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PHYSICS

Physics data and formulae

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

[Turn over]

DATA — FUNDAMENTAL CONSTANTS AND VALUES

QUANTITY	SYMBOL	VALUE	UNITS
speed of light in vacuo	c	3.00×10^8	m s^{-1}
permeability of free space	μ_0	$4\pi \times 10^{-7}$	H m^{-1}
permittivity of free space	ϵ_0	8.85×10^{-12}	F m^{-1}
magnitude of the charge of electron	e	1.60×10^{-19}	C

QUANTITY	SYMBOL	VALUE	UNITS
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$\text{N m}^2 \text{kg}^{-2}$
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}
molar gas constant	R	8.31	$\text{J K}^{-1} \text{mol}^{-1}$
the Boltzmann constant	k	1.38×10^{-23}	J K^{-1}

[Turn over]

QUANTITY	SYMBOL	VALUE	UNITS
the Stefan constant	σ	5.67×10^{-8}	$\text{W m}^{-2} \text{K}^{-4}$
the Wien constant	α	2.90×10^{-3}	m K
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
magnitude of electron charge/mass ratio	$\frac{e}{m_e}$	1.76×10^{11}	C kg^{-1}

QUANTITY	SYMBOL	VALUE	UNITS
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67 (3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_p}$	9.58×10^7	$C\ kg^{-1}$
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67 (5) \times 10^{-27}$	kg
[Turn over]			

QUANTITY	SYMBOL	VALUE	UNITS
gravitational field strength	<i>g</i>	9.81	N kg⁻¹
acceleration due to gravity	<i>g</i>	9.81	m s⁻²
atomic mass unit (1u is equivalent to 931.5 MeV)	u	1.661 × 10⁻²⁷	kg

ALGEBRAIC EQUATION

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

ASTRONOMICAL DATA

BODY	MASS/kg	MEAN RADIUS/m
Sun	1.99×10^{30}	6.96×10^8
Earth	5.97×10^{24}	6.37×10^6

[Turn over]

GEOMETRICAL EQUATIONS

arc length $= r\theta$

circumference of circle $= 2\pi r$

area of circle $= \pi r^2$

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

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

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

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PARTICLE PHYSICS

CLASS	NAME	SYMBOL	REST ENERGY/MeV
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	e^\pm	0.510999
	muon	μ^\pm	105.659
mesons	π meson	π^\pm	139.576
		π^0	134.972

CLASS	NAME	SYMBOL	REST ENERGY/MeV
	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

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PHOTONS AND ENERGY LEVELS

photon energy $E = hf = \frac{hc}{\lambda}$

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 $c = f\lambda$

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

period

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

first harmonic

$$w = \frac{\lambda D}{s}$$

fringe spacing

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 $n_1 > n_2$

[Turn over]

MECHANICS

moments

$$\text{moment} = Fd$$

**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**

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

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

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

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

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

[Turn over]

MATERIALS

$$\text{density } \rho = \frac{m}{V}$$

$$\text{Hooke's law } F = k \Delta L$$

$$\text{Young modulus} = \frac{\textit{tensile stress}}{\textit{tensile strain}}$$

$$\text{tensile stress} = \frac{F}{A}$$

$$\text{tensile strain} = \frac{\Delta L}{L}$$

$$\text{energy stored } E = \frac{1}{2} F \Delta L$$

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

END OF DATA SHEET

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