

STUDY EDITION

PHYSICS DATA BOOKLET

The physics reference tables, annotated page for page: the constants, the conversions, the circuit symbols and every equation, on the page you already know.



Course
Physics, standard level and higher level

First examination
2025

Themes
A Space, time and motion · B The particulate nature of matter · C Wave behaviour · D Fields · E Nuclear and quantum physics

How to use it
Every table, section label and page break sits where the original puts it, so the page you revise from here is the page you turn to there.

Printing
A4, scale 100%, background graphics on. One sheet prints as one page, 17 in all.

Annotated study edition — always sit the exam with the official booklet your school issues.

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INDEX CONTENTS

—	Introduction	PROSE	1
—	Mathematical equations	1 PAGE	2
—	Uncertainties • Fundamental constants	1 PAGE	3
—	Metric (SI) multipliers • Unit conversions	1 PAGE	4
—	Electrical circuit symbols • Electromagnetic spectrum	1 PAGE	5
A	Space, time and motion	2 PAGES	6–7
B	The particulate nature of matter	2 PAGES	8–9
C	Wave behaviour	2 PAGES	10–11
D	Fields	2 PAGES	12–13
E	Nuclear and quantum physics	PAGE 13	13

Reading the tables. The left column carries the section label the course uses — A.1, B.4, E.2 and so on. The middle column names the section. The right column holds its equations, one to a line.

Magnitudes only. Every equation in this booklet relates the magnitudes of the quantities involved. No vector notation is used anywhere, so $F = ma$ is a statement about sizes, not directions.

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1 INTRODUCTION

This booklet collects the reference material a Physics course keeps coming back to: the electrical circuit symbols, the mathematics the course expects you to apply, the physical constants and unit conversions, and the equations that belong to each theme and topic.

Keep it open while you work rather than reaching for it only in an examination. The course guide points at these same equations from the “Understandings” sections, which keeps the emphasis where it belongs: on reading a situation and choosing the right relationship, instead of memorising symbols, constants and formulas.

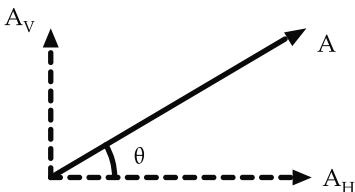
The content is in two parts. The first part is used throughout the course — symbols, mathematics, constants and conversions. The second part gathers the equations for the individual themes and topics. Throughout, every equation is written for the magnitude of the quantity only; vector notation is not used.

In an examination you must have a clean copy of the official booklet. Schools obtain it and make sure that every student has one. Use this page-for-page re-creation to rehearse, and the official copy on the day.

Where the sections sit. Pages 2 to 5 hold the mathematics, the constants and conversions, and the symbols and spectrum. Pages 6 to 13 then run through themes A to E, each section marked standard level and higher level or additional higher level.

Standard level and higher level. Sections marked *additional higher level* are examined at HL only. They sit in their own block below the shared material, exactly as they do in the printed booklet.

2 MATHEMATICAL EQUATIONS

Area of a triangle	$A = \frac{1}{2}(bh)$ where b is the base, h is the height
Area of a circle	$A = \pi r^2$ where r is the radius
Circumference of a circle	$C = 2\pi r$
Volume of a cuboid	$V = lwh$ where l is the length, w is the width, h is the height
Volume of a cylinder	$V = \pi r^2 h$
Volume of a prism	$V = Ah$ where A is the area of cross-section
Volume of a sphere	$V = \frac{4}{3}\pi r^3$
Area of the curved surface of a cylinder	$A = 2\pi rh$
Vectors	 $A_H = A \cos \theta$ $A_V = A \sin \theta$
Trigonometric relationships	$\tan \theta = \frac{\sin \theta}{\cos \theta}$ $\sin^2 \theta + \cos^2 \theta = 1$

3 UNCERTAINTIES

If: $y = a \pm b$	then: $\Delta y = \Delta a + \Delta b$
If: $y = \frac{ab}{c}$	then: $\frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$
If: $y = a^n$	then: $\frac{\Delta y}{y} = \left n \frac{\Delta a}{a} \right $

3 FUNDAMENTAL CONSTANTS

QUANTITY	SYMBOL	APPROXIMATE VALUE
Acceleration of free fall	g	9.8 m s^{-2} (Earth's surface)
Gravitational constant	G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Avogadro constant	N_A	$6.02 \times 10^{23} \text{ mol}^{-1}$
Gas constant	R	$8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	k_B	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Stefan-Boltzmann constant	σ	$5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Coulomb constant	k	$8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$
Permittivity of free space	ϵ_0	$8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
Permeability of free space	μ_0	$4\pi \times 10^{-7} \text{ T m A}^{-1}$
Speed of light in vacuum	c	$3.00 \times 10^8 \text{ m s}^{-1}$
Planck constant	h	$6.63 \times 10^{-34} \text{ J s}$
Elementary charge	e	$1.60 \times 10^{-19} \text{ C}$
Electron rest mass	m_e	$9.110 \times 10^{-31} \text{ kg} = 0.000549 \text{ u} = 0.511 \text{ MeV c}^{-2}$
Proton rest mass	m_p	$1.673 \times 10^{-27} \text{ kg} = 1.007276 \text{ u} = 938 \text{ MeV c}^{-2}$
Neutron rest mass	m_n	$1.675 \times 10^{-27} \text{ kg} = 1.008665 \text{ u} = 940 \text{ MeV c}^{-2}$
(Unified) atomic mass unit	u	$1.661 \times 10^{-27} \text{ kg} = 931.5 \text{ MeV c}^{-2}$
Solar constant	S	$1.36 \times 10^3 \text{ W m}^{-2}$
Fermi radius	R_0	$1.20 \times 10^{-15} \text{ m}$

4 METRIC (SI) MULTIPLIERS

PREFIX	ABBREVIATION	VALUE
peta	P	10 ¹⁵
tera	T	10 ¹²
giga	G	10 ⁹
mega	M	10 ⁶
kilo	k	10 ³
hecto	h	10 ²
deca	da	10 ¹
deci	d	10 ⁻¹
centi	c	10 ⁻²
milli	m	10 ⁻³
micro	μ	10 ⁻⁶
nano	n	10 ⁻⁹
pico	p	10 ⁻¹²
femto	f	10 ⁻¹⁵

4 UNIT CONVERSIONS

	Angle	1 radian (rad) = $\frac{180^\circ}{\pi}$
	Temperature	temperature (K) = temperature (°C) + 273
	Distance	1 light year (ly) = 9.46×10^{15} m
	Distance	1 parsec (pc) = 3.26 ly
	Distance	1 astronomical unit (AU) = 1.50×10^{11} m
	Energy	1 kilowatt-hour (kWh) = 3.60×10^6 J
	Photon energy × wavelength	$hc = 1.99 \times 10^{-25}$ J m = 1.24×10^{-6} eV m

5 ELECTRICAL CIRCUIT SYMBOLS



Cell



Battery



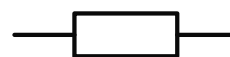
Switch



Voltmeter



Ammeter



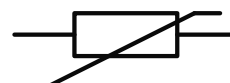
Resistor



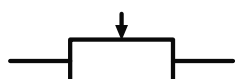
Variable resistor



Light-dependent resistor (LDR)



Thermistor



Potentiometer



Lamp



Light emitting diode (LED)



Heating element

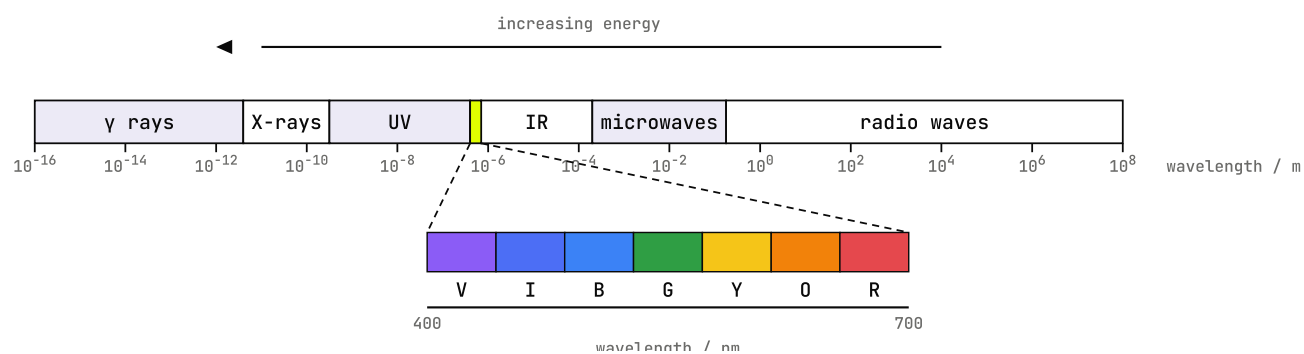


Motor



Earth (ground)

5 ELECTROMAGNETIC SPECTRUM



A SPACE, TIME AND MOTION

SL • HL STANDARD LEVEL AND HIGHER LEVEL

A.1	Kinematics	$s = \frac{u + v}{2}t$ $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
A.2	Forces and momentum	$F_f \leq \mu_s F_N$ $F_f = \mu_d F_N$ $F_H = -kx$ $F_d = 6\pi\eta rv$ $F_b = \rho Vg$ $F_g = mg$ $p = mv$ $J = F\Delta t$ $F = ma = \frac{\Delta p}{\Delta t}$ $a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$ $v = \frac{2\pi r}{T} = \omega r$
A.3	Work, energy and power	$W = F_s \cos \theta$ $E_k = \frac{1}{2}mv^2 = \frac{p^2}{2m}$ $\Delta E_p = mg\Delta h$ $E_H = \frac{1}{2}k\Delta x^2$ $P = \frac{\Delta W}{\Delta t} = Fv$ $\eta = \frac{\text{useful work out}}{\text{total work in}} = \frac{\text{useful power out}}{\text{total power in}}$

AHL ADDITIONAL HIGHER LEVEL

A.4	Rigid body mechanics	$\tau = Fr \sin \theta$ $\Delta \theta = \frac{\omega_i + \omega_f}{2} t$ $\omega_f = \omega_i + \alpha t$ $\Delta \theta = \omega_i t + \frac{1}{2} \alpha t^2$ $\omega_f^2 = \omega_i^2 + 2\alpha \Delta \theta$ $I = \Sigma mr^2$ $\tau = I\alpha$ $L = I\omega$ $\Delta L = \tau \Delta t$ $\Delta L = \Delta(I\omega)$ $E_k = \frac{1}{2} I \omega^2 = \frac{L^2}{2I}$
A.5	Galilean and special relativity	$x' = x - vt$ $t' = t$ $u' = u - v$ $x' = \gamma \left(x - vt \right) \text{ where } \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$ $t' = \gamma \left(t - \frac{vx}{c^2} \right)$ $u' = \frac{u - v}{1 - \frac{uv}{c^2}}$ $(\Delta s)^2 = (c\Delta t)^2 - \Delta x^2$ $\Delta t = \gamma \Delta t_0$ $L = \frac{L_0}{\gamma}$ $\tan \theta = \frac{v}{c}$

B THE PARTICULATE NATURE OF MATTER

SL • HL STANDARD LEVEL AND HIGHER LEVEL

B.1	Thermal energy transfers	$\rho = \frac{m}{V}$ $E_k = \frac{3}{2}k_B T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta t} = -kA \frac{\Delta T}{\Delta x}$ $L = \sigma AT^4$ $b = \frac{L}{4\pi d^2}$ $\lambda_{\max} T = 2.9 \times 10^{-3} \text{ m K}$
B.2	Greenhouse effect	$\text{emissivity} = \frac{\text{power radiated per unit area}}{\sigma T^4}$ $\text{albedo} = \frac{\text{total scattered power}}{\text{total incident power}}$
B.3	Gas laws	$P = \frac{F}{A}$ $n = \frac{N}{N_A}$ $\frac{PV}{T} = \text{constant}$ $PV = nRT = Nk_B T$ $P = \frac{1}{3}\rho v^2$ $U = \frac{3}{2}nRT = \frac{3}{2}Nk_B T$

B.5

Current and circuits

$$I = \frac{\Delta q}{\Delta t}$$
$$V = \frac{W}{q}$$
$$R = \frac{V}{I}$$
$$\rho = \frac{RA}{L}$$
$$P = IV = I^2 R = \frac{V^2}{R}$$

SERIES CIRCUITS	PARALLEL CIRCUITS
$I = I_1 = I_2 = \dots$	$I = I_1 + I_2 + \dots$
$V = V_1 + V_2 + \dots$	$V = V_1 = V_2 = \dots$
$R_s = R_1 + R_2 + \dots$	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

$$\varepsilon = I(R + r)$$

AHL ADDITIONAL HIGHER LEVEL

B.4	Thermodynamics	$Q = \Delta U + W$ $W = P\Delta V$ $\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}Nk_B\Delta T$ $\Delta S = \frac{\Delta Q}{T}$ $S = k_B \ln \Omega$ $PV^{\frac{5}{3}} = \text{constant}$ $\eta = \frac{\text{useful work}}{\text{input energy}}$ $\eta_{\text{Carnot}} = 1 - \frac{T_c}{T_h}$
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C WAVE BEHAVIOUR

SL • HL STANDARD LEVEL AND HIGHER LEVEL

C.1	Simple harmonic motion	$a = -\omega^2 x$ $T = \frac{1}{f} = \frac{2\pi}{\omega}$ $T = 2\pi\sqrt{\frac{m}{k}}$ $T = 2\pi\sqrt{\frac{l}{g}}$
C.2	Wave model	$v = f\lambda = \frac{\lambda}{T}$
C.3	Wave phenomena	$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$ Constructive interference: path difference = $n\lambda$ Destructive interference: path difference = $\left(n + \frac{1}{2}\right)\lambda$ $s = \frac{\lambda D}{d}$
C.5	Doppler effect	$\frac{\Delta f}{f} = \frac{\Delta \lambda}{\lambda} \approx \frac{v}{c}$

AHL ADDITIONAL HIGHER LEVEL

C.1	Simple harmonic motion	$x = x_0 \sin(\omega t + \varphi)$ $v = \omega x_0 \cos(\omega t + \varphi)$ $v = \pm \omega \sqrt{x_0^2 - x^2}$ $E_T = \frac{1}{2} m \omega^2 x_0^2$ $E_P = \frac{1}{2} m \omega^2 x^2$
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AHL **ADDITIONAL HIGHER LEVEL (CONTINUED)**

C.3	Wave phenomena	$\theta = \frac{\lambda}{b}$ $n\lambda = d\sin\theta$
C.5	Doppler effect	Moving source: $f' = f\left(\frac{v}{v \pm u_s}\right)$ Moving observer: $f' = f\left(\frac{v \pm u_o}{v}\right)$

Why this page is short. Only two higher level sections run past the previous page: the diffraction results of C.3, and the moving source and moving observer forms of the Doppler effect in C.5. Everything else in theme C is already on page 10.

D FIELDS

SL • HL STANDARD LEVEL AND HIGHER LEVEL

D.1	Gravitational fields	$F = G \frac{m_1 m_2}{r^2}$ $g = \frac{F}{m} = G \frac{M}{r^2}$
D.2	Electric and magnetic fields	$F = k \frac{q_1 q_2}{r^2} \text{ where } k = \frac{1}{4\pi\epsilon_0}$ $E = \frac{F}{q}$ $E = \frac{V}{d}$
D.3	Motion in electromagnetic fields	$F = qvB\sin\theta$ $F = BIL\sin\theta$ $\frac{F}{L} = \mu_0 \frac{I_1 I_2}{2\pi r}$

AHL ADDITIONAL HIGHER LEVEL

D.1	Gravitational fields	$E_p = -G \frac{m_1 m_2}{r}$ $V_g = -G \frac{M}{r}$ $g = -\frac{\Delta V_g}{\Delta r}$ $W = m\Delta V_g$ $v_{\text{esc}} = \sqrt{\frac{2GM}{r}}$ $v_{\text{orbital}} = \sqrt{\frac{GM}{r}}$
D.2	Electric and magnetic fields	$E_p = k \frac{q_1 q_2}{r}$ $V_e = \frac{kQ}{r}$ $E = -\frac{\Delta V_e}{\Delta r}$ $W = q\Delta V_e$

D.4	Induction	$\Phi = BA \cos \theta$ $\varepsilon = -N \frac{\Delta \Phi}{\Delta t}$ $\varepsilon = BvL$
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E NUCLEAR AND QUANTUM PHYSICS

SL · HL STANDARD LEVEL AND HIGHER LEVEL

E.1	Structure of the atom	$E = hf$
E.3	Radioactive decay	$E = mc^2$
E.5	Fusion and stars	$d(\text{parsec}) = \frac{1}{p(\text{arc-second})}$

AHL ADDITIONAL HIGHER LEVEL

E.1	Structure of the atom	$R = R_0 A^{\frac{1}{3}}$ $E = -\frac{13.6}{n^2} \text{ eV}$ $mvr = \frac{nh}{2\pi}$
E.2	Quantum physics	$E_{\text{max}} = hf - \Phi$ $\lambda = \frac{h}{p}$ $\lambda_f - \lambda_i = \Delta\lambda = \frac{h}{m_e c} (1 - \cos \theta)$
E.3	Radioactive decay	$N = N_0 e^{-\lambda t}$ $A = \lambda N = \lambda N_0 e^{-\lambda t}$ $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$