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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}	$\mathrm{m\ s^{-1}}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$\mathrm{H\ m^{-1}}$
permittivity of free space	ε_0	8.85×10^{-12}	$\mathrm{F\ m^{-1}}$
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$\mathrm{N\ m^2\ kg^{-2}}$
the Avogadro constant	N_A	6.02×10^{23}	$\mathrm{mol^{-1}}$
molar gas constant	R	8.31	$\mathrm{JK^{-1}\ mol^{-1}}$
the Boltzmann constant	k	1.38×10^{-23}	$\mathrm{J\ K^{-1}}$

QUANTITY	SYMBOL	VALUE	UNITS
the Stefan constant	σ	5.67×10^{-8}	$\mathrm{Wm^{-2}\,K^{-4}}$
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	$\frac{e}{m_{\mathrm{e}}}$	1.76×10^{11}	$\mathrm{C\,kg^{-1}}$
proton rest mass (equivalent to 1.00728 u)	m_{p}	$1.67\,(3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_{\mathrm{p}}}$	9.58×10^{7}	$\mathrm{C\,kg^{-1}}$
neutron rest mass (equivalent to 1.00867 u)	m_{n}	$1.67\,(5) \times 10^{-27}$	kg

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QUANTITY	SYMBOL	VALUE	UNITS
gravitational field strength	g	9.81	$\mathrm{N\ kg^{-1}}$
acceleration due to gravity	g	9.81	$\mathrm{m\ s^{-2}}$
atomic mass unit (1 u is equivalent to 931.5 MeV)	u	1.661×10^{-27}	kg

ALGEBRAIC EQUATION

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

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}

GEOMETRICAL EQUATIONS

arc length = $r\theta$

circumference of circle = $2\pi r$

area of circle = πr^2

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

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

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

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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	$\mu^\pm$	105.659
mesons	π meson	$\pi^\pm$	139.576
		π^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
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:	$e^+, \overline{\nu_e}, \mu^+, \overline{\nu_\mu}$	-1

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PHOTONS AND ENERGY LEVELS

photon energy	$E = hf = \frac{hc}{\lambda}$
photoelectricity	$hf = \phi + E_{\text{k (max)}}$
energy levels	$hf = E_1 - E_2$
de Broglie wavelength	$\lambda = \frac{h}{p} = \frac{h}{mv}$

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 $n_1 > n_2$

[Turn over]

MECHANICS

moments

$$\text{moment} = Fd$$

velocity and acceleration

$$v = \frac{\Delta s}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t}$$

equations of motion

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

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

force

$$F = ma$$

force

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

impulse

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

work, energy and power

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

$$E_k = \frac{1}{2} m v^2 \qquad \Delta E_p = mg\,\Delta h$$

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

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

MATERIALS

density $\rho = \frac{m}{V}$ **Hooke's law** $F = k\,\Delta L$

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

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

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

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 $R_T = R_1 + R_2 + R_3 + \ldots$

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

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

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

END OF DATA SHEET

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