With Missing Equations Added

GCE A LEVEL – NEW

A420U10-A420U30-1A

S17-A420U101A

PHYSICS – A level components 1 – 3
Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each A level Physics examination.

Centres are asked to issue this booklet to candidates at the start of the course to enable them to become familiar with its contents and layout.

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Values and Conversions

Avogadro constant	N_A	$= 6{\cdot}02 \times 10^{23}\ \text{mol}^{-1}$
Fundamental electronic charge	e	$= 1{\cdot}60 \times 10^{-19}\ \text{C}$
Mass of an electron	m_e	$= 9{\cdot}11 \times 10^{-31}\ \text{kg}$
Molar gas constant	R	$= 8{\cdot}31\ \text{J mol}^{-1}\text{K}^{-1}$
Acceleration due to gravity at sea level	g	$= 9{\cdot}81\ \text{m s}^{-2}$
Gravitational field strength at sea level	g	$= 9{\cdot}81\ \text{N kg}^{-1}$
Universal constant of gravitation	G	$= 6{\cdot}67 \times 10^{-11}\ \text{N m}^2\text{kg}^{-2}$
Planck constant	h	$= 6{\cdot}63 \times 10^{-34}\ \text{J s}$
Boltzmann constant	k	$= 1{\cdot}38 \times 10^{-23}\ \text{J K}^{-1}$
Speed of light in vacuo	c	$= 3{\cdot}00 \times 10^{8}\ \text{m s}^{-1}$
Permittivity of free space	ε_0	$= 8{\cdot}85 \times 10^{-12}\ \text{F m}^{-1}$
Permeability of free space	μ_0	$= 4\pi \times 10^{-7}\ \text{H m}^{-1}$
Stefan constant	σ	$= 5{\cdot}67 \times 10^{-8}\ \text{W m}^{-2}\text{K}^{-4}$
Wien constant	W	$= 2{\cdot}90 \times 10^{-3}\ \text{m K}$
Hubble constant	H_0	$= 2{\cdot}20 \times 10^{-18}\ \text{s}^{-1}$

$T/\text{K} = \theta/°\text{C} + 273{\cdot}15$

1 parsec $= 3.09 \times 10^{16}$ m

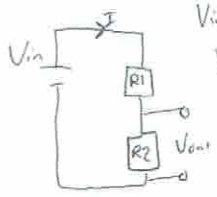
1 u $= 1{\cdot}66 \times 10^{-27}$ kg $\quad \simeq 931\ \text{MeV} = 931\ \text{MeV}/c^2$

1 eV $= 1{\cdot}60 \times 10^{-19}$ J

$\frac{1}{4\pi\varepsilon_0} \approx 9.0 \times 10^9\ \text{F}^{-1}\text{m}$

$\%\Delta = \frac{\text{absolute uncertainty}}{\text{value}} \times 100$

absolute uncertainty = range/2 or resolution (whichever is bigger)



$V_{in} = IR_1 + IR_2$

$V_{out} = IR_2$

$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1+R_2}$

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M = molar
M_r = mass of
m = mass of pa
N = no. particles
k = Boltzmen constant
n = no. moles R = molar Gas Constant

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Component 1

$\rho = \frac{m}{V}$	$T = 2\pi\sqrt{\frac{l}{g}}$
$v = u + at$	$pV = nRT$ and $pV = NkT$
$x = \frac{1}{2}(u+v)t$	$p = \frac{1}{3}\rho c^2 = \frac{1}{3}\frac{N}{V}mc^2$
$x = ut + \frac{1}{2}at^2$ or $vt - \frac{1}{2}at^2$	$M / \text{kg} = \frac{M_r}{1000}$
$v^2 = u^2 + 2ax$	$n = \frac{\text{total mass}}{\text{molar mass}}$
$\Sigma F = ma$	$k = \frac{R}{N_A}$
$p = mv$	$U = \frac{3}{2}nRT = \frac{3}{2}NkT$
$W = Fx\cos\theta$	$W = p\Delta V$
$\Delta E = mg\Delta h$	$\Delta U = Q - W$ = heat added to − work done by
$E = \frac{1}{2}kx^2$ = $\frac{1}{2}Fx$	$Q = mc\Delta\theta$
$E = \frac{1}{2}mv^2$	$I = \frac{\Delta Q}{\Delta t}$
$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$	$I = nAve$
$P = \frac{W}{t} = \frac{\Delta E}{t}$	$R = \frac{V}{I}$ $E = VQ$
$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$	$P = IV = I^2R = \frac{V^2}{R}$
$\omega = \frac{\theta}{t}$	$R = \frac{\rho l}{A}$
$v = \omega r$ = $\frac{2\pi r}{T}$	$V = E - Ir$
$a = \omega^2 r$ = $\frac{v^2}{r}$	$\frac{V}{V_{\text{total}}}\left[\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}}\right] = \frac{R}{R_{\text{total}}}$
$a = \frac{v^2}{r}$	$C = \frac{Q}{V}$
$F = \frac{mv^2}{r}$	$C = \frac{\varepsilon_0 A}{d}$
$F = m\omega^2 r$	$E = \frac{V}{d}$
$a = -\omega^2 x$	$U = \frac{1}{2}QV$ = $\frac{1}{2}CV^2$
$x = A\cos(\omega t + \varepsilon)$	$Q = Q_0\left(1 - e^{-\frac{t}{RC}}\right)$ CHARGING
$T = \frac{2\pi}{\omega}$	$Q = Q_0 e^{-\frac{t}{RC}}$ DISCHARGING
$v = -A\omega\sin(\omega t + \varepsilon)$ $a = -A\omega^2\cos(\omega t + \varepsilon)$	$F = kx$
$T = 2\pi\sqrt{\frac{m}{k}}$ $\left(\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{g}{l}}\right)$	$\sigma = \frac{F}{A}$

$\langle KE \rangle = \frac{3}{2}k$

$W = \Delta E$

$I = Ft = \Delta P$

$L = \theta r$

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

$\omega = 2\pi f$

Component 2

In series

$V_{R_1} = \left(\frac{R_1}{R_1+R_2}\right)V$

$V_{C_1} = \left(\frac{C_2}{C_1+C_2}\right)V$

$1\text{ rad} = \frac{180^\circ}{\pi}$

potential E = U = $\frac{1}{2}kx^2$

KE = KE = $\frac{1}{2}mv^2$

Total = E = KE + U = $\frac{1}{2}kA^2$ = $\frac{1}{2}mv_{max}^2$ = $\frac{1}{2}mA^2\omega^2$

(63% different from original)

τ = time to fall by factor of e

$\tau = RC$ (capacitor)

$\frac{W}{V} = \frac{1}{2}\sigma\varepsilon$ = area under $\sigma - \varepsilon$

$\varepsilon = \frac{\Delta l}{l}$	$n = \frac{c}{v}$
$E = \frac{\sigma}{\varepsilon} = \frac{FL_0}{\Delta L A} \Rightarrow F = \left(\frac{EA}{L_0}\right)\Delta L \Rightarrow k = \frac{EA}{L_0}$	$n_1 v_1 = n_2 v_2$
$W = \frac{1}{2}Fx = \frac{1}{2}kx^2$ (area under $F - x$)	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}$	$n_1 \sin\theta_C = n_2$
$F = G\frac{M_1 M_2}{r^2}$	$E_{k\max} = hf - \phi$ $\quad E_{phot} = hf = \frac{hc}{\lambda}$ $\quad E_{k\max} = eV_{stop}$
$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$	$p = \frac{h}{\lambda}$ $\quad hf_{threshold} = \phi$
$g = \frac{GM}{r^2}$	$A = \lambda N$ (decay constant × no. nuclei = activity)
$V_E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$	$N = N_0 e^{-\lambda t}$
$PE = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r}$	$A = A_0 e^{-\lambda t}$
$V_g = -\frac{GM}{r}$	$N = \frac{N_0}{2^x}$
$PE = -\frac{GM_1 M_2}{r}$	$A = \frac{A_0}{2^x}$
$W = q\Delta V_E$	$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$ $\quad \lambda = \frac{\ln K}{T_{1/K}}$ $\quad T_{\frac{1}{K}}$ = time taken to fall by a factor of K
$W = m\Delta V_g$	
$\lambda_{\max} = \frac{W}{T}$	
$P = A\sigma T^4$	
$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} = \frac{\Delta f}{f}$	
$v = H_0 D$ Universe age $= \frac{1}{H_0}$	
$\rho_c = \frac{3H_0^2}{8\pi G}$	$E = mc^2$
$r_1 = \frac{M_2}{M_1 + M_2}d$	$F = BIl\sin\theta$ (current carrying conductor)
$T = 2\pi\sqrt{\frac{d^3}{G(M_1 + M_2)}}$	$F = Bqv\sin\theta$ (moving charge)
$T = \frac{1}{f}$	$B = \frac{\mu_0 I}{2\pi a}$ $\quad V_H = \frac{BI}{qnb}$
$c = f\lambda$	$B = \mu_0 nI$ (at solenoid centre)
$\lambda = \frac{a\Delta y}{D}$	$\Phi = AB\cos\theta$
$d\sin\theta = n\lambda$	flux linkage $N\Phi$

	leptons		quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)	up (u)	down (d)
charge (e)	-1	0	$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1	0	0

number of photons per second

$I = \frac{Nhf}{4\pi r^2}$

Photon Pressure = $\frac{\text{Intensity}}{c}$

$\lambda = \frac{1}{\tau}$

$-$ = decay, $+$ = growth

$X_t = X_0 e^{\pm\lambda t}$

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= original $\times \frac{1}{K}$

$I = \frac{L}{4\pi r^2}$

Kepler's Laws
I: ellipse ...
II: area swept ...
III: $T^2 \propto r^3$

Component 3

Constructive interference $= |d_2 - d_1| = n\lambda$

destructive $= \ldots = (n + \frac{1}{2})\lambda$

$V_E = BLv$

$V_E = -\frac{\Delta(N\phi)}{\Delta t}$ (often $= \frac{\Delta\phi}{\Delta t}$)

$V_E = \omega NBA\sin(\omega t + \ldots)$ (for AC generator)

OPTION A

flux linkage = $BAN\cos\omega t$	$X_L = \omega L$
$V = \omega BAN\sin\omega t$	$X_C = \dfrac{1}{\omega C}$
$I_{rms} = \dfrac{I_0}{\sqrt{2}}$	$Z = \sqrt{X^2 + R^2}$
$V_{rms} = \dfrac{V_0}{\sqrt{2}}$	$Q = \dfrac{V_L}{V_R}\left(= \dfrac{V_c}{V_R}\right)$
$V_{rms} = \dfrac{\omega BAN}{\sqrt{2}}$	$Q = \dfrac{\omega_0 L}{R}$

OPTION B

$I = I_0\ e^{-\mu x}$	$f = 42.6\times10^6 B$
$Z = c\rho$	$H = DW_R$
$\dfrac{\Delta f}{f_0} = \dfrac{2v}{c}\cos\theta$	$E = HW_T$

OPTION C

$Ft = mv - mu$	$\tau = I\alpha$
$e = \dfrac{\text{Relative speed after collision}}{\text{Relative speed before collision}}$	$L = I\omega$
$e = \sqrt{\dfrac{h}{H}}$	$KE = \frac{1}{2}I\omega^2$
$I = \frac{2}{5}mr^2$	$p = p_0 - \frac{1}{2}\rho v^2$
$I = \frac{2}{3}mr^2$	$F_D = \frac{1}{2}\rho v^2 AC_D$
$\alpha = \dfrac{\omega_2 - \omega_1}{t}$	

OPTION D

$I = \dfrac{P}{A} = \dfrac{P}{4\pi r^2}$	$\dfrac{\Delta Q}{\Delta t} = -AK\dfrac{\Delta\theta}{\Delta x}$
$E = \frac{1}{2}A\rho v^3$	$P = UA\Delta\theta \quad \Rightarrow U = \dfrac{K}{\Delta x}$

equal

This is Power

$P = \dfrac{\Delta Q}{\Delta t}$

$\dfrac{1}{U_T} = \dfrac{1}{U_1} + \dfrac{1}{U_2} \cdots$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

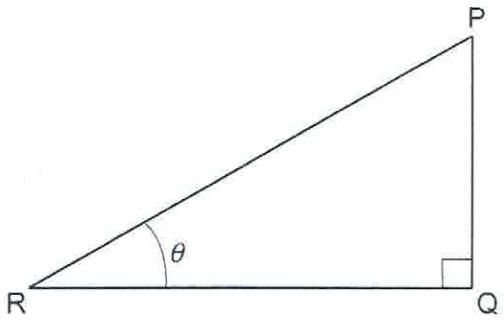
Areas and Volumes

Area of a circle = $\pi r^2 = \frac{\pi d^2}{4}$

Area of a triangle = $\frac{1}{2}$ base × height

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{QR}{PR}, \quad \tan\theta = \frac{PQ}{QR}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. ln) or $\log_{10}$.]

$\log(ab) = \log a + \log b$ $\qquad$ $\log\left(\frac{a}{b}\right) = \log a - \log b$

$\log x^n = n \log x$ $\qquad$ $\log_e e^{kx} = \ln e^{kx} = kx$

$\log_e 2 = \ln 2 = 0{\cdot}693$