

**Advanced Subsidiary GCE (H156)  
Advanced GCE (H556)**

**Physics A**

**Data, Formulae and Relationships Booklet**

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.

This document consists of **8** pages.

**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  | $g$          | $9.81 \text{ m s}^{-2}$  |
| 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 | $\epsilon_0$ | $8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \text{ (F m}^{-1}\text{)}$ |
| 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   | $m_\alpha$   | $6.646 \times 10^{-27} \text{ kg}$   |
| Stefan constant            | $\sigma$     | $5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$                                      |

### 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

$$\text{moment} = Fx$$

$$\text{torque} = Fd$$

density

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

pressure

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

$$p = h\rho g$$

work, energy and power

$$W = Fx \cos \theta$$

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

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

$$P = Fv$$

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      | $\mathcal{E} = I(R + r)$ ; $\mathcal{E} = V + Ir$  |
| 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                    | $v = f\lambda$ $f = \frac{1}{T}$ $I = \frac{P}{A}$ $\lambda = \frac{ax}{D}$                          |
| 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

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

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

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

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

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

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

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

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

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

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

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

$$\tau = CR$$

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

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

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

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

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

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


---

radius of nucleus

$$R = r_0 A^{1/3}$$


---

radioactivity

$$A = \lambda N; \quad \frac{\Delta N}{\Delta t} = - \lambda N$$

$$\lambda t_{1/2} = \ln(2)$$

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

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


---

Einstein's mass-energy equation

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


---

attenuation of X-rays

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


---

ultrasound

$$Z = \rho c$$

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

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


---

---

# OCR

Oxford Cambridge and RSA

**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](http://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 Copyright Team, First Floor, 9 Hills Road, Cambridge CB2 1GE.

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.