

# Physics A

## Data and Formulae Booklet

### DATA

#### FUNDAMENTAL CONSTANTS AND VALUES

| <i>Quantity</i>                                              | <i>Symbol</i> | <i>Value</i>              | <i>Units</i>                      |
|--------------------------------------------------------------|---------------|---------------------------|-----------------------------------|
| speed of light in vacuo                                      | $c$           | $3.00 \times 10^8$        | $\text{m s}^{-1}$                 |
| permeability of free space                                   | $\mu_0$       | $4\pi \times 10^{-7}$     | $\text{H m}^{-1}$                 |
| permittivity of free space                                   | $\epsilon_0$  | $8.85 \times 10^{-12}$    | $\text{F m}^{-1}$                 |
| magnitude of the charge of electron                          | $e$           | $1.60 \times 10^{-19}$    | C                                 |
| the Planck constant                                          | $h$           | $6.63 \times 10^{-34}$    | J s                               |
| gravitational constant                                       | $G$           | $6.67 \times 10^{-11}$    | $\text{N m}^2 \text{kg}^{-2}$     |
| the Avogadro constant                                        | $N_A$         | $6.02 \times 10^{23}$     | $\text{mol}^{-1}$                 |
| molar gas constant                                           | $R$           | 8.31                      | $\text{J K}^{-1} \text{mol}^{-1}$ |
| the Boltzmann constant                                       | $k$           | $1.38 \times 10^{-23}$    | $\text{J K}^{-1}$                 |
| the Stefan constant                                          | $\sigma$      | $5.67 \times 10^{-8}$     | $\text{W m}^{-2} \text{K}^{-4}$   |
| the Wien constant                                            | $\alpha$      | $2.90 \times 10^{-3}$     | m K                               |
| electron rest mass<br>(equivalent to $5.5 \times 10^{-4}$ u) | $m_e$         | $9.11 \times 10^{-31}$    | kg                                |
| electron charge/mass ratio                                   | $e/m_e$       | $1.76 \times 10^{11}$     | $\text{C kg}^{-1}$                |
| proton rest mass<br>(equivalent to 1.00728 u)                | $m_p$         | $1.67(3) \times 10^{-27}$ | kg                                |
| proton charge/mass ratio                                     | $e/m_p$       | $9.58 \times 10^7$        | $\text{C kg}^{-1}$                |
| neutron rest mass<br>(equivalent to 1.00867 u)               | $m_n$         | $1.67(5) \times 10^{-27}$ | kg                                |
| gravitational field strength                                 | $g$           | 9.81                      | $\text{N kg}^{-1}$                |
| acceleration due to gravity                                  | $g$           | 9.81                      | $\text{m s}^{-2}$                 |
| atomic mass unit<br>(1u is equivalent to 931.5 MeV)          | u             | $1.661 \times 10^{-27}$   | kg                                |

#### GEOMETRICAL EQUATIONS

|                                 |                         |
|---------------------------------|-------------------------|
| <i>arc length</i>               | $= r\theta$             |
| <i>circumference of circle</i>  | $= 2\pi r$              |
| <i>area of circle</i>           | $= \pi r^2$             |
| <i>surface area of cylinder</i> | $= 2\pi rh$             |
| <i>volume of cylinder</i>       | $= \pi r^2 h$           |
| <i>area of sphere</i>           | $= 4\pi r^2$            |
| <i>volume of sphere</i>         | $= \frac{4}{3} \pi r^3$ |

#### ASTRONOMICAL DATA

| <i>Body</i> | <i>Mass/kg</i>        | <i>Mean radius/m</i> |
|-------------|-----------------------|----------------------|
| Sun         | $1.99 \times 10^{30}$ | $6.96 \times 10^8$   |
| Earth       | $5.98 \times 10^{24}$ | $6.37 \times 10^6$   |

## AS FORMULAE

## PARTICLE PHYSICS

## Rest energy values

| class   | name        | symbol    | rest energy /MeV |
|---------|-------------|-----------|------------------|
| photon  | photon      | $\gamma$  | 0                |
| lepton  | neutrino    | $\nu_e$   | 0                |
|         |             | $\nu_\mu$ | 0                |
|         | electron    | $e^\pm$   | 0.510999         |
|         | muon        | $\mu^\pm$ | 105.659          |
| mesons  | $\pi$ meson | $\pi^\pm$ | 139.576          |
|         |             | $\pi^0$   | 134.972          |
|         | K meson     | $K^\pm$   | 493.821          |
|         |             | $K^0$     | 497.762          |
| baryons | proton      | p         | 938.257          |
|         | neutron     | n         | 939.551          |

## Properties of quarks

antiquarks have opposite signs

| type     | charge          | baryon number  | strangeness |
|----------|-----------------|----------------|-------------|
| <b>u</b> | $+\frac{2}{3}e$ | $+\frac{1}{3}$ | 0           |
| <b>d</b> | $-\frac{1}{3}e$ | $+\frac{1}{3}$ | 0           |
| <b>s</b> | $-\frac{1}{3}e$ | $+\frac{1}{3}$ | -1          |

## Properties of Leptons

|                                                         | lepton number |
|---------------------------------------------------------|---------------|
| particles: $e^-, \nu_e; \mu^-, \nu_\mu$                 | +1            |
| antiparticles: $e^+, \bar{\nu}_e; \mu^+, \bar{\nu}_\mu$ | -1            |

## Photons and Energy Levels

photon energy  $E = hf = hc/\lambda$ photoelectricity  $hf = \phi + E_k$ energy levels  $hf = E_1 - E_2$ de Broglie wavelength  $\lambda = \frac{h}{p} = \frac{h}{mv}$ 

## ELECTRICITY

current and pd  $I = \frac{\Delta Q}{\Delta t}$   $V = \frac{W}{Q}$   $R = \frac{V}{I}$ emf  $\varepsilon = \frac{E}{Q}$   $\varepsilon = I(R + r)$ resistors in series  $R = R_1 + R_2 + R_3 + \dots$ resistors in parallel  $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$ resistivity  $\rho = \frac{RA}{L}$ power  $P = VI = I^2 R = \frac{V^2}{R}$ alternating current  $I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$   $V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$ 

## MECHANICS

moments moment =  $Fd$ velocity and acceleration  $v = \frac{\Delta s}{\Delta t}$   $a = \frac{\Delta v}{\Delta t}$ equations of motion  $v = u + at$   $s = \frac{(u+v)}{2}t$ 

$$v^2 = u^2 + 2as \quad s = ut + \frac{at^2}{2}$$

force  $F = ma$ work, energy and power  $W = Fs \cos \theta$   
 $E_k = \frac{1}{2}mv^2$   $\Delta E_p = mg\Delta h$   
 $P = \frac{\Delta W}{\Delta t}$ ,  $P = Fv$ efficiency =  $\frac{\text{useful output power}}{\text{input power}}$ 

## MATERIALS

density  $\rho = \frac{m}{V}$  Hooke's law  $F = k \Delta L$ Young's modulus =  $\frac{\text{tensile stress}}{\text{tensile strain}}$  tensile stress =  $\frac{F}{A}$   
tensile strain =  $\frac{\Delta L}{L}$ energy stored  $E = \frac{1}{2}F\Delta L$ 

## WAVES

wave speed  $c = f\lambda$  period  $T = \frac{1}{f}$ fringe spacing  $w = \frac{\lambda D}{s}$  diffraction grating  $d \sin \theta = n\lambda$ refractive index of a substance  $s$ ,  $n = \frac{c}{c_s}$ for two different substances of refractive indices  $n_1$  and  $n_2$ ,law of refraction  $n_1 \sin \theta_1 = n_2 \sin \theta_2$ critical angle  $\sin \theta_c = \frac{n_2}{n_1}$  for  $n_1 > n_2$