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Physics data and formulae

For use in exams from the June 2016 Series onwards

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	F m^{-1}
magnitude of the charge of electron	e	1.60×10^{-12}	C
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}
the Stefan constant	σ	5.67×10^{-8}	W m^{-2}
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

electron charge/mass ratio	$\frac{e}{m_e}$	1.76×10^{11}	C kg ⁻¹
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_p}$	9.58×10^7	C kg ⁻¹
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	N kg ⁻¹
acceleration due to gravity	g	9.81	m s ⁻²
atomic mass unit (1u is equivalent to 931.5 MeV)	u	1.661×10^{-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	1.99×10^{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 = $2\pi rh$

curved surface area of cylinder = $4\pi r^2$

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	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
	K meson	K^\pm	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

[Turn over]

Particle Physics

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	$f = \frac{1}{T}$
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first harmonic	$f = \frac{1}{2l} \sqrt{\frac{T}{\mu}}$
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fringe spacing	$w = \frac{\lambda D}{s}$	diffraction grating	$d \sin \theta = n\lambda$
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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 $n_1 > n_2$

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

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

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

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

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

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

[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 RT

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

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