SQA Databook for HN Physics

For use in Higher National Courses

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Relationships for Physics 1

$$v=\frac{s}{t}$$

$$v=f\lambda$$

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

$$\sin\theta_c=\frac{1}{n}$$

$$n=\frac{\sin\theta_1}{\sin\theta_2}=\frac{\lambda_1}{\lambda_2}=\frac{v_1}{v_2}$$

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

$$A=\frac{N}{t}$$

$$D=\frac{E}{m}$$

$$H=Dw_r$$

$$\dot{H}=\frac{H}{t}$$

$$V=IR$$

$$\sum E=\sum IR$$

$$R_T=R_1+R_2+.....$$

$$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+.....$$

$$\frac{R_1}{R_2}=\frac{R_3}{R_4}$$

$$V_1=\frac{R_1}{(R_1=R_2)}\times V_S$$

$$P=\frac{E}{t}$$

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

$$\frac{N_s}{N_p}=\frac{V_s}{V_p}=\frac{I_p}{I_s}$$

$$\text{Cost}=\text{unit cost}\left(\sum \text{Pt}\right)$$

$$\text{Random uncertainties}=\frac{\text{max value}-\text{min value}}{\text{number of values}}$$

Relationships for Physics 2

$$v=\frac{s}{t}$$

$$v=f\lambda$$

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

$$n\lambda=path\ difference$$

$$(n+1/2)\lambda=path\ difference$$

$$d\sin\theta=n\lambda$$

$$n=\frac{\sin\theta_1}{\sin\theta_2}$$

$$E=hf$$

$$E=hf-hf_o$$

$$hf=E_1-E_2$$

$$I=Nhf=N_Ahf$$

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

$$P=\frac{F}{A}$$

$$P=\rho gh$$

$$E_w=Fd$$

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

$$E_p=mgh$$

$$\rho_1 A_1 v_1=\rho_2 A_2 v_2$$

$$P+\rho gh+\frac{1}{2}\rho v^2=\text{constant}$$

$$Q=A\text{v}$$

$$T_{mix}=\frac{(T_1m_1+T_2m_2)}{(m_1+m_2)}$$

$$PV=nRT$$

$$PV=N_Ak_aT$$

$$Q=kA\left(\frac{\Delta T}{x}\right)$$

$$E_h=cm\Delta T$$

$$E_h=l_Vm\quad E_h=l_fm$$

$$H=Ae\sigma T^4$$

$$v=\frac{s}{t}$$

$$v=f\lambda$$

$$\lambda=\frac{c}{f}$$

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

$$n\lambda=path\ difference$$

$$(n+1/2)\lambda=path\ difference$$

$$d\sin\theta=n\lambda$$

$$n=\frac{\sin\theta_1}{\sin\theta_2}=\frac{\lambda_1}{\lambda_2}=\frac{v_1}{v_2}$$

$$\sin\theta_c=\frac{1}{n}$$

$$n\lambda=n_o+\frac{A}{\lambda^2}\left(\frac{B}{\lambda^2}+.....\right)$$

$$E=hf$$

$$E=hf-hf_o$$

$$hf=E_1-E_2$$

$$I=Nhf$$

$$w_2-w_1=hf$$

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

$$y=A\sin(k\theta-wt)$$

$$V_d=\frac{n_d-1}{n_f-n_c}$$

$$V=\frac{I_{\max}-I_{\min}}{I_{\max}+I_{\min}}\times 100$$

$$\tan\theta=\frac{y}{D}$$

$$\tan\theta=\frac{n_b}{n_a}$$

$$E_p=\int_{aperture}\cos(kr-\alpha x)\,dA$$

Electricity

$$V = IR$$

$$\sum E = \sum IR$$

$$R_T = R_1 + R_2 + ...$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + ...$$

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$V_1 = \frac{R_1}{(R_1 = R_2)} \times V_S$$

$$P = \frac{E}{t}$$

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

$$E = \frac{F}{Q}$$

$$g = \frac{f}{m}$$

$$F = \frac{1}{4\pi\varepsilon}\left(\frac{Q_1 Q_2}{r^2}\right)$$

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

$$E_w = qV$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$F = Il B \sin\theta$$

$$X_c = \frac{V}{I}$$

$$X = \frac{1}{2\pi f C}$$

$$\varepsilon = -L\frac{dI}{dt}$$

$$E = \frac{1}{2}LI^2$$

$$E = \frac{1}{2}QV = \frac{1}{2}CV^2$$

$$X_L = \frac{V}{I}$$

$$X_L = 2\pi f L$$

Radiation

$$A = \frac{N}{t}$$

$$D = \frac{E}{m}$$

$$H = Dw_r$$

$$\dot{H} = \frac{H}{t}$$

$$N(n) = NAe^{\frac{-En}{kT}}$$

Gas & Heat

$$T_{mix} = \frac{(T_1 m_1 + T_2 m_2)}{(m_1 + m_2)}$$

$$PV = nRT$$

$$PV = Nk_a T$$

$$E_h = cm\Delta T$$

$$E_h = l_V m \quad E_h = l_f m$$

$$\Delta l = \alpha l_1 (T_2 - T_1)$$

$$I = \sigma T^4$$

$$\lambda_{\max} = \frac{2.8978 \times 10^{-3}}{T}$$

Mechanics

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

$$a=\frac{(v-u)}{t}$$

$$F=ma$$

$$W=mg$$

$$\omega=\frac{\theta}{t}$$

$$\alpha=\frac{(\omega_2-\omega_1)}{t}$$

$$s=r\theta$$

$$v=r\alpha$$

$$a=r\alpha$$

$$I=md^2$$

$$I=Mk^2$$

$$IT=I\alpha=Mk^2\alpha$$

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

$$p=\frac{F}{A}$$

$$p=\rho gh$$

$$E_w=Fd$$

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

$$E_p=mgh$$

$$\rho_1 A_1 v_1=\rho_2 A_2 v_2$$

$$P+\rho gh+\frac{1}{2}\rho v^2=\text{constant}$$

$$\gamma=\frac{f}{d}$$

$$v=\frac{\pi\rho r^4}{8\eta l}$$

$$\sigma=\frac{F}{A}$$

$$\varepsilon=\frac{\Delta l}{l_o}$$

$$E=\frac{Fl}{Ae}$$

Quantum Mechanics

$$\Delta t = \frac{\Delta t_o}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$l = l_0\sqrt{1-\frac{v^2}{c^2}}$$

$$x' = \frac{x-ut}{\sqrt{1-\frac{u^2}{c^2}}}$$

$$y' = y; \quad z' = z$$

$$t' = \frac{t-\frac{ux}{c^2}}{\sqrt{1-\frac{u^2}{c^2}}}$$

$$v' = \frac{v_x - u}{\sqrt{1-\frac{uv_x}{c^2}}}$$

$$v_x = \frac{v'x+u}{1+\frac{uv'_x}{c^2}}$$

$$f = \sqrt{\frac{c+u}{c-u}}\, f_o$$

$$f = \sqrt{\frac{c-u}{c+u}}\, f_o$$

$$\vec{p} = \frac{m\vec{v}}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$K = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} - mc^2$$

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

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

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

$$\Delta x \Delta p_x \geq \frac{\hbar}{2}$$ (Position and momentum)

$$\Delta t \Delta E \geq \frac{\hbar}{2}$$ (energy and time)

$$\hbar = \frac{h}{2\pi}$$

$$-\frac{\hbar^2}{2m}\frac{d^2\Psi(x)}{dx^2} + U(x)\psi(x,t) = i\hbar\frac{\delta\Psi(x,t)}{\delta t}$$

$$\Psi(x,t) = \Psi(x)e^{\frac{-iEt}{h}}$$

$$-\frac{h^2}{2m}\frac{d^2\Psi(x)}{dx^2} + U(x)\Psi(x) = E\Psi(x)$$

$$E_n = \frac{P_n^2}{2m} = \frac{n^2h^2}{8mL^2} = \frac{n^2\pi^2\hbar^2}{2mL^2} \quad (n = 1, 2, 3\ldots)$$

$$\Psi_n(x) = \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi x}{L}\right) \quad (n = 1, 2, 3, \ldots)$$

$$E = K + mc^2 = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$E^2 = \left(mc^2\right)^2 + \left(pc\right)^2$$

$$E = mc^2$$

$$\int_{-\infty}^{\infty} \left|\Psi(x)^2\right| dx = 1$$

$$T = Ge^{-2kL}$$

Fundamental Physics Constants

Name	*Symbol*	*Value*
Gravitational constant	G	$6{\cdot}67408 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$
Mass of the earth	M_E	$5{\cdot}972 \times 10^{24}\ kg$
Radius of the earth	r_E	$6{,}371 \times 10^{3}\ m$
Planck's constant	*h*	$6{\cdot}63 \times 10^{-34}\ J\ s$
Boltzmann's constant	*k*	$1{\cdot}38066 \times 10^{-23}\ J\ K^{-1}$
Stefan — Boltzmann constant	σ	$5{\cdot}67 \times 10^{-8}\ W\ m^{-2}\ K^{-4}$
Wien's constant	-	$2{\cdot}90 \times 10^{-3}\ m\ K$
Avogadro's number	N_A	$6{\cdot}022 \times 10^{23}$
Gas constant	R	$8{\cdot}314510\ J\ mol^{-1}\ K^{-1}$
Monatomic Adiabatic index	-	1·67
Mass of electron	m_e	$9{\cdot}10939 \times 10^{-31}\ kg$
Mass of neutron	m_n	$1{\cdot}67493 \times 10^{-27}\ kg$
Mass of proton	M_p	$1{\cdot}67262 \times 10^{-27}\ kg$
Electron volt	eV	$1{\cdot}603 \times 10^{-19}\ J$
Permittivity of free space	ε_o	$8{\cdot}854 \times 10^{-12}\ C^2\ N\ m^{-2}$
	$1/4\pi\epsilon_o$	$8{\cdot}987 \times 10^{9}\ N\ m^2\ C^{-2}$
Permeability of free space	μ_o	$4\pi \times 10^{-7}\ N\ A^{-2}$

DATA SHEET

Standard Pressure and Temperature

Quantity	*Symbol*	*Value*
Standard temperature	T	273 K
Standard pressure	P	$1{\cdot}013 \times 10^5$ Pa
Molar volume of an ideal gas	-	$\frac{V}{n} = 0{\cdot}0224\ m^3\ mol^{-1}$

Common Physical Quantities

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Speed of light in vacuum	c	$3{\cdot}00 \times 10^8\ m\ s^{-1}$	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}$ kg
Magnitude of the charge on an electron	e	$1{\cdot}60 \times 10^{-19}$ C	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}$ kg
Gravitational acceleration on Earth	g	$9{\cdot}81\ m\ s^{-2}$	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}$ kg
Planck's constant	h	$6{\cdot}63 \times 10^{-34}$ J s			

Refractive Indices

The refractive indices refers to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive Index*	*Substance*	*Refractive Index*
Diamond	2·42	Water	1·33
Crown glass	1·50	Air	1·00

Spectra Lines

Element	*Wavelength* nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength* nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers

Element	*Wavelength* nm	*Colour*
Carbon dioxide	9550	Infrared
	10590	Infrared
Helium-neon	633	Red

Properties Of Selected Materials

Substance	*Density* $kg\,m^{-3}$	*Melting point* K	*Boiling point* K
Aluminium	$2{\cdot}70 \times 10^3$	933	2623
Copper	$8{\cdot}96 \times 10^3$	1357	2853
Ice	$9{\cdot}20 \times 10^2$	273	
Sea Water	$1{\cdot}02 \times 10^3$	264	377
Water	$1{\cdot}00 \times 10^3$	273	373
Air	1·29		
Hydrogen	$9{\cdot}00 \times 10^{-2}$	14	20

The gas densities refer to a temperature of 273 K and a pressure of $1{\cdot}01 \times 10^5$ Pa

Additional Relationships

Circle

$\text{circumference} = 2\pi r$

$\text{area} = \pi r^2$

Sphere

$\text{area} = 4\pi r^2$

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

Trigonometry

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

$\sin^2\theta + \cos^2\theta = 1$

Moment of inertia

point mass

$I = mr^2$

rod about centre

$I = \frac{1}{12}ml^2$

rod about end

$I = \frac{1}{3}ml^2$

disc about centre

$I = \frac{1}{2}mr^2$

sphere about centre

$I = \frac{2}{5}mr^2$

Table of standard derivatives

$f(x)$	$f'(x)$
$\sin ax$	$a\cos ax$
$\cos ax$	$-a\sin ax$

Table of standard integrals

$f(x)$	$\int f(x)dx$
$\sin ax$	$-\frac{1}{a}\cos ax + C$
$\cos ax$	$\frac{1}{a}\sin ax + C$

Electron Arrangements of Elements

Key

Atomic number
Symbol
Electron arrangement
Name

Group 1 (1)	Group 2 (2)	Transition Elements (3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Group 3 (13)	Group 4 (14)	Group 5 (15)	Group 6 (16)	Group 7 (17)	Group 0 (18)
1 **H** 1 Hydrogen																	2 **He** 2 Helium
3 **Li** 2,1 Lithium	4 **Be** 2,2 Beryllium											5 **B** 2,3 Boron	6 **C** 2,4 Carbon	7 **N** 2,5 Nitrogen	8 **O** 2,6 Oxygen	9 **F** 2,7 Fluorine	10 **Ne** 2,8 Neon
11 **Na** 2,8,1 Sodium	12 **Mg** 2,8,2 Magnesium											13 **Al** 2,8,3 Aluminium	14 **Si** 2,8,4 Silicon	15 **P** 2,8,5 Phosphorus	16 **S** 2,8,6 Sulfur	17 **Cl** 2,8,7 Chlorine	18 **Ar** 2,8,8 Argon
19 **K** 2,8,8,1 Potassium	20 **Ca** 2,8,8,2 Calcium	21 **Sc** 2,8,9,2 Scandium	22 **Ti** 2,8,10,2 Titanium	23 **V** 2,8,11,2 Vanadium	24 **Cr** 2,8,13,1 Chromium	25 **Mn** 2,8,13,2 Manganese	26 **Fe** 2,8,14,2 Iron	27 **Co** 2,8,15,2 Cobalt	28 **Ni** 2,8,16,2 Nickel	29 **Cu** 2,8,18,1 Copper	30 **Zn** 2,8,18,2 Zinc	31 **Ga** 2,8,18,3 Gallium	32 **Ge** 2,8,18,4 Germanium	33 **As** 2,8,18,5 Arsenic	34 **Se** 2,8,18,6 Selenium	35 **Br** 2,8,18,7 Bromine	36 **Kr** 2,8,18,8 Krypton
37 **Rb** 2,8,18,8,1 Rubidium	38 **Sr** 2,8,18,8,2 Strontium	39 **Y** 2,8,18,9,2 Yttrium	40 **Zr** 2,8,18,10,2 Zirconium	41 **Nb** 2,8,18,12,1 Niobium	42 **Mo** 2,8,18,13,1 Molybdenum	43 **Tc** 2,8,18,13,2 Technetium	44 **Ru** 2,8,18,15,1 Ruthenium	45 **Rh** 2,8,18,16,1 Rhodium	46 **Pd** 2,8,18,18,0 Palladium	47 **Ag** 2,8,18,18,1 Silver	48 **Cd** 2,8,18,18,2 Cadmium	49 **In** 2,8,18,18,3 Indium	50 **Sn** 2,8,18,18,4 Tin	51 **Sb** 2,8,18,18,5 Antimony	52 **Te** 2,8,18,18,6 Tellurium	53 **I** 2,8,18,18,7 Iodine	54 **Xe** 2,8,18,18,8 Xenon
55 **Cs** 2,8,18,18,8,1 Caesium	56 **Ba** 2,8,18,18,8,2 Barium	57 **La** 2,8,18,18,9,2 Lanthanum	72 **Hf** 2,8,18,32,10,2 Hafnium	73 **Ta** 2,8,18,32,11,2 Tantalum	74 **W** 2,8,18,32,12,2 Tungsten	75 **Re** 2,8,18,32,13,2 Rhenium	76 **Os** 2,8,18,32,14,2 Osmium	77 **Ir** 2,8,18,32,15,2 Iridium	78 **Pt** 2,8,18,32,17,1 Platinum	79 **Au** 2,8,18,32,18,1 Gold	80 **Hg** 2,8,18,32,18,2 Mercury	81 **Tl** 2,8,18,32,18,3 Thallium	82 **Pb** 2,8,18,32,18,4 Lead	83 **Bi** 2,8,18,32,18,5 Bismuth	84 **Po** 2,8,18,32,18,6 Polonium	85 **At** 2,8,18,32,18,7 Astatine	86 **Rn** 2,8,18,32,18,8 Radon
87 **Fr** 2,8,18,32,18,8,1 Francium	88 **Ra** 2,8,18,32,18,8,2 Radium	89 **Ac** 2,8,18,32,18,9,2 Actinium	104 **Rf** 2,8,18,32,32,10,2 Rutherfordium	105 **Db** 2,8,18,32,32,11,2 Dubnium	106 **Sg** 2,8,18,32,32,12,2 Seaborgium	107 **Bh** 2,8,18,32,32,13,2 Bohrium	108 **Hs** 2,8,18,32,32,14,2 Hassium	109 **Mt** 2,8,18,32,32,15,2 Meitnerium	110 **Ds** 2,8,18,32,32,17,1 Darmstadtium	111 **Rg** 2,8,18,32,32,18,1 Roentgenium	112 **Cn** 2,8,18,32,32,18,2 Copernicium						

Lanthanides	57 **La** 2,8,18,18,9,2 Lanthanum	58 **Ce** 2,8,18,20,8,2 Cerium	59 **Pr** 2,8,18,21,8,2 Praseodymium	60 **Nd** 2,8,18,22,8,2 Neodymium	61 **Pm** 2,8,18,23,8,2 Promethium	62 **Sm** 2,8,18,24,8,2 Samarium	63 **Eu** 2,8,18,25,8,2 Europium	64 **Gd** 2,8,18,25,9,2 Gadolinium	65 **Tb** 2,8,18,27,8,2 Terbium	66 **Dy** 2,8,18,28,8,2 Dysprosium	67 **Ho** 2,8,18,29,8,2 Holmium	68 **Er** 2,8,18,30,8,2 Erbium	69 **Tm** 2,8,18,31,8,2 Thulium	70 **Yb** 2,8,18,32,8,2 Ytterbium	71 **Lu** 2,8,18,32,9,2 Lutetium
Actinides	89 **Ac** 2,8,18,32,18,9,2 Actinium	90 **Th** 2,8,18,32,18,10,2 Thorium	91 **Pa** 2,8,18,32,20,9,2 Protactinium	92 **U** 2,8,18,32,21,9,2 Uranium	93 **Np** 2,8,18,32,22,9,2 Neptunium	94 **Pu** 2,8,18,32,24,8,2 Plutonium	95 **Am** 2,8,18,32,25,8,2 Americium	96 **Cm** 2,8,18,32,25,9,2 Curium	97 **Bk** 2,8,18,32,27,8,2 Berkelium	98 **Cf** 2,8,18,32,28,8,2 Californium	99 **Es** 2,8,18,32,29,8,2 Einsteinium	100 **Fm** 2,8,18,32,30,8,2 Fermium	101 **Md** 2,8,18,32,31,8,2 Mendelevium	102 **No** 2,8,18,32,32,8,2 Nobelium	103 **Lr** 2,8,18,32,32,9,2 Lawrencium