

**Physics (B): Physics in Context**  
**Unit 1 Harmony and Structure in the Universe**

**PHYB1**

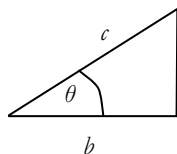
**Data and Formulae Booklet**

**FUNDAMENTAL CONSTANTS AND  
OTHER NUMERICAL DATA**

Quantity	Symbol	Value	Units
speed of light in vacuo	$c$	$3.00 \times 10^8$	$\text{m s}^{-1}$
Planck constant	$h$	$6.63 \times 10^{-34}$	J s
gravitational constant	$G$	$6.67 \times 10^{-11}$	$\text{N m}^2 \text{kg}^{-2}$
gravitational field strength	$g$	9.81	$\text{N kg}^{-1}$
acceleration due to gravity	$g$	9.81	$\text{m s}^{-2}$
electron rest mass	$m_e$	$9.11 \times 10^{-31}$	kg
	$m_e$	$5.5 \times 10^{-4} \text{ u}$	
electron charge	$e$	$-1.60 \times 10^{-19}$	C
proton rest mass	$m_p$	$1.67(3) \times 10^{-27}$	kg
	$m_p$	1.00728 u	
neutron rest mass	$m_n$	$1.67(5) \times 10^{-27}$	kg
	$m_n$	1.00867 u	
permittivity of free space	$\epsilon_0$	$8.85 \times 10^{-12}$	$\text{F m}^{-1}$
molar gas constant	$R$	8.31	$\text{J K}^{-1} \text{mol}^{-1}$
Boltzmann constant	$k$	$1.38 \times 10^{-23}$	$\text{J K}^{-1}$
Avogadro constant	$N_A$	$6.02 \times 10^{23}$	$\text{mol}^{-1}$
Wien constant	$\alpha$	$2.90 \times 10^{-3}$	m K

**GEOMETRICAL  
EQUATIONS**

arc length	$r\theta$
circumference of circle	$2\pi r$
area of circle	$\pi r^2$
surface area of sphere	$4\pi r^2$
volume of sphere	$\frac{4}{3}\pi r^3$
surface area of cylinder	$2\pi rh$
volume of cylinder	$\pi r^2 h$
	$\sin \theta = \frac{a}{c}$
	$\cos \theta = \frac{b}{c}$
	$\tan \theta = \frac{a}{b}$
	$c^2 = a^2 + b^2$



**Unit Conversions**

1 atomic mass unit (u)	$1.661 \times 10^{-27} \text{ kg}$
1 year (y)	$3.15 \times 10^7 \text{ s}$
1 parsec (pc)	$3.08 \times 10^{16} \text{ m}$
1 parsec	3.26 ly
1 light year (ly)	$9.46 \times 10^{15} \text{ m}$

**Particle Properties**

**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: $e^-, \nu_e; \mu^-, \nu_\mu; \tau^-, \nu_\tau$	+1
antiparticles: $e^+, \bar{\nu}_e; \mu^+, \bar{\nu}_\mu; \tau^+, \bar{\nu}_\tau$	-1

## AS FORMULAE

	Waves	Quantum Physics and Astrophysics
wave speed	$c = f\lambda$	photon energy $E = hf$
period	$T = \frac{1}{f}$	Einstein equation $hf = \phi + E_{k(\max)}$
intensity	$I = \frac{P}{A}$	line spectrum equation $hf = E_1 - E_2$
stretched string frequency	$f = \frac{1}{2L} \sqrt{\frac{T}{\mu}}$	de Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$
beat frequency	$f = f_1 - f_2$	Doppler shift for $v \ll c$ $\frac{\Delta f}{f} = -\frac{\Delta \lambda}{\lambda} = \frac{v}{c}$
fringe spacing	$w = \frac{\lambda D}{s}$	Wien's law $\lambda_{\max} T = 0.0029 \text{ m K}$
diffraction grating	$n\lambda = d \sin \theta$	Hubble law $v = Hd$
half beam width	$\sin \theta = \frac{\lambda}{a}$	intensity for a point source $I = \frac{P}{4\pi r^2}$
refractive index of a substance (s)	$n = \frac{c}{c_s}$	<b>Electricity</b>
for two different substances of refractive indices $n_1$ and $n_2$	$n_1 \sin i_1 = n_2 \sin i_2$	current $I = \frac{\Delta Q}{\Delta t}$
critical angle	$\sin \theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$	electromotive force (emf) $\varepsilon = \frac{E}{Q}$
	<b>Mechanics</b>	$\varepsilon = I(R + r)$
speed or velocity	$v = \frac{\Delta s}{\Delta t}$	resistance $R = \frac{V}{I}$
acceleration	$a = \frac{\Delta v}{\Delta t}$	resistors in series $R = R_1 + R_2 + R_3 + \dots$
equations of motion	$v = u + at$ $s = \frac{(u+v)}{2}t$ $v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$	resistors in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$
force	$F = ma$	resistivity $\rho = \frac{RA}{L}$
change in potential energy	$\Delta E_p = mg\Delta h$	power $P = VI = I^2R = \frac{V^2}{R}$
kinetic energy	$E_k = \frac{1}{2}mv^2$	potential divider formula $V_o = \left(\frac{R_1}{R_1 + R_2}\right) \times V_i$
momentum	$p = mv$	energy $E = VI$
impulse	$F\Delta t = \Delta(mv)$	efficiency $\frac{\text{useful output power}}{\text{input power}}$
spring stiffness	$k = \frac{F}{\Delta L}$	<b>Energy production and transmission</b>
energy stored for $F \propto L$	$E = \frac{1}{2}F\Delta L$	rate of heat transfer by conduction $= UA \Delta \theta$
work done	$W = Fs \cos \theta$	maximum power for a wind turbine $= \frac{1}{2} \pi r^2 \rho v^3$
power	$P = \frac{\Delta W}{\Delta t} = Fv$	
density	$\rho = \frac{m}{V}$	