



# Data, Formulae and Relationships Booklet (Revised Version 2.1)

GCE Advanced Level and Advanced Subsidiary

## Physics A

Physics units G481, G482, G484, G485

### Instructions to Exams Officer/Invigilator

- Do not send this Data Sheet for marking; it should be retained in the centre or destroyed.

These data, formulae and relationships are for the use of candidates following the Physics A specification.

Clean copies of this booklet must be available in the examination room, and must be given up to the invigilator at the end of the examination.

Copies of this booklet may be used for teaching.

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## Data

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

speed of light in a vacuum	$c$	$3.00 \times 10^8 \text{ m s}^{-1}$
permittivity of free space	$\epsilon_0$	$8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \text{ (F m}^{-1}\text{)}$
elementary charge	$e$	$1.60 \times 10^{-19} \text{ C}$
Planck constant	$h$	$6.63 \times 10^{-34} \text{ J s}$
gravitational constant	$G$	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
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	$k$	$1.38 \times 10^{-23} \text{ J K}^{-1}$
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	$m_\alpha$	$6.646 \times 10^{-27} \text{ kg}$
acceleration of free fall	$g$	$9.81 \text{ m s}^{-2}$

## Conversion factors

unified atomic mass unit

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

electron-volt

$$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$$

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

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

$$1 \text{ light year} \approx 9.5 \times 10^{15} \text{ m}$$

## Mathematical equations

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

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

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

$$\text{curved surface area of cylinder} = 2\pi r h$$

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

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

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

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

$$\text{For small angle } \theta \Rightarrow \sin\theta \approx \tan\theta \approx \theta \text{ and } \cos\theta \approx 1$$

$$\lg(AB) = \lg(A) + \lg(B)$$

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

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

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

## Formulae and relationships

### Unit 1 – Mechanics

$$F_x = F \cos \theta$$

$$F_y = F \sin \theta$$

$$a = \frac{\Delta v}{\Delta t}$$

$$v = u + at$$

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

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

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

$$F = ma$$

$$W = mg$$

$$\text{moment} = Fx$$

$$\text{torque} = Fd$$

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

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

$$W = Fx \cos \theta$$

$$E_k = \frac{1}{2} mv^2$$

$$E_p = mgh$$

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

$$F = kx$$

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

$$\text{stress} = \frac{F}{A}$$

$$\text{strain} = \frac{x}{L}$$

$$\text{Young modulus} = \frac{\text{stress}}{\text{strain}}$$

### Unit 2 – Electrons, Waves and Photons

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

$$I = Anev$$

$$W = VQ$$

$$V = IR$$

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

$$P = VI \quad P = I^2R \quad P = \frac{V^2}{R}$$

$$W = VIt$$

$$\text{e.m.f.} = V + Ir$$

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

$$v = f\lambda$$

$$\lambda = \frac{ax}{D}$$

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

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

$$hf = \phi + \text{KE}_{\text{max}}$$

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

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

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

## Unit 4 – Newtonian World

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

$$v = \frac{2\pi r}{T}$$

$$a = \frac{v^2}{r}$$

$$F = \frac{mv^2}{r}$$

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

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

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

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

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

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

$$a = -(2\pi f)^2 x$$

$$x = A \cos(2\pi ft)$$

$$v_{\max} = (2\pi f) A$$

$$E = mc\Delta\theta$$

$$pV = NkT$$

$$pV = nRT$$

$$E = \frac{3}{2} kT$$

## Unit 5 – Fields, Particles and Frontiers of Physics

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

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

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

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

$$F = BIL \sin\theta$$

$$F = BQv$$

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

induced e.m.f. = – rate of change of magnetic flux linkage

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

$$Q = VC$$

$$W = \frac{1}{2} QV \quad W = \frac{1}{2} CV^2$$

time constant =  $CR$

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

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

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

$$A = \lambda N$$

$$A = A_0 e^{-\lambda t}$$

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

$$\lambda t_{1/2} = 0.693$$

$$\Delta E = \Delta mc^2$$

$$I = I_0 e^{-\mu x}$$

$$Z = \rho c$$

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

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$\text{age of Universe} = \frac{1}{H_0}$$

$$\rho_0 = \frac{3H_0^2}{8\pi G}$$

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