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

Data, Formulae and Relationships Booklet



INSTRUCTIONS

- Do **not** send this Booklet for marking. Keep it in the centre or recycle it.

INFORMATION

- This document has **8** pages.

Physics A

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 ms^{-2} |
| elementary charge | e | $1.60 \times 10^{-19} \text{ C}$ |
| speed of light in a vacuum | c | $3.00 \times 10^8 \text{ ms}^{-1}$ |
| Planck constant | h | $6.63 \times 10^{-34} \text{ Js}$ |
| 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 | $1.38 \times 10^{-23} \text{ JK}^{-1}$ |
| gravitational constant | G | $6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ |
| permittivity of free space | ϵ_0 | $8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \text{ (F m}^{-1}\text{)}$ |
| 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

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

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

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

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

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

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

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

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

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

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

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

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

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

(Note: $\lg = \log_{10}$ 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 | moment = Fx |
| | torque = Fd |

| | |
|---------|----------------------|
| density | $\rho = \frac{m}{V}$ |
|---------|----------------------|

| | |
|----------|-------------------|
| pressure | $p = \frac{F}{A}$ |
| | $p = h\rho g$ |

| | |
|------------------------|---|
| work, energy and power | $W = Fx \cos \theta$ |
| | efficiency = $\frac{\text{useful energy output}}{\text{total energy input}} \times 100\%$ |
| | $P = \frac{W}{t}$ |
| | $P = Fv$ |

| | |
|-----------------------|---|
| 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 | $P = VI, P = I^2R$ 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 | $v = f\lambda$ $f = \frac{1}{T}$ $I = \frac{P}{A}$ $\lambda = \frac{a \times D}{D}$ |
| 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

$$pV = NkT; pV = nRT$$

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

$$\frac{1}{2}m\overline{c^2} = \frac{3}{2}kT$$

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

circular motion

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

$$v = \omega r$$

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

$$F = \frac{mv^2}{r}; F = m\omega^2 r$$

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

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

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

$$v = H_0 d$$

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

Module 6 – Particles and medical physics

capacitance and capacitors

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

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

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

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

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

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

$$\tau = CR$$

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

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

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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