

# **Modified Enlarged 36pt**

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**AS Level Physics B (H157)**

**A Level Physics B (H557)**

**Data, Formulae and Relationships Booklet**

**READ INSTRUCTIONS OVERLEAF**

CST990

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# **INSTRUCTIONS**

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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

speed of light

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

permittivity of free space

$$\epsilon_0 \quad 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \\ (\text{or } \text{F m}^{-1})$$

electric force constant

$$k = \frac{1}{4\pi\epsilon_0} \quad 8.98 \times 10^9 \text{ N m}^2 \text{ C}^{-2} \\ (\approx 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2})$$

permeability of free space

$$\mu_0 \quad 4\pi \times 10^{-7} \text{ N A}^{-2} (\text{or } \text{H m}^{-1})$$

charge on electron

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

**mass of electron**

$$m_e \quad 9.11 \times 10^{-31} \text{ kg} = 0.00055 \text{ u}$$

**mass of proton**

$$m_p \quad 1.673 \times 10^{-27} \text{ kg} = 1.0073 \text{ u}$$

**mass of neutron**

$$m_n \quad 1.675 \times 10^{-27} \text{ kg} = 1.0087 \text{ u}$$

**mass of alpha particle**

$$m_\alpha \quad 6.646 \times 10^{-27} \text{ kg} = 4.0015 \text{ u}$$

**Avogadro constant**

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

**Planck constant**

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

**Boltzmann constant**

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

**molar gas constant**

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

**gravitational force constant**

$$G \quad 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$

## OTHER DATA

**standard temperature and pressure (stp)**  
 **$273\text{ K } (0\text{ }^{\circ}\text{C}), 1.01 \times 10^5\text{ Pa}$**   
**(1 atmosphere)**

**molar volume of a gas at stp**  
 **$V_{\text{m}} \quad 2.24 \times 10^{-2}\text{ m}^3$**

**gravitational field strength at the Earth's surface in the UK**  
 **$g \quad 9.81\text{ N kg}^{-1}$**

## CONVERSION FACTORS

**unified atomic mass unit**  
 **$1\text{ u} \quad = 1.661 \times 10^{-27}\text{ kg}$**

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

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

**$1\text{ light year} \approx 10^{16}\text{ m}$**

# MATHEMATICAL CONSTANTS AND EQUATIONS

$$e = 2.72 \quad \pi = 3.14$$
$$1 \text{ radian} = 57.3^\circ$$

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

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

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

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

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

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

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

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

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

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

# PREFIXES

$10^{-12}$	$10^{-9}$	$10^{-6}$	$10^{-3}$	$10^3$	$10^6$	$10^9$
p	n	$\mu$	m	k	M	G



# FORMULAE AND RELATIONSHIPS

## IMAGING AND SIGNALLING

**focal length**

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$

**linear magnification**

$$m = \frac{v}{u}$$

**refractive index**

$$n = \frac{\sin i}{\sin r} = \frac{C_{1\text{st medium}}}{C_{2\text{nd medium}}}$$

**noise limitation on maximum bits per sample**

$$b = \log_2 \left( \frac{V_{\text{total}}}{V_{\text{noise}}} \right)$$

**alternatives,  $N$ , provided by  $b$  bits**

$$N = 2^b, b = \log_2 N$$

# ELECTRICITY

current

$$\mathbf{I} = \frac{\Delta Q}{\Delta t}$$

potential difference

$$\mathbf{V} = \frac{W}{Q}$$

power and energy

$$\mathbf{P} = \mathbf{IV} = \mathbf{I^2R}, \mathbf{W} = \mathbf{VIt}$$

e.m.f and potential difference

$$\mathbf{V} = \boldsymbol{\varepsilon} - \mathbf{Ir}$$

conductors in series and parallel

$$\frac{1}{\mathbf{G}} = \frac{1}{\mathbf{G}_1} + \frac{1}{\mathbf{G}_2} + \dots$$

$$\mathbf{G} = \mathbf{G}_1 + \mathbf{G}_2 + \dots$$

resistors in series and parallel

$$\mathbf{R} = \mathbf{R}_1 + \mathbf{R}_2 + \dots$$

$$\frac{1}{\mathbf{R}} = \frac{1}{\mathbf{R}_1} + \frac{1}{\mathbf{R}_2} + \dots$$

**potential divider**

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

**conductivity and resistivity**

$$G = \frac{\sigma A}{L} \quad R = \frac{\rho L}{A}$$

**capacitance**

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

**energy stored in a capacitor**

$$E = \frac{1}{2} QV = \frac{1}{2} CV^2$$

**discharge of capacitor**

$$\frac{dQ}{dt} = -\frac{Q}{RC}$$

$$Q = Q_0 e^{-t/RC} \quad \tau = RC$$

# MATERIALS

Hooke's law

$$F = kx$$

elastic strain energy

$$\frac{1}{2} kx^2$$

Young modulus

$$E = \frac{\text{stress}}{\text{strain}},$$

$$\text{stress} = \frac{\text{tension}}{\text{cross-sectional area}},$$

$$\text{strain} = \frac{\text{extension}}{\text{original length}}$$

# GASES

kinetic theory of gases

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

ideal gas equation

$$pV = nRT = NkT$$

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# MOTION AND FORCES

momentum

$$p = mv$$

impulse

$$F\Delta t$$

force

$$F = \frac{\Delta(mv)}{\Delta t}$$

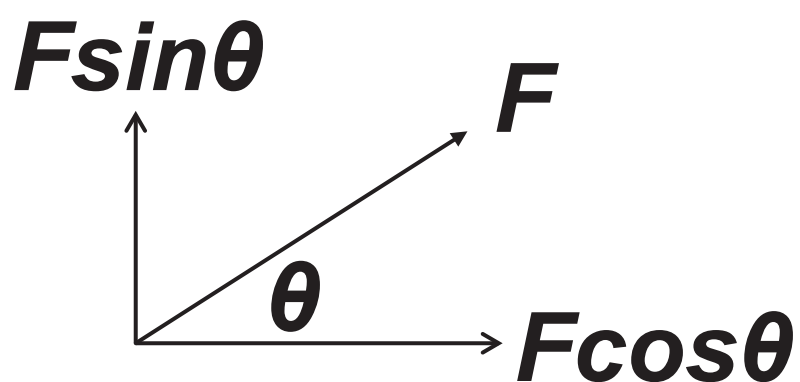
work done

$$W = Fx \quad \Delta E = F\Delta s$$

power

$$P = Fv, \quad P = \frac{\Delta E}{t}$$

components of a vector in two perpendicular directions



**equations for uniformly accelerated motion**

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

$$v = u + at$$

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

**for circular motion**

$$a = \frac{v^2}{r}, F = \frac{mv^2}{r} = mr\omega^2$$

## **ENERGY AND THERMAL EFFECTS**

**energy**

$$\Delta E = mc\Delta\theta$$

**average energy approximation**

$$\text{average energy} \sim kT$$

**Boltzmann factor**

$$e^{-\frac{E}{kT}}$$

# WAVES

wave formula

$$v = f\lambda$$

frequency and period

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

diffraction grating

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

# OSCILLATIONS

simple harmonic motion

$$\frac{d^2x}{dt^2} = a = -\left(\frac{k}{m}\right)x = -\omega^2x$$

$$x = A \cos(\omega t)$$

$$x = A \sin(\omega t)$$

$$\omega = 2\pi f$$



## Periodic time

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$\text{total energy } E = \frac{1}{2} kA^2 = \frac{1}{2} mv^2 + \frac{1}{2} kx^2$$

# ATOMIC AND NUCLEAR PHYSICS

## radioactive decay

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

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

half life  $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$

## radioactive dose and risk

absorbed dose = energy deposited per unit mass

effective dose = absorbed dose × quality factor

risk = probability × consequence

## mass–energy relationship

$$E_{\text{rest}} = mc^2$$

## relativistic factor

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

## relativistic energy

$$E_{\text{total}} = \gamma E_{\text{rest}}$$

**energy–frequency relationship for photons**

$$**$E = hf$**$$

**de Broglie  $\lambda = \frac{h}{p}$**

## **FIELD AND POTENTIAL**

**for all fields**

$$**\text{field strength} = - \frac{dV}{dr} \approx - \frac{\Delta V}{\Delta r}**$$

**gravitational fields**

$$**$g = \frac{F}{m}, E_{\text{grav}} = - \frac{GmM}{r}$**$$

$$**$V_{\text{grav}} = - \frac{GM}{r}, F = - \frac{GmM}{r^2}$**$$

**electric fields**

$$**$E = \frac{F}{q} = \frac{V}{d},$**$$

$$**\text{electrical potential energy} = \frac{kQq}{r}**$$

$$**$V_{\text{electric}} = \frac{kQ}{r}, F = \frac{kQq}{r^2}$**$$

# ELECTROMAGNETISM

**magnetic flux**

$$\phi = BA$$

**force on a current carrying conductor**

$$F = ILB$$

**force on a moving charge**

$$F = qvB$$

**Induced e.m.f**

$$\varepsilon = - \frac{d(N\phi)}{dt}$$

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