General Certificate of Education
Advanced Subsidiary Examination
June 2009

Physics A PHYA2

Unit 2 Mechanics, Materials and Waves

Data and Formulae Booklet

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_o	$4\pi \times 10^{-7}$	$H\ m^{-1}$
permittivity of free space	ε_o	8.85×10^{-12}	$F\ m^{-1}$
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}	$N\ m^2\ kg^{-2}$
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}
molar gas constant	R	8.31	$J\ K^{-1}\ mol^{-1}$
the Boltzmann constant	k	1.38×10^{-23}	$J\ K^{-1}$
the Stefan constant	σ	5.67×10^{-8}	$W\ m^{-2}\ K^{-4}$
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
electron charge/mass ratio	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	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 931.3 MeV)	u	1.661×10^{-27}	kg

ASTRONOMICAL DATA

Body	*Mass/kg*	*Mean radius/m*
Sun	1.99×10^{30}	6.96×10^{8}
Earth	5.98×10^{24}	6.37×10^{6}

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
surface area of cylinder	$= 2\pi rh$
volume of cylinder	$= \pi r^2 h$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

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AS FORMULAE

PARTICLE PHYSICS

Rest energy values

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^-, ν_e ; μ^-, ν_μ	+1
antiparticles: e^+, $\overline{\nu_e}$; μ^+, $\overline{\nu_\mu}$	–1

Photons and Energy Levels

photon energy $E = hf = hc/\lambda$

photoelectricity $hf = \phi + E_{K(max)}$

energy levels $hf = E_1 - E_2$

de Broglie Wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

ELECTRICITY

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

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

resistors in series $R = R_1 + R_2 + R_3 + \ldots$

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

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

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

alternating current $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

MECHANICS

moments moment = Fd

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \frac{(u+v)}{2}t$

$v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$

force $F = ma$

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

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

WAVES

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

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 $n_1 > n_2$