



**AS**

# **Physics data and formulae**

**For use in exams from the June 2016 Series onwards**

**DATA - FUNDAMENTAL CONSTANTS AND VALUES**

<b>Quantity</b>	<b>Symbol</b>	<b>Value</b>	<b>Units</b>
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	$e$	$1.60 \times 10^{-19}$	$\text{C}$
the Planck constant	$h$	$6.63 \times 10^{-34}$	$\text{J s}$
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	$\alpha$	$2.90 \times 10^{-3}$	$\text{m K}$
electron rest mass (equivalent to $5.5 \times 10^{-4}$ u)	$m_e$	$9.11 \times 10^{-31}$	$\text{kg}$

electron charge/mass ratio	$\frac{e}{m_e}$	$1.76 \times 10^{11}$	C kg <sup>-1</sup>
proton rest mass (equivalent to 1.00728 u)	$m_p$	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_p}$	$9.58 \times 10^7$	C kg <sup>-1</sup>
neutron rest mass (equivalent to 1.00867 u)	$m_n$	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	$g$	9.81	N kg <sup>-1</sup>
acceleration due to gravity	$g$	9.81	m s <sup>-2</sup>
atomic mass unit (1u is equivalent to 931.5 MeV)	u	$1.661 \times 10^{-27}$	kg

[Turn over]

**ALGEBRAIC EQUATION**

quadratic equation  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

**ASTRONOMICAL DATA**

Body	Mass/kg	Mean radius/m
Sun	$1.99 \times 10^{30}$	$6.96 \times 10^8$
Earth	$5.97 \times 10^{24}$	$6.37 \times 10^6$

**GEOMETRICAL EQUATIONS**

arc length  $= r\theta$

circumference of circle  $= 2\pi r$

area of circle  $= \pi r^2$

curved surface area of cylinder  $= 2\pi rh$

area of sphere  $= 4\pi r^2$

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

## Particle Physics

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

[Turn over]

**Properties of quarks**  
antiquarks have opposite signs

Type	Charge	Baryon number	Strangeness
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-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

$$hf = \phi + E_k (\text{max})$$

energy levels

$$hf = E_1 - E_2$$

de Broglie wavelength

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

[Turn over]

**Waves**

wave speed  $c = f\lambda$       period  $f = \frac{1}{T}$

first harmonic  $f = \frac{1}{2l} \sqrt{\frac{T}{\mu}}$

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  $n_1 > n_2$



**Mechanics****moments**

**moment =  $Fd$**

**velocity and  
acceleration**

**$v = \frac{\Delta s}{\Delta t}$**

**$a = \frac{\Delta v}{\Delta t}$**

**equations of  
motion**

**$v = u + at$**

**$s = \left( \frac{u+v}{2} \right) t$**

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

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

**force**

**$F = ma$**

**force**

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

**impulse**

**$F \Delta t = \Delta(mv)$**

**work, energy  
and power**

**$W = F s \cos \theta$**

**$E_k = \frac{1}{2} m v^2$**

**$\Delta E_p = mg \Delta h$**

**$P = \frac{\Delta W}{\Delta t}$  ,  $P = Fv$**

**$efficiency = \frac{useful\ output\ power}{input\ power}$**

**[Turn over]**

**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  $E = \frac{1}{2} F \Delta L$

**Electricity**

current and pd  $I = \frac{\Delta Q}{\Delta t}$      $V = \frac{W}{Q}$      $R = \frac{V}{I}$

resistivity  $\rho = \frac{RA}{L}$

resistors in series  $R_T = R_1 + R_2 + R_3 + \dots$

resistors in parallel  $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$

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

emf  $\varepsilon = \frac{E}{Q}$      $\varepsilon = I(R + r)$

**There are no formulae printed on this page**

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