



# Physics A

# PHYA1

## Unit 1 Particles, Quantum Phenomena and Electricity

### 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	$\epsilon_0$	$8.85 \times 10^{-12}$	$\text{F m}^{-1}$
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 (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 (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 (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 (1u is equivalent to 931.3 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  $hf = \phi + E_{K(\max)}$

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  $P = VI = I^2R = \frac{V^2}{R}$

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  $v = u + at$   $s = \frac{(u+v)t}{2}$

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

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 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  $n_1 > n_2$