K (0}^\circ\text{C)}, 1.01 \times 10^5 \text{ Pa (1 atmosphere)}$
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

$$e = 2.72$$

$$\pi = 3.14$$

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

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

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

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

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

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

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

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

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

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

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

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

## PREFIXES

$$10^{-12}$$

p

$$10^{-9}$$

n

$$10^{-6}$$

μ

$$10^{-3}$$

m

$$10^3$$

k

$$10^6$$

M

$$10^9$$

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**

$$V = \varepsilon - Ir$$

**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

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

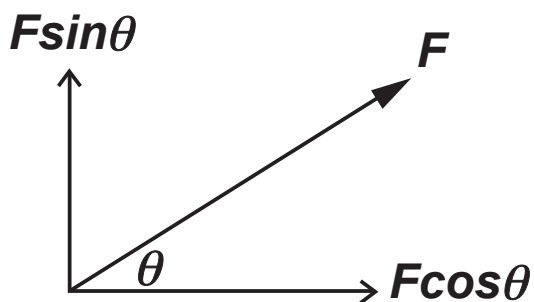
work done

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

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 × 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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