

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced Subsidiary GCE (H156)**

**Advanced GCE (H556)**

**Physics A**

**DATA, FORMULAE AND  
RELATIONSHIPS BOOKLET**

**INSTRUCTIONS TO EXAMS OFFICER/  
INVIGILATOR**

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THE CENTRE OR DESTROYED.**

**READ INSTRUCTIONS OVERLEAF**



**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.**

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# 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

$$g \quad 9.81 \text{ m s}^{-2}$$

elementary charge

$$e \quad 1.60 \times 10^{-19} \text{ C}$$

speed of light  
in a vacuum

$$c \quad 3.00 \times 10^8 \text{ m s}^{-1}$$

Planck constant

$$h \quad 6.63 \times 10^{-34} \text{ J s}$$

Avogadro  
constant

$$N_A \quad 6.02 \times 10^{23} \text{ mol}^{-1}$$

molar gas  
constant

$$R \quad 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$$

Boltzmann  
constant

$$k \quad 1.38 \times 10^{-23} \text{ J K}^{-1}$$

<b>gravitational constant</b>	<b><math>G</math></b>	<b><math>6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}</math></b>
<b>permittivity of free space</b>	<b><math>\epsilon_0</math></b>	<b><math>8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}</math> <b>(<math>\text{F m}^{-1}</math>)</b></b>
<b>electron rest mass</b>	<b><math>m_e</math></b>	<b><math>9.11 \times 10^{-31} \text{ kg}</math></b>
<b>proton rest mass</b>	<b><math>m_p</math></b>	<b><math>1.673 \times 10^{-27} \text{ kg}</math></b>
<b>neutron rest mass</b>	<b><math>m_n</math></b>	<b><math>1.675 \times 10^{-27} \text{ kg}</math></b>
<b>alpha particle rest mass</b>	<b><math>m_\alpha</math></b>	<b><math>6.646 \times 10^{-27} \text{ kg}</math></b>
<b>Stefan constant</b>	<b><math>\sigma</math></b>	<b><math>5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}</math></b>

## 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 =  $1.661 \times 10^{-27}$  kg

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

day                      1 day =  $8.64 \times 10^4$  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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

# FORMULAE AND RELATIONSHIPS

## MODULE 2 – FOUNDATIONS OF PHYSICS

**vectors**

$$F_x = F \cos \theta$$

$$F_y = F \sin \theta$$

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## 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**

$$W = Fx \cos \theta$$

**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**

$$I = \frac{Anevt}{l}$$

---

**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**

$$v = f\lambda$$

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

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

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

---

**refraction**

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

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

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

---

quantum physics      $E = hf$       $E = \frac{hc}{\lambda}$

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

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

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## 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**

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

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

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

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

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

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

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**magnetic field**

$$F = BIL\sin\theta$$

$$F = BQv$$

---

**electromagnetism**     $\phi = BA\cos\theta$

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

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

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**radius of nucleus**     $R = r_0 A^{1/3}$

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

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

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

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

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**Einstein's  
mass-energy  
equation**

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

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# attenuation of X-rays

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

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# 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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