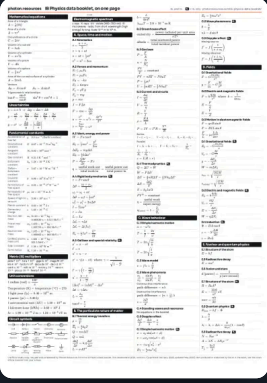


Print it: one-page versions



On one page

Every official formula on a single A4 side. Print it, pin it up.

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One sheet, annotated

The same, with short pointers and the key formulas the booklet leaves out, in mint.

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SL student? Skip the HL lines: SL-only [one page](#) · [annotated](#) (free PDFs). [All booklets](#)

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	$V = \pi r^2 h$ PHOTON NOTE Used for wires: the volume of a wire of length L is its cross-section times L.
Volume of a prism	$V = Ah$ where A is the area of cross-section
Volume of a sphere	$V = \frac{4}{3}\pi r^3$ PHOTON NOTE Needed for Stokes' drag and buoyancy questions on spheres.
Area of the curved surface of a cylinder	$A = 2\pi r h$
Vectors	$A_H = A \cos \theta \quad A_V = A \sin \theta$ θ is measured from the horizontal PHOTON NOTE Check where θ is measured from. If the angle is given to the vertical, cos and sin swap.
Trigonometric relationships	$\tan \theta = \frac{\sin \theta}{\cos \theta} \quad \sin^2 \theta + \cos^2 \theta = 1$

Surface area of a sphere

$$A = 4\pi r^2$$

Used with the Stefan–Boltzmann law for stars and in the inverse-square law $b = L/4\pi d^2$.

Small-angle approximation

$$\sin \theta \approx \tan \theta \approx \theta \text{ (radians)}$$

Behind $s = \lambda D/d$ and $\theta = \lambda/b$. Valid for small angles only.

Uncertainties

If: $y = a \pm b$

then:

$$\Delta y = \Delta a + \Delta b$$

PHOTON NOTE

Adding or subtracting: add the absolute uncertainties.

If: $y = \frac{ab}{c}$

then:

$$\frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$$

PHOTON NOTE

Multiplying or dividing: add the fractional (or percentage) uncertainties.

If: $y = a^n$

then:

$$\frac{\Delta y}{y} = \left| n \frac{\Delta a}{a} \right|$$

PHOTON NOTE

A power multiplies the fractional uncertainty. A square root halves it ($n = \frac{1}{2}$).

Percentage uncertainty

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

Round the final uncertainty to one significant figure, then round the value to match.

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	$1.38 \times 10^{-23} \text{ J K}^{-1}$
		PHOTON NOTE $R = N_A k_B$, so you can switch between per-mole and per-particle forms.
Stefan–Boltzmann constant	σ	$5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Coulomb constant	k	$8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$
		PHOTON NOTE Do not confuse with k_B , the spring constant k or thermal conductivity k .
Permittivity of free space	ϵ_0	$8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$

Quantity	Symbol	Approximate value
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	$1.60 \times 10^{-19} \text{ C}$
PHOTON NOTE Also the conversion $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$.		
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	$1.661 \times 10^{-27} \text{ kg} = 931.5 \text{ MeV } c^{-2}$
PHOTON NOTE Mass defect in $\text{u} \times 931.5$ gives binding energy in MeV directly.		
Solar constant	S	$1.36 \times 10^3 \text{ W m}^{-2}$
Fermi radius	R_0	$1.20 \times 10^{-15} \text{ m}$
PHOTON NOTE Used in $R = R_0 A^{1/3}$ (HL).		

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

$$1 \text{ radian (rad)} \equiv \frac{180^\circ}{\pi}$$

PHOTON NOTE

Calculator in radians for SHM, ω and $\theta = \lambda/b$.

$$\text{Temperature (K)} = \text{temperature (}^{\circ}\text{C)} + 273$$

PHOTON NOTE

Gas laws, Wien's law and Stefan–Boltzmann always need kelvin.

$$1 \text{ light year (ly)} = 9.46 \times 10^{15} \text{ m}$$

$$1 \text{ parsec (pc)} = 3.26 \text{ ly}$$

$$1 \text{ astronomical unit (AU)} = 1.50 \times 10^{11} \text{ m}$$

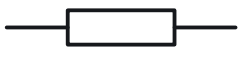
$$1 \text{ kilowatt-hour (kWh)} = 3.60 \times 10^6 \text{ J}$$

$$hc = 1.99 \times 10^{-25} \text{ J m} = 1.24 \times 10^{-6} \text{ eV m}$$

PHOTON NOTE

Shortcut for photons: $E \text{ (eV)} = 1.24 \times 10^{-6} / \lambda \text{ (m)}$.

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

← higher energy, shorter wavelength

longer wavelength →

γ rays	X-rays	UV	Visible	IR	Microwaves	Radio waves
below 10^{-11}	10^{-11} to 10^{-8}	10^{-8} to 4×10^{-7}	400–700 nm	7×10^{-7} to 10^{-3}	10^{-3} to 10^{-1}	above 10^{-1}

Visible light: violet 400 nm to red 700 nm (VIBGYOR).

PHOTON NOTE

The IB booklet shows this on a wavelength scale from 10^{-16} m to 10^8 m. Band edges are approximate: the bands overlap.

A. Space, time and motion

Standard level and higher level

A.1 Kinematics

$$s = \frac{u + v}{2}t$$

PHOTON NOTE

Average velocity $\times$ time. Uniform acceleration only, like all four of these.

$$v = u + at$$

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

$$v^2 = u^2 + 2as$$

PHOTON NOTE

No time in it: use it when t is neither given nor asked for.

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Projectiles

$$v_x = u \cos \theta \text{ (constant)} \quad v_y = u \sin \theta - gt$$

Split into horizontal and vertical. Only the vertical motion accelerates. Air resistance ignored.

A.2 Forces and momentum

$$F_f \leq \mu_s F_N$$

PHOTON NOTE

Static friction rises to match the push, up to $\mu_s F_N$. At that limit the object starts to slide.

$$F_f = \mu_d F_N$$

PHOTON NOTE

Dynamic friction once it slides.

$$F_H = -kx$$

PHOTON NOTE

Hooke's law. The minus sign shows the force opposes the extension.

$$F_d = 6\pi\eta rv$$

PHOTON NOTE

Stokes' law: small sphere, slow, smooth (laminar) flow. η is viscosity.

$$F_b = \rho Vg$$

PHOTON NOTE

Buoyancy. ρ is the fluid's density and V the volume displaced.

$$F_g = mg$$

$$p = mv$$

$$J = F\Delta t$$

PHOTON NOTE

Impulse = change in momentum = area under the F–t graph.

$$F = ma = \frac{\Delta p}{\Delta t}$$

PHOTON NOTE

Use $\Delta p/\Delta t$ when the mass changes (rockets, jets of water).

$$a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$$

PHOTON NOTE

Centripetal acceleration points to the centre. It is not a new force: find which force provides it.

$$v = \frac{2\pi r}{T} = \omega r$$

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Conservation of momentum

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

Holds whenever no external force acts. Kinetic energy is conserved only in elastic collisions.

Terminal velocity (sphere in fluid)

$$mg = F_b + 6\pi\eta r v_t$$

Weight balances buoyancy plus drag.

A.3 Work, energy and power

$$W = F s \cos \theta$$

PHOTON NOTE

θ is the angle between force and displacement.

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

$$\Delta E_p = mg\Delta h$$

PHOTON NOTE

Only near the Earth's surface, where g is constant.

$$E_H = \frac{1}{2}k\Delta x^2$$

PHOTON NOTE

Elastic energy = area under the F - x graph.

$$P = \frac{\Delta W}{\Delta t} = Fv$$

$$\eta = \frac{\text{useful work out}}{\text{total work in}} = \frac{\text{useful power out}}{\text{total power in}}$$

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Work-energy principle

$$W_{\text{net}} = \Delta E_k$$

Often faster than forces and kinematics.

Energy density

$$\text{energy density} = \frac{\text{energy}}{\text{volume}}$$

Specific energy is energy per unit mass. Watch which one is asked.

A.4 Rigid body mechanics HL

$$\tau = Fr \sin \theta$$

$$\Delta \theta = \frac{\omega_f + \omega_i}{2} t$$

PHOTON NOTE

The four rotational equations mirror A.1: $s \rightarrow \theta$, $u \rightarrow \omega_i$, $v \rightarrow \omega_f$, $a \rightarrow \alpha$.

$$\omega_f = \omega_i + \alpha t$$

$$\Delta \theta = \omega_i t + \frac{1}{2} \alpha t^2$$

$$\omega_f^2 = \omega_i^2 + 2\alpha \Delta \theta$$

$$I = \Sigma mr^2$$

PHOTON NOTE

Moments of inertia of standard shapes are given in the question when needed.

$$\tau = I\alpha$$

$$L = I\omega$$

$$\Delta L = \tau \Delta t$$

$$\Delta L = \Delta(I\omega)$$

PHOTON NOTE

With no external torque, $L\omega$ stays constant (a skater pulling in her arms spins faster).

$$E_k = \frac{1}{2} I \omega^2 = \frac{L^2}{2I}$$

A.5 Galilean and special relativity HL

$$x' = x - vt$$

PHOTON NOTE

Galilean transformations: everyday speeds.

$$t' = t$$

$$u' = u - v$$

$$x' = \gamma(x - vt) \text{ where } \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

PHOTON NOTE

Lorentz transformations. γ is always ≥ 1 .

$$t' = \gamma \left(t - \frac{vx}{c^2} \right)$$

$$u' = \frac{u - v}{1 - \frac{uv}{c^2}}$$

$$(\Delta s)^2 = (c\Delta t)^2 - \Delta x^2$$

PHOTON NOTE

The spacetime interval is the same in every frame.

$$\Delta t = \gamma \Delta t_0$$

PHOTON NOTE

Δt_0 is proper time: measured by the clock that is present at both events.

$$L = \frac{L_0}{\gamma}$$

PHOTON NOTE

L_0 is proper length: measured in the object's own rest frame.

$$\tan \theta = \frac{v}{c}$$

PHOTON NOTE

Angle of the x' and ct' axes on a spacetime diagram.

B. The particulate nature of matter

Standard level and higher level

B.1 Thermal energy transfers

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

$$\overline{E_k} = \frac{3}{2}k_B T$$

PHOTON NOTE

Average kinetic energy of one particle of an ideal gas. T in kelvin.

$$Q = mc\Delta T$$

PHOTON NOTE

c is specific heat capacity.

$$Q = mL$$

PHOTON NOTE

During a change of state the temperature does not change.

$$\frac{\Delta Q}{\Delta t} = kA \frac{\Delta T}{\Delta x}$$

PHOTON NOTE

Conduction. Here k is thermal conductivity, not the Coulomb constant.

$$L = \sigma AT^4$$

PHOTON NOTE

Here L is luminosity (power), not latent heat. A for a star is $4\pi R^2$.

$$b = \frac{L}{4\pi d^2}$$

PHOTON NOTE

Apparent brightness falls with the square of distance.

$$\lambda_{\max} T = 2.9 \times 10^{-3} \text{ m K}$$

PHOTON NOTE

Wien's law. Hotter objects peak at shorter wavelength.

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Black-body radius of a star

$$R = \sqrt{\frac{L}{4\pi\sigma T^4}}$$

Combine $L = \sigma AT^4$ with $A = 4\pi R^2$.

B.2 Greenhouse effect

$$\text{emissivity} = \frac{\text{power radiated per unit area}}{\sigma T^4}$$

PHOTON NOTE

1 for a perfect black body.

$$\text{albedo} = \frac{\text{total scattered power}}{\text{total incident power}}$$

PHOTON NOTE

Earth's average albedo is about 0.3.

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Power radiated by a real surface

$$P = e\sigma AT^4$$

Emissivity e scales the black-body value.

Mean incoming intensity on Earth

$$\frac{S}{4}$$

The solar constant spread over the whole sphere (πR^2 facing the Sun, $4\pi R^2$ in total).

B.3 Gas laws

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

$$n = \frac{N}{N_A}$$

$$\frac{PV}{T} = \text{constant}$$

PHOTON NOTE

Fixed amount of gas. T in kelvin.

$$PV = nRT = Nk_B T$$

$$P = \frac{1}{3}\rho v^2$$

PHOTON NOTE

Kinetic theory. Here v^2 means the mean of the squared speeds.

$$U = \frac{3}{2}nRT = \frac{3}{2}Nk_B T$$

PHOTON NOTE

Internal energy of an ideal monatomic gas: kinetic only.

B.5 Current and circuits

$$I = \frac{\Delta q}{\Delta t}$$

$$V = \frac{W}{q}$$

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

PHOTON NOTE

Defines resistance. Ohm's law is the special case where R stays constant.

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

PHOTON NOTE

Resistivity: a property of the material, not of the wire.

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

Series: $I = I_1 = I_2 = \dots$ $V = V_1 + V_2 + \dots$ $R_s = R_1 + R_2 + \dots$

Parallel: $I = I_1 + I_2 + \dots$ $V = V_1 = V_2 = \dots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

PHOTON NOTE

Adding a resistor in parallel always lowers the total resistance.

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

PHOTON NOTE

r is the internal resistance of the cell.

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Terminal potential difference

$$V = \varepsilon - Ir$$

The 'lost volts' Ir grow as the current rises.

Potential divider

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

With an LDR or thermistor this makes light or temperature sensors.

B.4 Thermodynamics HL

$$Q = \Delta U + W$$

PHOTON NOTE

W is work done BY the gas. Sign conventions are the usual source of lost marks.

$$W = P\Delta V$$

PHOTON NOTE

Constant pressure only. Otherwise use the area under the P–V graph.

$$\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}Nk_B\Delta T$$

$$\Delta S = \frac{\Delta Q}{T}$$

$$S = k_B \ln \Omega$$

PHOTON NOTE

Ω is the number of microstates.

$$PV^{\frac{5}{3}} = \text{constant}$$

PHOTON NOTE

Adiabatic change of an ideal monatomic gas ($Q = 0$).

$$\eta = \frac{\text{useful work}}{\text{input energy}}$$

$$\eta_{\text{Carnot}} = 1 - \frac{T_c}{T_h}$$

PHOTON NOTE

The maximum possible efficiency. Temperatures in kelvin.

C. Wave behaviour

Standard level and higher level

C.1 Simple harmonic motion

$$a = -\omega^2 x$$

PHOTON NOTE

The definition of SHM: acceleration proportional to displacement and opposite in direction.

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

PHOTON NOTE

Mass on a spring.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

PHOTON NOTE

Simple pendulum, small angles. Mass does not affect T.

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Angular frequency

$$\omega = 2\pi f$$

Rearranged from the booklet line above. Used constantly.

C.2 Wave model

$$v = f\lambda = \frac{\lambda}{T}$$

PHOTON NOTE

Frequency is set by the source. When a wave changes medium, v and λ change, f does not.

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Intensity and amplitude

$$I \propto A^2$$

Double the amplitude, four times the intensity.

Inverse-square law

$$I \propto \frac{1}{r^2}$$

For a point source radiating equally in all directions.

C.3 Wave phenomena

$$\frac{n_1}{n_2} = \frac{\sin \theta_2}{\sin \theta_1} = \frac{v_2}{v_1}$$

PHOTON NOTE

Snell's law. Note the order: n_1 on top pairs with $\sin \theta_2$ on top. Angles from the normal.

Constructive interference: path difference = $n\lambda$

Destructive interference: path difference = $(n + \frac{1}{2})\lambda$

$$s = \frac{\lambda D}{d}$$

PHOTON NOTE

Double slit: s is fringe spacing, D slit-to-screen distance, d slit separation.

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Critical angle

$$\sin c = \frac{n_2}{n_1}$$

Going from the denser medium (n_1) to the less dense one (n_2). Beyond c : total internal reflection.

C.4 Standing waves and resonance

The IB booklet gives no equations for this topic.

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String fixed at both ends, or pipe open at both ends

$$\lambda_n = \frac{2L}{n}, \quad f_n = \frac{nv}{2L} \quad (n = 1, 2, 3, \dots)$$

C.4 has no equations in the booklet. Draw the pattern first: node–antinode spacing is $\lambda/4$.

Pipe closed at one end

$$\lambda_n = \frac{4L}{n}, \quad f_n = \frac{nv}{4L} \quad (n = 1, 3, 5, \dots)$$

Only odd harmonics.

C.5 Doppler effect

$$\frac{\Delta f}{f} = \frac{\Delta \lambda}{\lambda} \approx \frac{v}{c}$$

PHOTON NOTE

Light, or any wave where $v \ll c$. Redshift means moving away.

C.1 Simple harmonic motion **HL**

$$x = x_0 \sin(\omega t + \phi)$$

PHOTON NOTE

ϕ is the phase. Use cos if the motion starts at maximum displacement.

$$v = \omega x_0 \cos(\omega t + \phi)$$

$$v = \pm \omega \sqrt{x_0^2 - x^2}$$

PHOTON NOTE

Maximum speed ωx_0 at the centre ($x = 0$).

$$E_T = \frac{1}{2} m \omega^2 x_0^2$$

PHOTON NOTE

Total energy is constant.

$$E_p = \frac{1}{2} m \omega^2 x^2$$

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Kinetic energy in SHM

$$E_k = \frac{1}{2} m \omega^2 (x_0^2 - x^2)$$

$$E_T - E_p.$$

C.3 Wave phenomena **HL**

$$\theta = \frac{\lambda}{b}$$

PHOTON NOTE

Single slit: angle to the first minimum, in radians. b is the slit width.

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

PHOTON NOTE

Diffraction grating. $d = 1 / (\text{lines per metre})$.

C.5 Doppler effect **HL**

$$\text{Moving source: } f' = f \left(\frac{v}{v \pm u_s} \right)$$

PHOTON NOTE

Source approaching: use minus (frequency rises).

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

PHOTON NOTE

Observer approaching: use plus.

D. Fields

Standard level and higher level

D.1 Gravitational fields

$$F = G \frac{m_1 m_2}{r^2}$$

PHOTON NOTE

r is centre to centre, not surface to surface.

$$g = \frac{F}{m} = G \frac{M}{r^2}$$

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Kepler's third law (circular orbit)

$$T^2 = \frac{4\pi^2}{GM} r^3$$

From $G Mm/r^2 = m 4\pi^2 r/T^2$, $T^2 \propto r^3$.

D.2 Electric and magnetic fields

$$F = k \frac{q_1 q_2}{r^2} \text{ where } k = \frac{1}{4\pi\epsilon_0}$$

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

$$E = \frac{V}{d}$$

PHOTON NOTE

Uniform field between parallel plates only.

D.3 Motion in electromagnetic fields

$$F = qvB \sin \theta$$

PHOTON NOTE

Use the right-hand rule. Flip the direction for negative charges.

$$F = BIL \sin \theta$$

$$\frac{F}{L} = \mu_0 \frac{I_1 I_2}{2\pi r}$$

PHOTON NOTE

Parallel wires: same direction attract, opposite repel.

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Radius of a charge in a magnetic field

$$r = \frac{mv}{qB}$$

From $qvB = mv^2/r$. The magnetic force does no work, so the speed stays the same.

Velocity selector

$$v = \frac{E}{B}$$

When the electric and magnetic forces balance.

D.1 Gravitational fields HL

$$E_p = -G \frac{m_1 m_2}{r}$$

PHOTON NOTE

Zero at infinity, so it is always negative.

$$V_g = -G \frac{M}{r}$$

$$g = -\frac{\Delta V_g}{\Delta r}$$

PHOTON NOTE

Field strength = minus the gradient of the potential.

$$W = m\Delta V_g$$

$$v_{\text{esc}} = \sqrt{\frac{2GM}{r}}$$

$$v_{\text{orbital}} = \sqrt{\frac{GM}{r}}$$

PHOTON NOTE

Orbital speed does not depend on the satellite's mass.

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Total energy of an orbit

$$E_{\text{total}} = -\frac{GMm}{2r}$$

$$E_k = \frac{GMm}{2r} \text{ and } E_p = -\frac{GMm}{r}.$$

D.2 Electric and magnetic fields

HL

$$E_p = k \frac{q_1 q_2}{r}$$

$$V_e = \frac{kQ}{r}$$

PHOTON NOTE

Potential is a scalar: add potentials from several charges with their signs.

$$E = - \frac{\Delta V_e}{\Delta r}$$

$$W = q\Delta V_e$$

D.4 Induction

HL

$$\Phi = BA \cos \theta$$

PHOTON NOTE

θ is between B and the normal to the area.

$$\varepsilon = -N \frac{\Delta \Phi}{\Delta t}$$

PHOTON NOTE

Faraday's law. The minus sign is Lenz's law.

$$\varepsilon = BvL$$

PHOTON NOTE

A rod moving through a field.

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Flux linkage

$$N\Phi$$

Unit: Wb turns.

E. Nuclear and quantum physics

Standard level and higher level

E.1 Structure of the atom

$$E = hf$$

PHOTON NOTE

Photon energy. For a transition, hf equals the difference between the two levels.

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Photon energy from wavelength

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

Use $hc = 1.24 \times 10^{-6} \text{ eV m}$ for answers in eV.

E.3 Radioactive decay

$$E = mc^2$$

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Binding energy from the mass defect

$$\Delta E = \Delta m c^2$$

Δm = (mass of separate nucleons) – (mass of nucleus). In u, multiply by 931.5 for MeV.

Whole half-lives

$$N = N_0 \left(\frac{1}{2}\right)^n$$

n is the number of half-lives. SL questions use whole numbers of half-lives.

E.5 Fusion and stars

$$d (\text{parsec}) = \frac{1}{p (\text{arc-second})}$$

PHOTON NOTE

Stellar parallax. Works for nearby stars only.

E.1 Structure of the atom HL

$$R = R_0 A^{\frac{1}{3}}$$

PHOTON NOTE

Nuclear density comes out the same for all nuclei.

$$E = -\frac{13.6}{n^2} \text{ eV}$$

PHOTON NOTE

Hydrogen only.

$$mvr = \frac{n\hbar}{2\pi}$$

PHOTON NOTE

Bohr model: angular momentum is quantised.

E.2 Quantum physics HL

$$E_{\text{max}} = hf - \Phi$$

PHOTON NOTE

Photoelectric effect. Φ is the work function. Intensity changes the number of electrons, not E_{max} .

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

PHOTON NOTE

de Broglie wavelength.

$$\lambda_f - \lambda_i = \Delta\lambda = \frac{h}{m_e c} (1 - \cos \theta)$$

PHOTON NOTE

Compton scattering.

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Threshold frequency

$$f_0 = \frac{\Phi}{h}$$

Below f_0 no electrons are emitted, however bright the light.

Stopping potential

$$eV_s = E_{\text{max}}$$

E.3 Radioactive decay HL

$$N = N_0 e^{-\lambda t}$$

PHOTON NOTE

Here λ is the decay constant, not wavelength.

$$A = \lambda N = \lambda N_0 e^{-\lambda t}$$

$$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$$

Source: IB Physics data booklet, first assessment 2025, version 1.1 (published February 2023, updated May 2023), retyped by Photon Resources. This is an unofficial study companion, not produced or endorsed by the International Baccalaureate. In the exam you use the clean official booklet your school provides. All notes and extra formulas are ours.