YOUR EDUCATION PLUS

IBDP: Physics SL & HL Formulas & Constants (annotated)

First Examinations 2016 (updated version 1.1)

Sub-Topic 1.2: Uncertainties and Errors - SL & HL

y = Result.

a, b, c = Quantities.

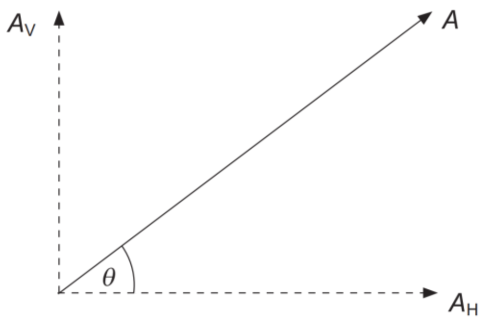
Δ = Uncertainty.

If: $y = a \pm b$
then: $\Delta y = \Delta a + \Delta b$
Adding/subtracting quantities: uncertainty in result will be sum of uncertainties of quantities.

If: $y = \frac{ab}{c}$
then: $\frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b} + \frac{\Delta c}{c}$
Multiplying/dividing quantities: % uncertainties of quantities are added together to obtain % uncertainty in result

If: $y = a^n$
then: $\frac{\Delta y}{y} = \left| n\frac{\Delta a}{a} \right|$
Powers of quantities: % uncertainty of quantity is multiplied by power to obtain % uncertainty in result.

Sub-Topic 1.3: Vectors and Scalars - SL & HL



$A_H = A\cos\theta$

$A_V = A\sin\theta$

Trigonometric rules of triangles are applied when taking components of vector quantities.

AH = Horizontal component.

AV = Vertical component.

Sub-Topic 2.1: Motion - SL & HL

v = Final velocity.

u = Initial velocity.

a = Acceleration ('g' for gravitational).

s = Displacement.

t = Time elapsed.

$v = u + at$

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

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

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

Equations applied to uniform motion (known as 'suvat' equations).

Sub-Topic 2.2: Forces - SL & HL

$F = ma$ Acceleration due to resultant force (Newton's 2nd law of motion).

$F_f \le \mu_s R$ Frictional force on a static object.

$F_f = \mu_d R$ Frictional force on a dynamic object.

F = Resultant force.

m = Mass.

a = Acceleration.

μs = Coefficient of static friction.

μd = " dynamic ".

Ff = Frictional force.

R = Normal reaction force.

Sub-Topic 2.3: Work, Energy and Power - SL & HL

W = Work done.

F = Force.

s = Displacement.

EK = Kinetic energy.

m = Mass.

v = Velocity.

EP = Potential energy.

k = Spring constant

x = Extension.

g = Earth's gravity.

h = Height.

$W = Fs\cos\theta$ Work done.

$E_K = \frac{1}{2}mv^2$ Kinetic energy.

$E_p = \frac{1}{2}k\Delta x^2$ Elastic potential energy (in a spring).

$\Delta E_p = mg\Delta h$ Gravitational potential energy.

$\text{power} = Fv$ Power.

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

Sub-Topic 2.4: Momentum and Impulse - SL & HL

$p = mv$ Momentum.

$F = \frac{\Delta p}{\Delta t}$ Resultant force due to momentum.

$E_K = \frac{p^2}{2m}$ Kinetic energy.

$\text{impulse} = F\Delta t = \Delta p$

p = Momentum.

m = Mass.

v = Velocity.

F = Force.

t = Time.

EK = Kinetic energy.

****** For Best Results ******

Use units within the formulas. It is more work, but it guarantees a correct answer.

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Sub-Topic 3.1: Thermal Concepts - SL & HL

Q = Energy/heat.
m = Mass.
c = Specific heat capacity.
T = Temperature.
L = Specific latent heat.

$Q = mc\Delta T$ Energy/heat given/received in changing an object's temperature.

$Q = mL$ Energy/heat given/received in changing an object's phase.

Sub-Topic 3.2: Modelling a Gas - SL & HL

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

$n = \frac{N}{N_A}$ Number of moles of a substance.

$pV = nRT$ Ideal gas law.

$\bar{E}_K = \frac{3}{2}k_B T = \frac{3}{2}\frac{R}{N_A}T$ Average kinetic energy per molecule of a gas.

p = Pressure.
F = Force.
A = Area.
n = Number of moles.
N = Number of atoms.
NA = Avogadro's constant.
V = Volume.
R = Gas constant.
T = Temperature.
EK = Kinetic energy.
kb = Boltzmann's constant.

Sub-Topic 4.1: Oscillations - SL & HL

T = Period.
f = Frequency.

$T = \frac{1}{f}$ Period (time taken to complete 1 oscillation).

Sub-Topic 4.2: Travelling Waves - SL & HL

c = Velocity.
f = Frequency.
λ = Wavelength.

$c = f\lambda$ Speed of a wave.

Sub-Topic 4.3: Wave Characteristics - SL & HL

I = Intensity.
A = Amplitude.
x = Distance from source.
I0 = Original intensity.
θ = Angle of polarizer.

$I \propto A^2$ Intensity of a wave vs. amplitude.

$I \propto x^{-2}$ Intensity of a wave's radiation at a certain distance from the source.

$I = I_0 \cos^2\theta$ Transmitted intensity of light incident on a polariser (Malus's law).

Sub-Topic 4.4: Wave Behaviour - SL & HL

$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$ Refraction when a wave crosses a boundary between 2 media (Snell's law).

$s = \frac{\lambda D}{d}$ Fringe spacing in double slit diffraction.

Constructive interference:
path difference $= n\lambda$

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

Maxima/minima on screen in double slit diffraction.

n1/n2 = Index of refraction.
θ = Angle of incidence/refraction.
v = Wave velocity.
s = Fringe spacing.
λ = Wavelength.
D = Distance to screen.
d = Slit spacing.
n = Any integer (order of minimum/maximum).

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Variables	Sub-Topic 5.1: Electric Fields - SL & HL	Sub-Topic 5.2: Heating Effect of Electric Currents - SL & HL	Variables
I = Current. q = Charge. t = Time. F = Force. k = Coulomb constant. r = Separation distance. ε0 = Permittivity of free space. V = Potential. W = Work done. E = Electric field strength. n = Number of charges per unit volume. A = X-sectional area. v = Drift velocity.	$I = \frac{\Delta q}{\Delta t}$ Current. $F = k\frac{q_1 q_2}{r^2}$ Force experienced by 2 charges (Coulomb's law). $k = \frac{1}{4\pi\varepsilon_0}$ Coulomb constant. $V = \frac{W}{q}$ Potential difference. $E = \frac{F}{q}$ Electric field strength. $I = nAvq$ Current in a wire.	Kirchhoff's circuit laws: $\Sigma V = 0$ (loop) $\Sigma I = 0$ (junction) $R = \frac{V}{I}$ Resistance. $P = VI = I^2R = \frac{V^2}{R}$ Power supplied/dissipated. $R_{total} = R_1 + R_2 + \ldots$ Total resistance of resistors in series. $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ Total resistance of resistors in parallel. $\rho = \frac{RA}{L}$ Resistivity of material of a wire.	V = Potential. I = Current. R = Resistance. P = Power. ρ = Resistivity. A = X-sectional area. L = Length.

Variables	Sub-Topic 5.3: Electric Cells - SL & HL	Sub-Topic 5.4: Magnetic Effects of Electric Currents - SL & HL	Variables
ε = Emf. I = Current. R = Resistance. r = Internal resistance.	$\varepsilon = I(R + r)$ Emf of a cell.	$F = qvB\sin\theta$ Force on a charge moving through a magnetic field. $F = BIL\sin\theta$ Force on a current-carrying wire in a magnetic field.	F = Force. q = Charge. v = Velocity of charge. B = Magnitude of magnetic field. θ = Angle with field.

Variables	Sub-Topic 6.1: Circular Motion - SL & HL	Sub-Topic 6.2: Newton's Law of Gravitation - SL & HL	Variables
v = Velocity. ω = Angular velocity. r = Radius of circle. a = Acceleration. T = Period of rotation. F = Force. m = Mass.	$v = \omega r$ Velocity of body travelling in circle. $a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$ Centripetal acceleration. $F = \frac{mv^2}{r} = m\omega^2 r$ Centripetal force.	$F = G\frac{Mm}{r^2}$ Force experienced by 2 masses (Newton's law of gravitation). $g = \frac{F}{m}$ Field strength as experienced by a mass in the field. $g = G\frac{M}{r^2}$ Field strength at a certain distance from body.	F = Force. G = Gravitational constant. M = Mass of body. m = Mass of body (in a field). r = Separation distance of bodies. g = Gravitational field strength

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Sub-Topic 7.1: Discrete Energy and Radioactivity - SL & HL

E = Energy.
h = Planck's constant.
f = Frequency.
λ = Wavelength.
c = Speed of light.

$E = hf$ Energy of a photon.

$\lambda = \frac{hc}{E}$ Wavelength of a photon.

Sub-Topic 7.2: Nuclear Reactions - SL & HL

$\Delta E = \Delta mc^2$ Energy released when nucleons are assembled into nucleus.

E = Energy.
m = Mass.
c = Speed of light.

Sub-Topic 7.3: The Structure of Matter - SL & HL

e = Elementary charge.
u = Up.
d = Down.
c = Charm.
s = Strange.
t = Top.
b = Bottom.

Charge	Quarks			Baryon Number
$\frac{2}{3}e$	u	c	t	$\frac{1}{3}$
$-\frac{1}{3}e$	d	s	b	$\frac{1}{3}$

All quarks have a strangeness number of 0 except the strange quark that has a strangeness number of –1

Charge	Leptons		
–1	e	μ	τ
0	ν_e	ν_μ	ν_τ

All leptons have a lepton number of 1 and antileptons have a lepton number of –1

	Gravitational	Weak	Electromagnetic	Strong
Particles Experiencing	All	Quarks, Leptons	Charged	Quarks, Gluons
Particles Mediating	Graviton	W^+, W^-, Z^0	γ	Gluons

e = Electron.
u = Muon.
τ = Tau.
ν = Neutrino.

Sub-Topic 8.1: Energy Sources - SL & HL

A = Area swept out by turbine blades.
ρ = Air density.
v = Wind speed.

$\text{power} = \frac{\text{energy}}{\text{time}}$

$\text{power} = \frac{1}{2}A\rho v^3$ Power available from a wind turbine.

Sub-Topic 8.2: Thermal Energy Transfer - SL & HL

$P = e\sigma AT^4$ Power radiated by a body.

$\lambda_{max}(\text{metres}) = \frac{2.90 \times 10^{-3}}{T(\text{kelvin})}$ Wavelength at which intensity of radiation is at a maximum.

$I = \frac{\text{power}}{A}$ Intensity of radiation.

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

P = Power.
e = Emissivity.
σ = Stefan-Boltzmann constant.
A = Area.
T = Temperature.
λ = Wavelength.
I = Intensity.

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Sub-Topic 9.1: Simple Harmonic Motion – AHL only

$\omega = \frac{2\pi}{T}$	Angular frequency of oscillation.
$a = -\omega^2 x$	Acceleration of object in SHM.
$x = x_0 \sin\omega t; x = x_0 \cos\omega t$	Displacement of object in SHM.
$v = \omega x_0 \cos\omega t; v = -\omega x_0 \sin\omega t$	Velocity of object in SHM.
$v = \pm\omega\sqrt{(x_0{}^2 - x^2)}$	Velocity of object in SHM.
$E_K = \frac{1}{2}m\omega^2(x_0{}^2 - x^2)$	Kinetic energy of object in SHM.
$E_T = \frac{1}{2}m\omega^2 x_0{}^2$	Total energy of object in SHM.
pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$	Period of oscillation of a pendulum in SHM.
mass-spring: $T = 2\pi\sqrt{\frac{m}{k}}$	Period of oscillation of a mass on a spring in SHM.

ω = Angular frequency.

T = Period.

a = Acceleration.

x = Displacement from equilibrium.

x0 = Maximum displacement.

t = Time elapsed.

EK = Kinetic energy.

ET = Total energy.

l = Length of pendulum.

g = Gravitational field strength.

k = Spring constant.

Sub-Topic 9.2: Single-Slit Diffraction – AHL only

$\theta = \frac{\lambda}{b}$ Angle at which first minimum occurs in single-slit diffraction.

θ = Angle.

λ = Wavelength.

b = Slit width.

Sub-Topic 9.3: Interference – AHL only

$n\lambda = d\sin\theta$ Path difference between slits for a diffraction grating (constructive/ destructive interference).

Constructive interference: $2dn = \left(m + \frac{1}{2}\right)\lambda$

Destructive interference: $2dn = m\lambda$

Interference patterns for thin-film interference.

n = Any integer (for diffraction grating).

λ = Wavelength.

d = Slit spacing (for diffraction grating).

θ = Angle.

d = Thickness of medium (for TFI).

n = Refractive index of medium (for TFI).

m = Any integer (for TFI).

Sub-Topic 9.4: Resolution – AHL only

$\theta = 1.22\frac{\lambda}{b}$ First minimum for diffraction in a circular aperture.

$R = \frac{\lambda}{\Delta\lambda} = mN$ Resolvance of a diffraction grating.

θ = Angle.

λ = Wavelength.

b = Slit width/ diameter.

R = Resolvance

Δλ = Smallest possible resolvable wavelength difference.

m = Diffraction order.

N = Number of slits illuminated.

Sub-Topic 9.5: Doppler Effect – AHL only

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

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

$\frac{\Delta f}{f} = \frac{\Delta\lambda}{\lambda} \approx \frac{v}{c}$ Doppler effect for light.

f′ = Perceived frequency.

f = Actual frequency.

v = Wave speed.

us = Velocity of source.

uo = Velocity of observer.

λ = Wavelength.

v = Relative speed of observer and source.

c = Speed of light.

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	Sub-Topic 10.1: Describing Fields – AHL only	Sub-Topic 10.2: Fields at Work – AHL only	
W = Work done. q = Charge. Ve = Electric potential. m = Mass. Vg = Gravitational potential.	$W = q\Delta V_e$ Work done moving a charge between 2 points in a field. $W = m\Delta V_g$ Work done moving a mass between 2 points in a field. Potential. Field strength. Potential energy. Force.	$V_g = -\frac{GM}{r}$; $V_e = \frac{kQ}{r}$ $g = -\frac{\Delta V_g}{\Delta r}$; $E = -\frac{\Delta V_e}{\Delta r}$ $E_p = mV_g = -\frac{GMm}{r}$; $E_p = qV_e = \frac{kQq}{r}$ $F_g = \frac{GMm}{r^2}$; $F_e = \frac{kQq}{r^2}$ $v_{esc} = \sqrt{\frac{2GM}{r}}$ Escape velocity of a planet. $v_{orbit} = \sqrt{\frac{GM}{r}}$ Velocity of a body in circular orbit around another body.	Vg = Gravitational potential. Ve = Electric potential. G = Gravitational constant. k = Coulomb constant. M = Mass. Q = Charge. r = Separation distance. g = Gravitational field strength. E = Electric field strength. Ep = Potential energy. m = Mass. q = Charge. Fg = Gravitational force. Fe = Electric force. V(esc) = Escape velocity. V(orbit) = velocity of orbit.

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Φ = Magnetic flux.

B = B = Magnitude of magnetic field.

A = Area of coil.

N = Number of turns.

t = Time elapsed.

v = Speed of wire.

l = Length of wire.

I(rms) = Effective current.

I0 = Maximum current.

V(rms) = Effective pd.

V0 = Maximum pd.

R = Resistance

P(max) = Maximum power dissipated.

P = Power dissipated.

ε = Emf.

N = Number of turns.

p/s = Primary/ secondary.

Sub-Topic 11.1: Electromagnetic Induction – AHL only

$\Phi = BA\cos\theta$ Magnetic flux.

$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ Induced emf in a coil.

$\varepsilon = Bvl$ Induced emf in a conductor moving through a field.

$\varepsilon = BvlN$ Induced emf in a coiled wire moving through a field.

Sub-Topic 11.2: Power Generation and Transmission – AHL only

$I_{rms} = \frac{I_0}{\sqrt{2}}$ Effective (root mean square) current in an AC generator.

$V_{rms} = \frac{V_0}{\sqrt{2}}$ Effective (root mean square) potential difference in an AC generator.

$R = \frac{V_0}{I_0} = \frac{V_{rms}}{I_{rms}}$ Resistance.

$P_{max} = I_0 V_0$ Maximum power dissipated.

$\bar{P} = \frac{1}{2} I_0 V_0$ Average power dissipated.

$\frac{\varepsilon_p}{\varepsilon_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$ Ratios of emf, turns and current in a transformer.

Sub-Topic 11.3: Capacitance – AHL only

$C = \frac{q}{V}$ Capacitance of a capacitor.

$C_{parallel} = C_1 + C_2 + \ldots$ Capacitance of capacitors in parallel.

$\frac{1}{C_{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$ Capacitance of capacitors in series.

$C = \varepsilon\frac{A}{d}$ Capacitance of a capacitor.

$E = \frac{1}{2}CV^2$ Energy stored in a capacitor.

$\tau = RC$ Time constant for a circuit.

$q = q_0 e^{-\frac{t}{\tau}}$ Exponential decrease of charge stored for a discharging capacitor.

$I = I_0 e^{-\frac{t}{\tau}}$ Exponential decrease of current for a discharging capacitor.

$V = V_0 e^{-\frac{t}{\tau}}$

C = Capacitance.

q = Charge.

V = Potential (difference).

ε = Permittivity of dielectric material.

A = Area of plates.

d = Separation of plates.

E = Energy stored.

τ = Time constant.

R = Resistance.

q0 = Original charge.

t = Time elapsed.

I = Current.

I0 = Initial maximum current.

V0 = Initial maximum potential difference.

Examples using all of the formulas are available at:
www.YourEducationPlus.com

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	Sub-Topic 12.1: The Interaction of Matter with Radiation – AHL only	Sub-Topic 12.2: Nuclear Physics – AHL only	
E = Energy. h = Planck's constant. f = Frequency. Φ = Work function. n = State of atom. m = Mass. v = Velocity. r = Radius. Ψ = Wave function. V = Volume. x = Position. p = Momentum. t = Time.	$E = hf$ Energy of a photon. $E_{max} = hf - \Phi$ Kinetic energy of freed electron (photoelectric effect) (= e × stopping voltage). $E = -\frac{13.6}{n^2} eV$ Quantised energy of electron in the hydrogen atom. $mvr = \frac{nh}{2\pi}$ Angular momentum of the orbiting electron in the hydrogen atom. $P(r) = \lvert\psi\rvert^2 \Delta V$ Probability that an electron will be found within a small volume ΔV. $\Delta x \Delta p \geq \frac{h}{4\pi}$ Uncertainty in momentum and position of a particle (Heisenberg). $\Delta E \Delta t \geq \frac{h}{4\pi}$ Uncertainty in energy and lifetime of the state of a particle (Heisenberg).	$R = R_0 A^{\frac{1}{3}}$ Nuclear radius of an element. $N = N_0 e^{-\lambda t}$ Number of nuclei left in a radioactive sample. $A = \lambda N_0 e^{-\lambda t}$ Activity of a radioactive sample. $\sin\theta \approx \frac{\lambda}{D}$ First minimum of an electron diffraction pattern around a circular object.	R = Nuclear radius. R0 = Fermi radius (constant). A = Atomic mass number. N = Number of nuclei. N0 = Original number of nuclei. A = Activity. λ = Decay constant. θ = Angle of first minimum. λ = De Broglie wavelength. D = Diameter of circular object.

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Sub-Topic A.1: The Beginnings of Relativity – SL & HL	Sub-Topic A.2: Lorentz Transformations – SL & HL
$x' = x - vt$ $u' = u - v$	$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ $x' = \gamma(x - vt);\ \Delta x' = \gamma(\Delta x - v\Delta t)$ $t' = \gamma\left(t - \frac{vx}{c^2}\right);\ \Delta t' = \gamma\left(\Delta t - \frac{v\Delta x}{c^2}\right)$ $u' = \frac{u - v}{1 - \frac{uv}{c^2}}$ $\Delta t = \gamma \Delta t_0$ $L = \frac{L_0}{\gamma}$ $(ct')^2 - (x')^2 = (ct)^2 - (x)^2$
Sub-Topic A.3: Spacetime Diagrams – SL & HL	
$\theta = \tan^{-1}\left(\frac{v}{c}\right)$	

Sub-Topic A.4: Relativistic Mechanics – AHL only	Sub-Topic A.5: General Relativity – AHL only
$E = \gamma m_0 c^2$ $E_0 = m_0 c^2$ $E_K = (\gamma - 1) m_0 c^2$ $p = \gamma m_0 v$ $E^2 = p^2c^2 + m_0^2 c^4$ $qV = \Delta E_K$	$\frac{\Delta f}{f} = \frac{g\Delta h}{c^2}$ $R_s = \frac{2GM}{c^2}$ $\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{R_s}{r}}}$

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Sub-Topic B.1: Rigid Bodies and Rotational Dynamics - SL & HL	Sub-Topic B.2: Thermodynamics - SL & HL
$\Gamma = Fr\sin\theta$ $I = \sum mr^2$ $\Gamma = I\alpha$ $\omega = 2\pi f$ $\omega_f = \omega_i + \alpha t$ $\omega_f^2 = \omega_i^2 + 2\alpha\theta$ $\theta = \omega_i t + \frac{1}{2}\alpha t^2$ $L = I\omega$ $E_{K_{rot}} = \frac{1}{2}I\omega^2$	$Q = \Delta U + W$ $U = \frac{3}{2}nRT$ $\Delta S = \frac{\Delta Q}{T}$ $pV^{\frac{5}{3}} =$ constant (for monatomic gases) $W = p\Delta V$ $\eta = \frac{\text{useful work done}}{\text{energy input}}$ $\eta_{Carnot} = 1 - \frac{T_{cold}}{T_{hot}}$
Sub-Topic B.3: Fluids and Fluid Dynamics – AHL only	**Sub-Topic B.4: Force Vibrations and Resonance – AHL only**
$B = \rho_f V_f g$ $P = P_0 + \rho_f gd$ $Av =$ constant $\frac{1}{2}\rho v^2 + \rho gz + p =$ constant $F_D = 6\pi\eta rv$ $R = \frac{vr\rho}{\eta}$	$Q = 2\pi\frac{\text{energy stored}}{\text{energy dissipated per cycle}}$ $Q = 2\pi \times \text{resonant frequency} \times \frac{\text{energy stored}}{\text{power loss}}$

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	Sub-Topic C.1: Introduction to Imaging - SL & HL	Sub-Topic C.2: Imaging Instrumentation - SL & HL	
	$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$ $P=\frac{1}{f}$ $m=\frac{h_i}{h_o}=-\frac{v}{u}$ $M=\frac{\theta_i}{\theta_o}$ $M_{\text{near point}}=\frac{D}{f}+1;\ M_{\text{infinity}}=\frac{D}{f}$	$M=\frac{f_o}{f_e}$ **Sub-Topic C.3: Fiber Optics - SL & HL** $n=\frac{1}{\sin c}$ $\text{attenuation}=10\log\frac{I}{I_0}$ **Sub-Topic C.4: Medical Imaging – AHL only** $L_I=10\log\frac{I_1}{I_0}$ $I=I_0e^{-\mu x}$ $\mu x_{\frac{1}{2}}=\ln 2$ $Z=\rho c$	

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	Sub-Topic D.1: Stellar Quantities - SL & HL	Sub-Topic D.2: Stellar Characteristics and Stellar Evolution - SL & HL	
d = Distance from Earth to a star. p = Parallax angle. L = Luminosity. σ = Stefan-Boltzmann constant. A = Area. T = Temperature. b = Apparent brightness. d = Distance to star.	$d\,(\text{parsec}) = \frac{1}{p\,(\text{arc-second})}$ Distance to a star in parsec. $L = \sigma A T^4$ Luminosity of a star. $b = \frac{L}{4\pi d^2}$ Apparent brightness of a star.	$\lambda_{max} T = 2.9 \times 10^{-3}$ mK Relation between wavelength of maximum intensity radiation of a star and its temperature. $L \propto M^{3.5}$ Mass-luminosity relation for main sequence stars.	

	Sub-Topic D.3: Cosmology – SL & HL	Sub-Topic D.5: Further Cosmology – AHL only	
z = Red shift. λ(0) =Emitted wavelength. v = Relative velocity of light source. c = Speed of light. R = Cosmic scale factor. R(0) = H(0) = Hubble constant. d = Distance from Earth.	$z = \frac{\Delta\lambda}{\lambda_0} \approx \frac{v}{c}$ Red shift of a star/galaxy moving away from us. $z = \frac{R}{R_0} - 1$ Red shift depending on cosmic scale factor. $v = H_0 d$ $T \approx \frac{1}{H_0}$	$v = \sqrt{\frac{4\pi G\rho}{3}}r$ $\rho_c = \frac{3H^2}{8\pi G}$	λ = Wavelength. T = Temperature. L = Luminosity. M = Mass.

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Quantity	Symbol	Approximate Value
Acceleration of free fall (Earth's surface)	g	$9.81\,\text{m s}^{-2}$
Gravitational constant	G	$6.67 \times 10^{-11}\,\text{N m}^2\,\text{kg}^{-2}$
Avogadro's constant	N_A	$6.02 \times 10^{23}\,\text{mol}^{-1}$
Gas constant	R	$8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
Boltzmann's 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's 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	$1.20 \times 10^{-15}\,\text{m}$

***** Caution *****

These values are what the IB expects you to use. Using other values may cause errors due to rounding.

IBDP: Physics SL & HL Formulas & Constants (annotated)

First Examinations 2016 (updated version 1.1)

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