

Modified Enlarged 24pt
OXFORD CAMBRIDGE AND RSA EXAMINATIONS

AS Level Physics A (H156)
A Level Physics A (H556)

Data, Formulae and Relationships Booklet

READ INSTRUCTIONS OVERLEAF

DC (LK) 203716/1
© OCR 2020

CST992



INSTRUCTIONS

Do NOT send this Booklet for marking. Keep it in the centre or recycle it.

BLANK PAGE

BLANK PAGE

Data, Formulae and Relationships

DATA

Values are given to three significant figures, except where more – or fewer – are useful.

PHYSICAL CONSTANTS

acceleration of free fall	g	9.81 m s^{-2}
elementary charge	e	$1.60 \times 10^{-19} \text{ C}$
speed of light in a vacuum	c	$3.00 \times 10^8 \text{ m s}^{-1}$
Planck constant	h	$6.63 \times 10^{-34} \text{ J s}$
Avogadro constant	N_A	$6.02 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	R	$8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Boltzmann constant	k	$1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	ϵ_0	$8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$ (F m^{-1})
electron rest mass	m_e	$9.11 \times 10^{-31} \text{ kg}$
proton rest mass	m_p	$1.673 \times 10^{-27} \text{ kg}$
neutron rest mass	m_n	$1.675 \times 10^{-27} \text{ kg}$
alpha particle rest mass	m_α	$6.646 \times 10^{-27} \text{ kg}$
Stefan constant	σ	$5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

QUARKS

up quark	charge = $+\frac{2}{3}e$
down quark	charge = $-\frac{1}{3}e$
strange quark	charge = $-\frac{1}{3}e$

CONVERSION FACTORS

unified atomic mass unit	$1\text{ u} = 1.661 \times 10^{-27}\text{ kg}$
electronvolt	$1\text{ eV} = 1.60 \times 10^{-19}\text{ J}$
day	$1\text{ day} = 8.64 \times 10^4\text{ s}$
year	$1\text{ year} \approx 3.16 \times 10^7\text{ s}$
light year	$1\text{ light year} \approx 9.5 \times 10^{15}\text{ m}$
parsec	$1\text{ parsec} \approx 3.1 \times 10^{16}\text{ m}$

MATHEMATICAL EQUATIONS

arc length = $r\theta$

circumference of circle = $2\pi r$

area of circle = πr^2

curved surface area of cylinder = $2\pi rh$

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

area of trapezium = $\frac{1}{2}(a + b)h$

volume of cylinder = $\pi r^2 h$

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

$$\text{Pythagoras' theorem: } a^2 = b^2 + c^2$$

$$\text{cosine rule: } a^2 = b^2 + c^2 - 2bc \cos A$$

$$\text{sine rule: } \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

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

$$\log(AB) = \log(A) + \log(B) \quad (\text{Note: } \lg = \log_{10} \text{ and } \ln = \log_e)$$

$$\log\left(\frac{A}{B}\right) = \log(A) - \log(B)$$

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

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

FORMULAE AND RELATIONSHIPS

MODULE 2 – FOUNDATIONS OF PHYSICS

vectors

$$F_x = F \cos \theta$$

$$F_y = F \sin \theta$$

MODULE 3 – FORCES AND MOTION

uniformly accelerated motion

$$v = u + at$$

$$s = \frac{1}{2}(u + v)t$$

$$s = ut + \frac{1}{2}at^2$$

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

force

$$F = \frac{\Delta p}{\Delta t}$$

$$p = mv$$

turning effects

$$\text{moment} = Fx$$

$$\text{torque} = Fd$$

density

$$\rho = \frac{m}{V}$$

pressure

$$p = \frac{F}{A}$$

$$p = h\rho g$$

work, energy and power

$$W = Fx \cos \theta$$

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy output}} \times 100\%$$

$$P = \frac{W}{t}$$

$$P = Fv$$

springs and materials

$$F = kx$$

$$E = \frac{1}{2}Fx ; E = \frac{1}{2}kx^2$$

$$\sigma = \frac{F}{A}$$

$$\varepsilon = \frac{x}{L}$$

$$E = \frac{\sigma}{\varepsilon}$$

MODULE 4 – ELECTRONS, WAVES AND PHOTONS

charge

$$\Delta Q = I\Delta t$$

current

$$I = Anev$$

work done

$$W = VQ ; W = \varepsilon Q ; W = VIt$$

resistance and resistors

$$R = \frac{\rho L}{A}$$

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

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

power

$$P = VI, P = I^2R \text{ and } P = \frac{V^2}{R}$$

internal resistance

$$\mathcal{E} = I(R + r) ; \mathcal{E} = V + Ir$$

potential divider

$$V_{\text{out}} = \frac{R_2}{R_1 + R_2} \times V_{\text{in}}$$

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

waves

$$v = f\lambda$$

$$f = \frac{1}{T}$$

$$I = \frac{P}{A}$$

$$\lambda = \frac{a x}{D}$$

refraction

$$n = \frac{c}{v}$$

$$n \sin \theta = \text{constant}$$

$$\sin C = \frac{1}{n}$$

quantum physics	$E = hf$ $E = \frac{hc}{\lambda}$ $hf = \phi + KE_{\text{max}}$ $\lambda = \frac{h}{p}$
-----------------	---

MODULE 5 – NEWTONIAN WORLD AND ASTROPHYSICS

thermal physics	$E = mc\Delta\theta$ $E = mL$
-----------------	----------------------------------

ideal gases	$pV = NkT; \quad pV = nRT$ $pV = \frac{1}{3}Nm \overline{c^2}$ $\frac{1}{2}m \overline{c^2} = \frac{3}{2}kT$ $E = \frac{3}{2}kT$
-------------	---

circular motion	$\omega = \frac{2\pi}{T}; \quad \omega = 2\pi f$ $v = \omega r$ $a = \frac{v^2}{r}; \quad a = \omega^2 r$ $F = \frac{mv^2}{r}; \quad F = m\omega^2 r$
-----------------	--

oscillations

$$\omega = \frac{2\pi}{T}; \omega = 2\pi f$$

$$a = -\omega^2 x$$

$$x = A \cos \omega t; x = A \sin \omega t$$

$$v = \pm \omega \sqrt{A^2 - x^2}$$

gravitational field

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

$$F = -\frac{GMm}{r^2}$$

$$g = -\frac{GM}{r^2}$$

$$T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$$

$$V_g = -\frac{GM}{r}$$

$$\text{energy} = -\frac{GMm}{r}$$

astrophysics

$$hf = \Delta E; \frac{hc}{\lambda} = \Delta E$$

$$d \sin \theta = n\lambda$$

$$\lambda_{\max} \propto \frac{1}{T}$$

$$L = 4\pi r^2 \sigma T^4$$

cosmology

$$\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

$$p = \frac{1}{d}$$

$$v = H_0 d$$

$$t = H_0^{-1}$$

MODULE 6 – PARTICLES AND MEDICAL PHYSICS

capacitance and capacitors

$$C = \frac{Q}{V}$$

$$C = \frac{\epsilon_0 A}{d}$$

$$C = 4\pi\epsilon_0 R$$

$$C = C_1 + C_2 + \dots$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

$$W = \frac{1}{2} QV; \quad W = \frac{1}{2} \frac{Q^2}{C};$$

$$W = \frac{1}{2} V^2 C$$

$$\tau = CR$$

$$x = x_0 e^{-\frac{t}{CR}}$$

$$x = x_0 (1 - e^{-\frac{t}{CR}})$$

electric field

$$E = \frac{F}{Q}$$

$$F = \frac{Qq}{4\pi\epsilon_0 r^2}$$

$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$E = \frac{V}{d}$$

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

$$\text{energy} = \frac{Qq}{4\pi\epsilon_0 r}$$

magnetic field

$$F = BIL\sin\theta$$

$$F = BQv$$

electromagnetism

$$\phi = BA\cos\theta$$

$$\varepsilon = - \frac{\Delta(N\phi)}{\Delta t}$$

$$\frac{n_s}{n_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s}$$

radius of nucleus	$R = r_0 A^{1/3}$
radioactivity	$A = \lambda N; \frac{\Delta N}{\Delta t} = -\lambda N$ $\lambda t_{1/2} = \ln(2)$ $A = A_0 e^{-\lambda t}$ $N = N_0 e^{-\lambda t}$
Einstein's mass-energy equation	$\Delta E = \Delta mc^2$
attenuation of X-rays	$I = I_0 e^{-\mu x}$
ultrasound	$Z = \rho c$ $\frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$ $\frac{\Delta f}{f} = \frac{2v \cos \theta}{c}$

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact The OCR Copyright Team, The Triangle Building, Shaftesbury Road, Cambridge CB2 8EA.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.