

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE (H156)

Advanced GCE (H556)

Physics A

**DATA, FORMULAE AND
RELATIONSHIPS BOOKLET**

MODIFIED ENLARGED

The information in this booklet is for the use of candidates following the Advanced Subsidiary in Physics A (H156) or the Advanced GCE in Physics A (H556) 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

- **DO NOT SEND THIS DATA SHEET FOR MARKING; IT SHOULD BE RETAINED IN THE CENTRE OR DESTROYED.**



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 u = 1.661×10^{-27} kg |
| electronvolt | 1 eV = 1.60×10^{-19} J |
| day | 1 day = 8.64×10^4 s |
| year | 1 year $\approx 3.16 \times 10^7$ s |
| light year | 1 light year $\approx 9.5 \times 10^{15}$ m |
| parsec | 1 parsec $\approx 3.1 \times 10^{16}$ 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 = $4\pi r^2$

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

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

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

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

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

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

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

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

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

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

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

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

$$\varepsilon = I(R + r) ; \varepsilon = V + Ir$$

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

$$E = hf \quad E = \frac{hc}{\lambda}$$

$$hf = \phi + KE_{\text{max}}$$

$$\lambda = \frac{h}{p}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\tau = CR$$

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

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

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

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

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

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

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

$$Z = \rho c$$

$$\frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$$

$$\frac{\Delta f}{f} = \frac{2v \cos \theta}{c}$$

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