RevisionDojo

Physics

Data booklet

SL & HL, first assessment 2025

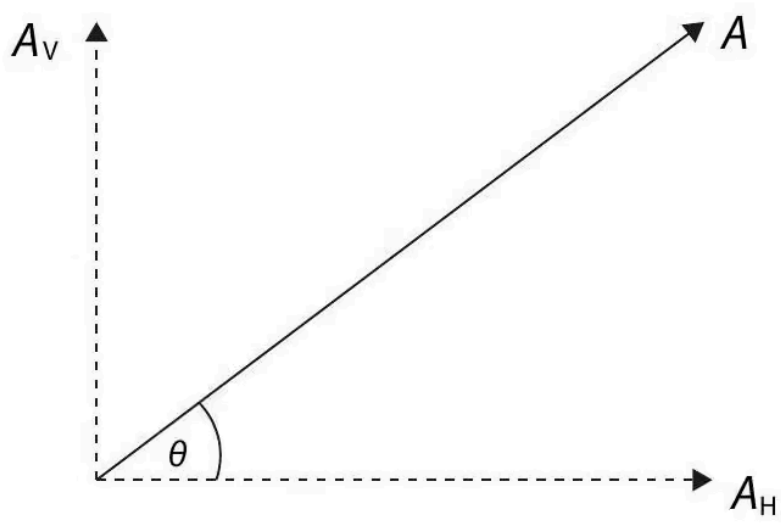
Equations, constants, circuit symbols and the electromagnetic spectrum, grouped by syllabus topic.

Provided in: Papers 1A, 1B and 2

Calculator: Scientific calculator, permitted in Papers 1A, 1B and 2

Contents

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	$A = 2\pi r h$
Vectors	 $A_H = A\cos\theta$ $A_V = A\sin\theta$
Trigonometric relationships	$\tan\theta = \frac{\sin\theta}{\cos\theta}$ $\sin^2\theta + \cos^2\theta = 1$

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: $\frac{\Delta y}{y} = \left\lvert n\frac{\Delta a}{a} \right\rvert$

Fundamental constants

Quantity	Symbol	Approximate value
Acceleration of free fall	g	$9.8\ \mathrm{ms^{-2}}$ (Earth's surface)
Gravitational constant	G	$6.67 \times 10^{-11}\mathrm{Nm^2\ kg^{-2}}$
Avogadro constant	N_A	$6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
Gas constant	R	$8.31\ \mathrm{JK^{-1}\ mol^{-1}}$
Boltzmann constant	k_B	$1.38 \times 10^{-23}\mathrm{JK^{-1}}$
Stefan-Boltzmann constant	σ	$5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$
Coulomb constant	k	$8.99 \times 10^{9}\mathrm{Nm^2C^{-2}}$
Permittivity of free space	ε_0	$8.85 \times 10^{-12}\mathrm{C^2\ N^{-1}\ m^{-2}}$
Permeability of free space	μ_0	$4\pi \times 10^{-7}\mathrm{TmA^{-1}}$
Speed of light in vacuum	c	$3.00 \times 10^{8}\ \mathrm{ms^{-1}}$
Planck constant	h	$6.63 \times 10^{-34}\mathrm{Js}$
Elementary charge	e	$1.60 \times 10^{-19}\mathrm{C}$
Electron rest mass	m_e	$9.110 \times 10^{-31}\ \mathrm{kg} = 0.000549\mathrm{u} = 0.511\mathrm{MeVc^{-2}}$
Proton rest mass	m_p	$1.673 \times 10^{-27}\ \mathrm{kg} = 1.007276\mathrm{u} = 938\mathrm{MeVc^{-2}}$
Neutron rest mass	m_n	$1.675 \times 10^{-27}\ \mathrm{kg} = 1.008665\mathrm{u} = 940\mathrm{MeVc^{-2}}$
(Unified) atomic mass unit	u	$1.661 \times 10^{-27}\ \mathrm{kg} = 931.5\mathrm{MeVc^{-2}}$
Solar constant	S	$1.36 \times 10^{3}\ \mathrm{W\ m^{-2}}$
Fermi radius	R_0	$1.20 \times 10^{-15}\ \mathrm{m}$

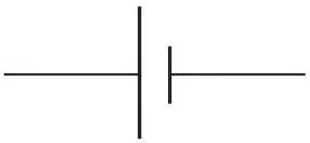
Metric (SI) multipliers

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}

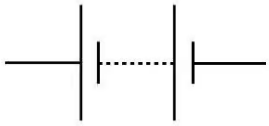
Unit conversions

- 1 radian $(\mathrm{rad}) \equiv \frac{180^\circ}{\pi}$
- Temperature (K) = temperature $(^\circ\mathrm{C}) + 273$
- 1 light year $(\mathrm{ly}) = 9.46 \times 10^{15}\ \mathrm{m}$
- 1 parsec $(\mathrm{pc}) = 3.26\mathrm{ly}$
- 1 astronomical unit $(\mathrm{AU}) = 1.50 \times 10^{11}\ \mathrm{m}$
- 1 kilowatt-hour $(\mathrm{kWh}) = 3.60 \times 10^{6}\ \mathrm{J}$
- $hc = 1.99 \times 10^{-25}\mathrm{Jm} = 1.24 \times 10^{-6}\mathrm{eVm}$

Electrical circuit symbols

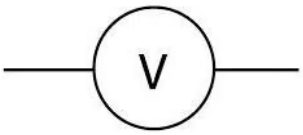


Cell

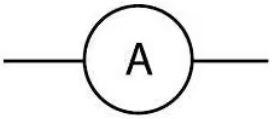


Battery

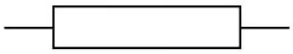
Switch



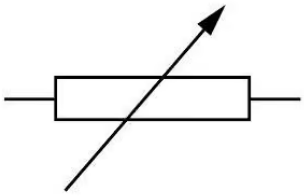
Voltmeter



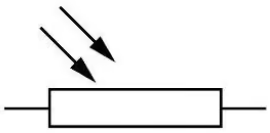
Ammeter



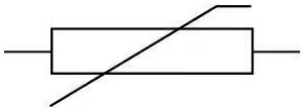
Resistor



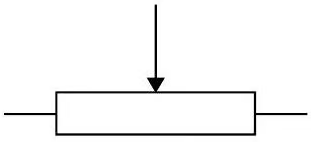
Variable resistor



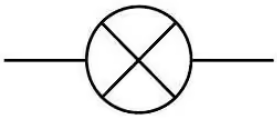
Light-dependent resistor (LDR)



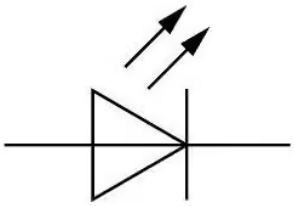
Thermistor



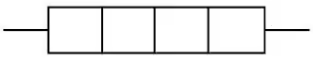
Potentiometer



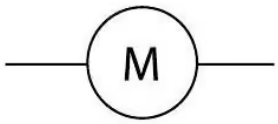
Lamp



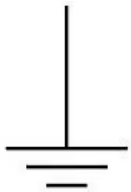
Light emitting diode (LED)



Heating element

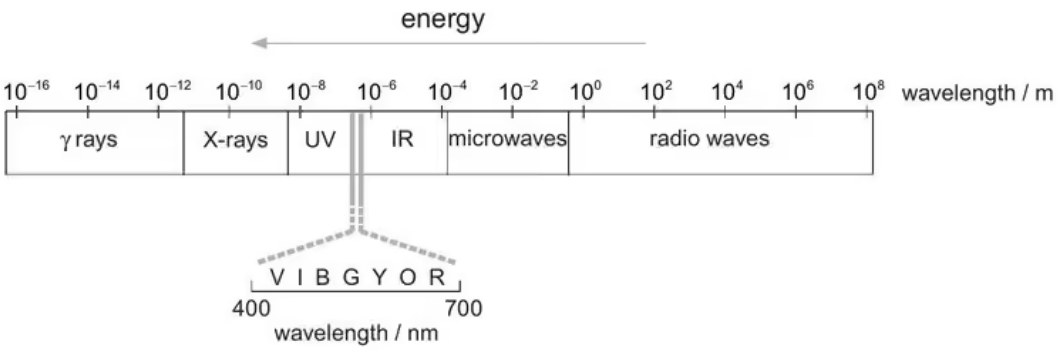


Motor



Earth (ground)

Electromagnetic spectrum



A. Space, time and motion

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	$F_\mathrm{f} \leq \mu_\mathrm{s} F_\mathrm{N}$ $F_\mathrm{f} = \mu_\mathrm{d} F_\mathrm{N}$ $F_\mathrm{H} = -kx$ $F_\mathrm{d} = 6\pi\eta r v$ $F_\mathrm{b} = \rho V g$ $F_\mathrm{g} = mg$ $p = mv$ $J = F\Delta t$ $F = ma = \frac{\Delta p}{\Delta t}$ $a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$ $v = \frac{2\pi r}{T} = \omega r$
A.3 Work, energy and power	$W = Fs\cos\theta$ $E_\mathrm{k} = \frac{1}{2}mv^2 = \frac{p^2}{2m}$ $\Delta E_\mathrm{p} = mg\Delta h$ $E_\mathrm{H} = \frac{1}{2}k\Delta x^2$ $P = \frac{\Delta W}{\Delta t} = Fv$ $\eta = \frac{\text{useful work out}}{\text{total work in}} = \frac{\text{useful power out}}{\text{total power in}}$

Additional higher level	
A.4 Rigid body mechanics	$\tau = Fr\sin\theta$ $\Delta\theta = \frac{\omega_{\mathrm{f}} + \omega_{\mathrm{i}}}{2}t$ $\omega_{\mathrm{f}} = \omega_{\mathrm{i}} + \alpha t$ $\Delta\theta = \omega_{\mathrm{i}}t + \frac{1}{2}\alpha t^2$ $\omega_{\mathrm{f}}^2 = \omega_{\mathrm{i}}^2 + 2\alpha\Delta\theta$ $I = \Sigma mr^2$ $\tau = I\alpha$ $L = I\omega$ $\Delta L = \tau\Delta t$ $\Delta L = \Delta(I\omega)$ $E_k = \frac{1}{2}I\omega^2 = \frac{L^2}{2I}$
A.5 Galilean and special relativity	$x' = x - vt$ $t' = t$ $u' = u - v$ $x' = \gamma(x - vt)$ 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

Standard level and higher level		
B.1 Thermal energy transfers	$\rho = \frac{m}{V}$ $\overline{E_{\mathrm{k}}} = \frac{3}{2}k_{\mathrm{B}}T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta x}$ $L = \sigma AT^4$ $b = \frac{L}{4\pi d^2}$ $\lambda_{\max}T = 2.9 \times 10^{-3}\mathrm{mK}$	
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	$P = \frac{F}{A}$ $n = \frac{N}{N_{\mathrm{A}}}$ $\frac{PV}{T} = \text{constant}$ $PV = nRT = Nk_{\mathrm{B}}T$ $P = \frac{1}{3}\rho v^2$ $U = \frac{3}{2}nRT = \frac{3}{2}Nk_{\mathrm{B}}T$	

B.5 Current and circuits	$I = \frac{\Delta q}{\Delta t}$ $V = \frac{W}{q}$ $R = \frac{V}{I}$ $\rho = \frac{RA}{L}$ $P = IV = I^2R = \frac{V^2}{R}$	
	Series circuits	Parallel circuits
	$I = I_1 = I_2 = \dots$ $V = V_1 + V_2 + \dots$ $R_s = R_1 + R_2 + \dots$	$I = I_1 + I_2 + \dots$ $V = V_1 = V_2 = \dots$ $\frac{1}{R_\text{p}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
	$\varepsilon = I(R + r)$	
Additional higher level		
B.4 Thermodynamics	$Q = \Delta U + W$ $W = P\Delta V$ $\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}Nk_\text{B}\Delta T$ $\Delta S = \frac{\Delta Q}{T}$ $S = k_\text{B} \ln \Omega$ $PV^{\frac{5}{3}} = \text{constant}$ $\eta = \frac{\text{useful work}}{\text{input energy}}$ $\eta_\text{Carnot} = 1 - \frac{T_\text{c}}{T_\text{h}}$	

C. Wave behaviour

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	$\frac{\Delta f}{f} = \frac{\Delta\lambda}{\lambda} \approx \frac{v}{c}$
Additional higher level	
C.1 Simple harmonic motion	$x = x_0 \sin(\omega t + \phi)$ $v = \omega x_0 \cos(\omega t + \phi)$ $v = \pm\omega\sqrt{x_0^2 - x^2}$ $E_{\mathrm{T}} = \frac{1}{2} m\omega^2 x_0^2$ $E_{\mathrm{p}} = \frac{1}{2} m\omega^2 x^2$

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: $f' = f\left(\frac{v \pm u_o}{v}\right)$

D. Fields

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	$F = k\frac{q_1 q_2}{r^2}$ where $k = \frac{1}{4\pi\varepsilon_0}$ $E = \frac{F}{q}$ $E = \frac{V}{d}$
D.3 Motion in electromagnetic fields	$F = qvB\sin\theta$ $F = BIL\sin\theta$ $\frac{F}{L} = \mu_0\frac{I_1 I_2}{2\pi r}$
Additional higher level	
D.1 Gravitational fields	$E_\mathrm{p} = -G\frac{m_1 m_2}{r}$ $V_\mathrm{g} = -G\frac{M}{r}$ $g = -\frac{\Delta V_\mathrm{g}}{\Delta r}$ $W = m\Delta V_\mathrm{g}$ $v_\mathrm{esc} = \sqrt{\frac{2GM}{r}}$ $v_\mathrm{orbital} = \sqrt{\frac{GM}{r}}$
D.2 Electric and magnetic fields	$E_\mathrm{p} = k\frac{q_1 q_2}{r}$ $V_\mathrm{e} = \frac{kQ}{r}$ $E = -\frac{\Delta V_\mathrm{e}}{\Delta r}$ $W = q\Delta V_\mathrm{e}$

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

E. Nuclear and quantum physics

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	$\mathrm{d}(\text{ parsec }) = \frac{1}{\mathrm{p}(\text{ arc-second })}$
Additional higher level	
E.1 Structure of the atom	$R = R_0 A^{\frac{1}{3}}$ $E = -\frac{13.6}{n^2}\mathrm{eV}$ $mvr = \frac{nh}{2\pi}$
E.2 Quantum physics	$E_{\max} = hf - \Phi$ $\lambda = \frac{h}{p}$ $\lambda_{\mathrm{f}} - \lambda_i = \Delta\lambda = \frac{h}{m_{\mathrm{e}}c}(1-\cos\theta)$
E.3 Radioactive decay	$N = N_0 e^{-\lambda t}$ $A = \lambda N = \lambda N_0 e^{-\lambda t}$ $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$