IB physics definitions and explanations

Quantities in italics are required definitions or explanations in the IB physics syllabus
Where the definition, etc, is from an exam markscheme:

- I have left the semicolons (;) in to indicate the number of points the definition was worth – one semicolon per mark.
- any words in brackets are not needed to gain the mark.
- OWTTE means 'or words to that effect' – ie equivalent phrasing is acceptable

Textbook references:

- W+H refers to Essential Principles of Physics by Whelan and Hodgson (2nd edition John Murray)
- Muncaster refers to A-level Physics by Roger Muncaster (Stanley Thornes)

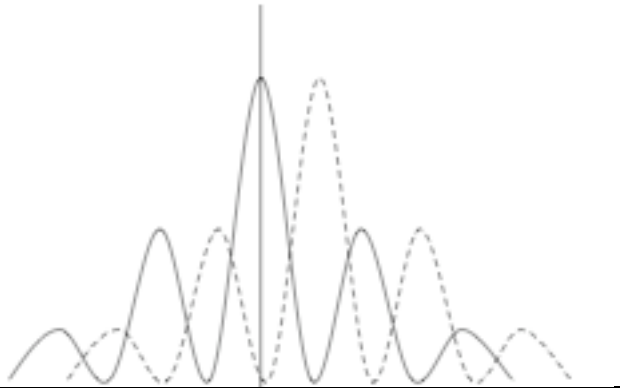
quantity	definition	reference
Physical measurement topic 1		
uncertainty		
systematic error		
Mechanics topics 2, 6, 9		
***displacement, s* [m]**	displacement of a particle is the length and direction of a line drawn to the particle from the origin	W+H p28
***velocity, v* [m s^{-1}]**	rate of change of position with time $\vec{v}_{average} = \frac{\Delta \vec{s}}{\Delta t}$	
***speed, v* [m s^{-1}]**	rate of distance travelled along a path $v_{average} = \frac{\text{distance travelled along the actual path}}{\text{time taken } \Delta t}$	
***acceleration, a* [m s^{-2}]**	rate of change of velocity with time $\vec{a}_{average} = \frac{\Delta \vec{v}}{\Delta t}$	
	change in velocity / rate of change of velocity; per unit time / with time; *(ratio idea essential to award this mark)*	N06H2 B1
(translational) equilibrium	a body in equilibrium has zero resultant force acting on it and therefore has zero acceleration	W+H p65
	sum of the (net) forces acting is zero;	M06H2 TZ1 A2
weight, W [N]	the weight of an object is the gravitational attraction of a massive body (eg Earth) for that object	W+H p37
conserved	any quantity which is conserved maintains a constant total value ▪ kinetic energy is conserved in elastic collisions ▪ total mechanical energy is conserved when friction is negligible and KE and PE are not changed to other forms (such as sound, internal energy) ▪ total mass is conserved in all non-relativistic situations ▪ total mass-energy is conserved in all situations	
conservation of energy	appropriate statement of principle of conservation of energy; *e.g. "Energy can not be created or destroyed, it just changes form."*	N05H2 B4
Newton's 1st law	a body will remain at constant velocity unless a net force acts on it	
Newton's 2nd law	the rate of change of momentum of a body is proportional to the net force acting on it $\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t}$ This simplifies to $\vec{F}_{net} = m\vec{a}$ when the mass of the body remains constant	
Newton's 3rd law	when two bodies A and B interact the force that A exerts on B is equal and opposite to the force that B exerts on A; ***or*** when a force acts on a body, an equal an opposite force acts on another body somewhere in the universe; ***[1 max]*** *Award **[0]** for "action and reaction are equal and opposite" unless they explain what is meant by the terms.*	N04H2 B3

quantity	definition	reference
***linear momentum, p* [kg m s^{-1}]**	the product of a body's mass and its velocity (therefore momentum is a vector with the same direction as the velocity) $\vec{p} = m\vec{v}$	
	momentum is mass x velocity; *allow an equation, with symbols explained.*	M05H2 TZ2 B1
	momentum is mass × velocity; *Allow an equation, with symbols explained.*	M08H2 TZ2 B1
***impulse, Δp* [kg m s^{-1}] or [N s]**	the change in momentum of a body, $\Delta\vec{p} = m\vec{v} - m\vec{u}$	
	impulse is force x time ***or*** change in momentum; *allow an equation, with symbols explained*	M05H2 TZ2 B1
	(impulse =) force x time for which force acts;	M08H2 TZ1 B1
	impulse is force × time / change in momentum; *Allow an equation, with symbols explained.*	M08H2 TZ2 B1
law of conservation of momentum	if the total external force acting upon a system is zero / for an isolated system; the momentum of the system is constant; *Award **[1 max]** if the answer is in terms of collisions.*	M05H2 TZ1 B1
	(vector) sum/total of momenta is constant; for isolated system;	M05H2 TZ2 B1
	if the net external force acting on a system is zero; then the total momentum of the system is constant (or in any one direction, is constant); *To achieve **[2]** answers should mention forces and should show what is meant by conserved. Award **[1 max]** for a definition such as "for a system of colliding bodies, the momentum is constant" and **[0]** for "a system of colliding bodies, momentum is conserved".*	N04H2 B3
	if the total (or net) external force acting on a system is zero / for an isolated system; the momentum of the system is constant/momentum before collision equals momentum after collision; ***[2]*** *Award **[1]** for "momentum before (collision)=momentum after (collision)".*	M06H2 TZ1 B4
	if the net external force acting on a system is zero / for an isolated system of interacting particles; the momentum of the system is constant / momentum before collision equals momentum after collision; ***[2]*** *Award **[1]** for momentum before collision equals momentum after collision.*	M06H2 TZ2 B4
	for isolated/closed system; total momentum remains constant;	N06H2 B1
	the momentum of a system (of interacting particles) is constant; if no external force acts on system / net force on system is zero / isolated system; [2] *A statement of "momentum before = momentum after" achieves first mark only.*	N07H2 B2
work, W [J]	force × distance (moved) in the direction of the force	M03H2 B2
power	the rate of working / work/time; *If equation is given, then symbols must be defined.*	M06H2 TZ2 B1
	the rate of working / $\frac{\text{work}}{\text{time}}$; *Ratio or rate must be clear.*	M08H2 TZ1 B4
kinetic energy, E_K [J]	the energy associated with a body because of its motion $E_K = \frac{1}{2}mv^2$	
potential energy, E_P [J]	the energy possessed by a system due to the relative positions of its component parts (ie due to the forces between the component parts)	
elastic collision	a collision in which the total KE is conserved	
	(a collision in which) kinetic energy is not lost / kinetic energy is conserved;	
inelastic collision	a collision in which some kinetic energy is transferred to other forms (eg internal energy, sound), therefore the total KE is less after the collision than before	
gravitational field strength	force exerted per unit mass; on a small / point mass;	M05H2 TZ1 B2

quantity	definition	reference
***g* [N kg^{-1}]**	the force exerted per unit mass; on a point mass; *Accept small mass or particle.*	N04H2 B2
	the force per unit mass; exerted on a point/small mass;	M07H2 TZ2 B2
test mass	a small mass which has a negligible effect on the gravitational field in which it is placed	
gravitational potential energy	the work done to move a body from infinity to a point in a gravitational field $E_P = -G\frac{m_1 m_2}{r}$	
***gravitational potential* *U* [J kg^{-1}]**	the work done per kilogram to move a body from infinity to a point in a gravitational field $V = -G\frac{m}{r}$	
	the work done per unit mass; in bringing a small/point mass; from infinity to the point (in the gravitational field);	M06H2 TZ2 A2
	the work done per unit mass; in bringing a small/point mass from infinity to a point (in the gravitational field); *Ratio idea essential for first mark*	M07H2 TZ1 B4
escape speed	speed of object at Earth's surface; so that it will escape from the gravitational field / travel to infinity;	M04H2 TZ1 B4
	speed (of object) at surface (of planet) / specified starting point; so that object may move to infinity / escape gravitational field of planet;	N06H2 B2
Thermal topics 3, 10		
temperature, T [K]	measure of how hot something is (it can be used to work out the direction of the natural flow of thermal energy between two objects in thermal contact) **OR** measure of the average K.E. of molecules it is measured on a defined scale (Celsius, Kelvin *etc*.)	N03H2 B4
	temperature is proportional to a measure of the average kinetic energy; of the molecules of the substance; *or*: idea that temperature shows natural direction of the flow of thermal energy; from high to low temperature / *OWTTE*; *(do not accept ìhot to coldî)* ***[2]*** *Award* ***[1 max]*** *for a rough and ready answer and* ***[2 max]*** *for a more detailed answer.*	N05H2 B1
thermal energy	thermal energy is the KE of the component particles of an object thus measured in joules	N03H2 B4
heat, Q [J]	energy transferred from one body to another due to a temperature difference	
thermal equilibrium	2 bodies that are in thermal contact are in thermal equilibrium when the net heat flow between them is zero, therefore the 2 bodies must have the same temperature	
microscopic	on the scale of atoms and molecules eg the microscopic properties of a gas are particle mass, velocity, kinetic energy, momentum	
macroscopic	on the scale of people (ie what we observe) eg the macroscopic properties of a gas are temperature, volume, pressure, density	
ideal gas	gas that obeys the equation $pV = nRT$ / no forces between molecules; at all pressures, volumes and temperatures / any other postulate;	M03H2 A2
	obeys the universal gas law / $\frac{pV}{T}$ equation ***or*** molecules are elastic spheres of negligible volume; at all values of pressure, volume and temperature ***or*** no mutual force of attraction/repulsion;	M04H2 TZ1 B4
	satisfies pV = nRT (at all p, V and T) / point molecules / no intermolecular forces; *Allow any other kinetic theory assumption*	N08H2 A3
kinetic theory of gases	a model of the microscopic behaviour of gas particles that explains the macroscopic behaviour of the gas (ie the ideal gas law, $\frac{pV}{T} = \text{constant}$)	

quantity	definition	reference
internal energy, U [J]	• the sum of all random kinetic energies and mutual potential energies of the particles of the body or system • internal energy does not include the kinetic energy or potential energy of the body as a whole • an ideal gas has no intermolecular forces therefore the gas particles have no mutual potential energies therefore the internal energy of an ideal gas depends only on the KE of the particles (temperature of gas)	
	sum of (random) kinetic (and potential energies); of the molecules of the system *(allow atoms or particles)*;	M03H2 B2
***mole, n* [mol]**	amount of substance of a system which contains as many elementary units as there are carbon atoms in 12 x 10^{-3} kg of carbon-12	W+H p9
molar mass	the mass of one mole of a substance	
Avogadro constant, N_A	the number of atoms in exactly 12 x 10^{-3} kg of the nuclide carbon-12	
***specific heat capacity c* [J kg^{-1} K^{-1}]**	specific heat capacity is the amount of energy required to raise the temperature of unit mass through 1 K;	N04H2 B1
	quantity of thermal energy (heat) required to raise temperature of unit mass; by one degree; *Award **[1 max]** for use of units, rather than quantities.*	M05H2 TZ2 B4
	quantity of (thermal) energy/heat required to raise temperature of unit mass; by one degree; or $c = \frac{\Delta Q}{m\Delta\theta}$ with ΔQ, m and $\Delta\theta$ explained;	N07H2 B2
***Heat (thermal) capacity C* [J k^{-1}]**	the amount of energy / heat required to raise the temperature of a substance / object through 1K/ C;	M05H2 TZ1 A3
	the energy/heat required to raise/change the temperature of a substance by1K/ C;	M07H2 TZ2 B3
evaporation	evaporation is the escape of molecules from the surface of the liquid	W+H p227
boiling	boiling occurs when molecules escape in the form of bubbles of vapour from the body of the liquid	W+H p228
***specific latent heat, l* [J kg^{-1}]**	energy per unit mass required to change the phase of a substance at its phase change temperature	
	specific latent heat of vaporisation: quantity of thermal energy/heat required to convert unit mass / mass of 1 kg of liquid to vapour/gas; with no change of temperature / at its boiling point;	M08H2 TZ2 B2
***pressure, p* [pascal, Pa]**	the pressure experienced by a body immersed in a fluid is the (normal) force per unit area exerted by the fluid on the surface of the body $p = \frac{F}{A}$	
indicator diagram	graph of pressure against volume for a gas	
isochoric (isovolumetric)	a process where the volume remains constant, therefore there is no work done ($W = p\Delta V = 0$)	
	a process that takes place at constant volume	M05H2 TZ1 B4
isobaric	a process where the pressure remains constant	
	a process that takes place at constant pressure	M05H2 TZ1 B4
isothermal	a process where the temperature remains constant, therefore the internal energy remains constant for an ideal gas, $\Delta U = 0$	
	change in which the temperature stays constant;	M07H2 TZ1 B3
adiabatic	a process where no heat enters or leaves the system, $Q = 0$	
	a process in which there is no energy (heat) exchange; between system and surrounding; ***or*** all the work done; either increases or decreases the internal energy of the system;	M05H2 TZ1 B4
	a compression or expansion / change in state (of the gas); in which no (thermal) energy is exchanged between the gas and the surroundings / in which the work done is equal to the change in internal energy of the gas;	M06H2 TZ2 B1

quantity	definition	reference
work (derivation)	force on piston = pA; where A is area of piston. Piston moves distance x; work done = pAx; $Ax = V$, so $W = p\ V$;	M03H2 B2
entropy, S [J K^{-1}]	S [J K^{-1}], measure of disorder of a system	
	the degree of disorder (in the system)	M04H2 TZ1 A3
2nd law of thermodynamics	total entropy (of the universe); is increasing;	M04H2 TZ1 A3
	in any process, (reaction, event *etc*.) the overall entropy of the universe/a closed system increases ;	M04H2 TZ2 B4
	total entropy of universe is increasing;	N06H2 A3
Waves topics 4, 11		
***displacement, x* [m]**	distance in a particular direction; *(accept in terms of energy transfer)* (of a particle) from its mean position;	M04S2 TZ1 B2
***amplitude, X_0* [m]**	magnitude of the maximum displacement from the equilibrium position	
***frequency, f* [Hz]**	frequency: number of oscillations/vibrations per unit time; *Do not accept specific units e.g. seconds.*	M05H2 TZ2 B2
***period, T* [s]**	time taken for one complete oscillation	
phase difference		
monochromatic	single frequency / single colour / *OWTTE*;	N04H3 H
simple harmonic motion (SHM)	the net force on (or acceleration of) the object is proportional to the displacement of the object from equilibrium and is directed towards equilibrium	N02H2 B4
damping	the process whereby energy is taken from the oscillating system (usually due to friction)	
natural frequency	that frequency (or frequencies) at which a system oscillates when disturbed from its equilibrium state	
resonance	a system resonates when a periodic force is applied to it; and the frequency of the force is equal to the natural frequency of vibration of the system / *OWTTE*;	M05H2 TZ1 B2
	maximum amplitude of oscillation; when a periodic force is applied to it and the frequency of the force is equal to the natural frequency of vibration of the system / OWTTE;	M07H2 TZ2 B2
wavefront	line joining (neighbouring) points that have the same phase / displacement	M03S2 B1
ray	direction in which wave (energy) is travelling	M03S2 B1
transverse wave	motion of the particles is perpendicular to direction of wave travel	N02S2 B3
longitudinal wave	motion of the particles is parallel to direction of wave travel	
wave *frequency*	the number of vibrations performed in each second by the source	W+H p97
wave *period*	the time for one complete vibration performed by the source	
***wavelength*, λ [m]**	wavelength: distance moved by wave during one oscillation of the source; *Accept distance between successive crests or troughs.*	M05H2 TZ2 B2
wave speed	distance travelled per unit time; by the energy of the wave / by a wavefront;	M04S2 TZ1 B2
wave *intensity*		
refractive index	ratio of speed of EM waves; in vacuum to their speed in medium; *Award **[0]** for quoting from the data booklet without additional information.* ***or*** definition as ratio of sin (angle of incidence) to sin (angle of refraction); explanation of how these angles are measured;	N04H3 H
	$\frac{\sin i}{\sin r}$ or $\frac{c}{v}$	N07H3 H
	the ratio of the speed of light in vacuum to the speed of light in the medium / the ratio of the sine of the angle of incidence to the sine of the angle of refraction;	M08H3 TZ1 H
dispersion	splitting/separation (of white light) into its component colours; because different frequencies have different refractive indices;	N06H3 H
	light (that is a combination of colors/wavelengths/frequencies) is divided/split into its component colours/wavelengths/frequencies;	M07H3 TZ1 H

quantity	definition	reference
	optical dispersion: speed of light in a medium depends on frequency; the refractive index depends on frequency; light of different frequencies refracted by different amounts / OWTTE;	N07H3 H
Doppler effect	change in received frequency of sound (wave); as a result of relative motion of source and observer; *Accept other general descriptions but award **[1 max]** for an answer that just gives an example of the Doppler effect.*	N05H2 B4
	observed change in frequency; when there is relative motion between source and observer;	N07H2 B4
	the difference between the emitted and received frequency; when there is relative motion between the source and the receiver;	N08H2 B2
diffraction		
superposition		
principle of superposition	when two (or more) waves meet; resultant **displacement** is the sum of the individual **displacements**;	M03H2 B1
	if two or more waves overlap / OWTTE; the resultant displacement at any point is found by adding the displacements produced by each individual wave / e.g. peak/trough meets peak/trough to give maximum/minimum / OWTTE;	M07H2 TZ2 B2
interference	constructive interference: when two waves meet; resultant displacement found by summing individual displacements; to give maximum displacement / displacement greater than that of an individual wave;	M08H2 TZ2 B3
coherent	waves with a constant / predictable phase / *OWTTE*; *Be generous as it is hard to describe in a few words. Look for understanding.*	N04H3 H
	sources whose phase difference is constant;	M07H2 TZ1 B2
Rayleigh criterion	*Award **[2]** for a clear statement or **[2]** for a clear diagram.* the maximum of one diffraction pattern is coincident with the first minimum of the other; *or*: 	N05H3 H
Electricity and Magnetism topics 5, 6, 12		
***electric potential difference V* [volt, V]**	energy per unit charge; *(ratio idea necessary)* to move positive test charge between points;	M04H2 TZ1 B1
electronvolt, eV	the work done to move one electron through a potential difference of 1 V	
***electric current, I* [ampere, A]**	the rate of flow of charge past a given cross-section (of the conductor)	W+H p372
***resistance, R* [ohm, Ω]**		
***electromotive force (emf),* ξ [volt, V]**	e.m.f.: the power supplied per unit current / the energy supplied per unit charge;	M07H2 TZ2 A2
	the power supplied per unit current / the energy supplied per unit charge;	M08H2 TZ1 B3
	work done per unit charge in moving charge completely around the circuit / power supplied per unit current;	N08H2 B4
source of emf	a device which can supply energy to an electric current	W+H p388

quantity	definition	reference
Ohm's law	*Ohm's law*: the resistance of a conductor is constant / current proportional to potential difference if its temperature is constant;	M07H2 TZ2 A2
electric field strength, ***E* [N C^{-1}]**	the force per unit charge felt by a positive test charge placed in the field	N03H2 B3
	the force exerted per unit charge; on a small positive (test) charge; ***[2]*** *Accept either "small" or "test" or both.*	N04S2 B3
***electric potential energy* [J]**	the electric potential energy of a system of charges is the work done to move the charges from ∞ separation to their current positions	
electric potential, ***V* [J C^{-1}]**	the work done per unit charge; in bringing a small positive charge; from infinity to that point; *A completely accurate definition is necessary for* ***maximum*** *3 points*	M04H2 TZ2 B1
	energy/work per unit charge; in bringing a small positive test charge / positive point charge from infinity / positive test charge; *Award* ***[0]*** *for quoting formula without definition of symbols.*	N05H2 B2
	the work required per unit charge; to bring a small positive charge / positive test charge / positive point charge from infinity to the point;	M08H2 TZ1 B3
magnetic flux, Φ **[weber, Wb]**	the magnetic flux through a region is a measure of the number of magnetic field lines passing through the region	Muncaster
	product of normal component of magnetic field strength and area that it links / *OWTTE*; $\Phi = BA\cos\theta$	M07H2 TZ1 A4
magnetic flux linkage ***NΦ* [weber, Wb]**	product of number of turns in a coil and the flux through the coil	Muncaster
Faraday's law of electromagnetic induction	e.m.f. (induced) proportional to; rate of change /cutting of (magnetic) flux (linkage);	M05H2 TZ2 B3
	the e.m.f. induced in a circuit/coil/loop is equal to/proportional to; the rate of change of flux linking the circuit/coil/loop; *Do not allow "induced current".*	M06H2 TZ2 B3
	e.m.f. is proportional/equal to rate of change of flux (linkage); *(do not allow "induced current")*	N06H2 B2
	the induced e.m.f. (in a loop) is proportional to the rate of change of the magnetic flux linkage (in the loop);	M07H2 TZ1 B2
	the induced e.m.f. is equal/proportional to the rate of change/cutting of (magnetic) flux;	M07H2 TZ2 B3
	e.m.f. induced proportional to/equal to; rate of change of flux (linkage) / rate of flux cutting;	M08H2 TZ2 A4
	the induced e.m.f. is equal/proportional to the (negative time) rate of change of the magnetic flux (linkage through the loop);	N08H2 B1
Lenz's law	the induced e.m.f. / current is in such a direction that its effect is to oppose the change to which it is due / *OWTTE*;	M06H2 TZ2 B3
	e.m.f./induced current acts in such a direction to (produce effects to) oppose the change causing it;	N06H2 B2
	induced e.m.f. / current acts in such a direction; to tend/produce effects to oppose the change causing it;	N07H2 B3
Atomic and Nuclear topics 7, 13		
photoelectric emission	the freeing of electrons from the surface of a metal when light of sufficiently high frequency is shone onto the metal	
de Broglie waves	any appropriate statement; *e.g.* all particles can be represented as (probability) waves; which predict the probability of locating the particle; de Broglie relationship with definition of the symbols; wavelength determined by momentum;	N05H2 B3
atom	the smallest neutral particle that represents an element	W+H 16.1 p126

quantity	definition	reference
molecule	smallest particle of a substance that can exist under normal conditions eg a helium molecule is a helium atom; an oxygen molecule is a pair of oxygen atoms	W+H 16.2 p127
nuclide	a species of atom whose nucleus contains a specified number of protons and a specified number of neutrons	W+H 63.4 p509
	an atom or nucleus that is characterized by the constituents of its nucleus / a particular type of atom or nucleus / *OWTTE*; (in particular) by its proton (atomic) number and its nucleon number / number of protons and number of neutrons;	M08H2 TZ1 A3
isotope	same atomic number but different mass number ***or*** in terms of numbers of protons and neutrons	M02S2 B3
	the nuclei of different isotopes of an element have the same number of protons; but different numbers of neutrons; *Look for a little more detail than say just "same atomic (proton) number, different mass (nucleon) number".*	M05H2 TZ1 B1
	isotope: nuclei of elements with different number of neutrons; *Accept same Z different A / OWTTE.*	N04S2 B1
	different forms of same element / nuclei having same proton number; with different nucleon / mass numbers;	N06H2 B4
	nuclides that have the same proton number but different nucleon number / same number of protons different number of neutrons;	M08H2 TZ1 A3
nucleon	a proton or a neutron; *Both needed to receive* ***[1]***.	M04H2 TZ2 B3
	(a nucleon is either) a proton or a neutron / *OWTTE*;	N05H2 A3
	proton or neutron;	M07H2 TZ2 B4
nucleon number A	number of nucleons in the nucleus of an atom (same as mass number)	W+H 63.4 p509
proton number Z	number of protons contained in the nucleus (same as atomic number)	W+H 63.4 p509
neutron number N	number of neutrons in the nucleus of an atom	W+H 63.4 p509
activity	the number of radioactive disintegrations per unit time	N00H2 A1
radioactive half-life	the time required for the activity to drop to half	N00H2 A1
	the time for the activity of a radioactive sample to decrease to half its initial activity	M02H2 B3
	time for the activity to halve in value / time for the number of nuclei to transmute to nuclei of another element / *OWTTE*;	N04H2 B1
	time for activity/mass/number of nuclei to halve; clear indication of what halves – original isotope, (not daughters);	M05H2 TZ2 B1
unified atomic mass unit	$\frac{1}{12}$ of mass of carbon 12 atom	W+H 63.4 p509
decay constant, λ **[s^{-1}]**	probability of decay / constant in expression $\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$; per unit time / $\frac{\mathrm{d}N}{\mathrm{d}t}$ and N explained;	M04H2 TZ1 B3
	the probability that a nucleus will decay in unit time;	N04H2 B1
	probability of decay (of nucleus) per unit time (ratio must be clear); ***or*** $\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$ with $\frac{\mathrm{d}N}{\mathrm{d}t}$, λ, and N explained;	N06H2 B4
mass defect	the mass of a nucleus is always less the total mass of its constituent nucleons, the difference in mass is called the ***mass defect***	
binding energy	***either***: the energy released when the nuclide is assembled from its individual components; ***or***: the energy required when the nucleus is separated into its individual components;	M01S3 B1

quantity	definition	reference
	the difference between the mass of the nucleus and the sum of the masses of its individual nucleons / the energy required to separate a nucleus into its component nucleons / *OWTTE*;	M04H2 TZ2 B3
	appropriate definition; *e.g.* energy released when a nucleus is formed from its constituent nucleons / (minimum) energy needed to break a nucleus up into its constituent nucleons	N05H2 A3
	the minimum energy required to (completely) separate the nucleons in a nucleus / the energy released when a nucleus is assembled from its constituent nucleons;	N08H2 B2
binding energy per nucleon	the binding energy of a nucleus divided by the number of nucleons in the nucleus	
Energy, power and climate change topic 8		
degraded energy		
***energy density* of a fuel [J kg^{-1}]**	amount of available energy stored in a fuel per unit mass	
albedo	fraction of solar radiation reaching Earth that is reflected back into space	
surface heat capacity C_S **[J K^{-1} m^{-2}]**	energy required to raise the temperature of 1 m^2 of the Earth's surface by 1 K	
coefficient of volume expansion γ **[K^{-1}]**	the fractional change in volume per degree change in temperature	IB Physics Subject Guide
Digital technology topic 14		
***capacitance, C* [F]**	$C = \frac{Q}{V}$ Capacitance is the charge in coulombs required to raise the potential of a conductor by 1 V, ie 1 F = 1 C V^{-1}	
***quantum efficiency* of a pixel**	quantum efficiency is the ratio of the number of photoelectrons emitted to the number of photons incident on the pixel.	IB Physics Subject Guide
***magnification* for CCD**	magnification is the ratio of the length of the image on the CCD to the length of the object.	IB Physics Subject Guide
Astrophysics option E		
***light year* [ly]**	distance travelled by light in a vacuum in one year	
***luminosity, L* [W]**	the total power emitted (by the star);	N06H3 F
	(total) power radiated / energy radiated per unit time;	M07H3 TZ1 F
	(total) power emitted;	M07H3 TZ2 F
	luminosity is the total power emitted (by a star);	N07H3 F
***apparent brightness, l* [W m^{-2}]**	the (incident) power per unit area on/received at the (surface of) Earth;	N06H3 F
	a measure of the brightness of a star as it appears from Earth (in a relative classification system);	M08H3 TZ1 F
	the apparent brightness is the power/rate of energy received per unit area at Earth;	N08H3 F
***parsec* [pc]**		
absolute magnitude	(apparent) magnitude if star were to be a "given" distance from Earth; distance of 10 pc;	N05H3 F
	absolute magnitude is a measure of, how bright an object appears / the apparent magnitude, when observed from a distance of 10pc;	M07H3 TZ1 F
	the apparent magnitude a star would have if viewed from a distance of 10 pc;	N08H3 F
apparent magnitude	how bright an object appears to be from Earth; *Do not award marks for "magnitude".*	N05H3 F
	apparent magnitude is a measure of how bright an object appears (from Earth);	M07H3 TZ1 F
	power received (from a star) by an observer (on Earth) per unit area (of the detector);	M08H3 TZ1 F
	a measure of the brightness of a star as it appears from Earth; in a relative classification / on a 1-6 scale/logarithmic scale;	N08H3 F
Electromagnetic waves option G		
principal axis	*principal axis*: a line at right angles to the plane of the lens and that passes through the (optical) centre of the lens / *OWTTE*;	M08H3 TZ2 H

quantity	definition	reference
focal point/ principal focus	the point on the principal axis to which rays parallel to the principal axis are brought to a focus after refraction by the lens / it is a point on the PA from which rays will be parallel to the PA after refraction by the lens.	M03H3 H
	the point on the principal axis of the lens; through which a ray parallel to the principal axis goes after refraction in the lens / *OWTTE*;	M08H3 TZ1 H
	principal focus: a point on the principal axis to which rays parallel to the principal axis pass after refraction (through the lens) / *OWTTE*;	M08H3 TZ2 H
***focal length, f* [m]**	the image distance for an infinite object distance	W+H p259
linear magnification		
***power* of a *convex lens, F* [D]**	reciprocal of the focal length, $F = \frac{1}{f}$	
***dioptre,* [D]**	unit of lens power, 1 D = 1 m^{-1}	
far point	the position of the furthest object that can be brought into focus by the unaided eye / *OWTTE*; *Accept the distance to the furthest object etc.*	N04H3 H
	For the normal eye, the far point may be assumed to be at infinity and the near point is conventionally taken as being a point 25 cm from the eye.	IB Physics Subject Guide
near point	if the object is nearer than this to the eye then the eye cannot focus it clearly	N03H3 H
	the position of the closest object that can be brought into focus by the unaided eye / *OWTTE*; *Accept the distance to the closest object etc.*	N04H3 H
	point closer than which eye cannot focus;	M07H3 TZ2 H
angular magnification	$\frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at eye}}$; *Allow* $\frac{\alpha}{\beta}$ if α and β *are shown correctly on the diagram.*	M04H3 TZ2 H
	ratio of angle subtended by image at eye to angle subtended by object at eye;	M08H3 TZ1 H
aberration	the phenomenon of a point object not giving rise to a point image	W+H p267
spherical aberration	rays parallel to principal axis at edge of lens brought to different focus from those near centre of lens / OWTTE; image blurred / OWTTE;	M07H3 TZ2 H
chromatic aberration	different amounts of refraction for different colours/wavelengths; colour fringing of image;	M07H3 TZ2 H
Relativity option H		
frame of reference	a system of coordinates; that enables the position of various objects to be specified / that enables measurements to be made / *OWTTE*;	M08H3 TZ2 G1
	means of locating an object in space;	M06H3 TZ1 G
	a system of coordinates; that enables the position of various objects to be specified / that enables measurements to be made / *OWTTE*;	M08H3 TZ2 G
inertial frame of reference	a reference frame that is moving with constant velocity (or uniform speed in a straight line)	M01H3 G
	frame moving with constant velocity / frame in which Newton's first law is valid;	M04H3 TZ2 G
	frame of reference is at rest or moving at constant velocity / reference frame within which Newton's first law is valid;	N05H3 G
	a coordinate system (in which measurements can be made); that is not accelerating / Newton's first law holds;	N06H3 G
	a frame that is not accelerating / a frame in which Newton's first law is valid;	N08H3 G
Galilean transformation	transformations made under the assumptions that time measurements (and space measurements) are independent of the observer; *Accept "absolute".*	M06H3 TZ2 G
2 postulates of Special Theory of Relativity	*postulate 1*: the speed of light in vacuum is the same for all inertial observers; *postulate 2*: the laws of physics are the same for all inertial observers;	M04S3 TZ1 G
	speed of light in a vacuum is the same for all inertial observers;	N04H3 G

quantity	definition	reference
	laws of physics are the same for all inertial observers; *The words underlined are needed for the mark. Award* ***[1 max]*** *if both are on the* *right lines but not precise. Give benefit of the doubt if inertial is only mentioned once.*	
	laws of physics are the same in all inertial frames of reference; speed of light in a vacuum is the same in all inertial frames of reference;	N05H3 G
	there is no preferred inertial reference frame / the laws of physics are the same for all inertial observers; the speed of light in a vacuum is constant; in all inertial reference frames/for all inertial observers;	N06H3 G
proper time interval	the time as measured on a clock that is stationary in the observer's frame of reference	N01H3 G
	the time interval measured by an observer of an event that happens at the same place according to that observer	M03H3 G
	the time interval between two events measured in the reference frame in which the two events occur at the same place	N03H3 G
	time interval between two events measured in a reference frame where the events occur at the same place;	M07H3 TZ2 G
time dilation	the time between any two events that occur at the same place in an inertial reference frame / the proper time in particular reference frame will be measured to be longer; by observers in any other inertial reference frame;	N06H3 G
proper length	the length of an object as measured by an observer who is at rest relative to the object	M03H3 G
	the length of an object as measured by an observer at rest with respect to the object	N03H3 G
	length measured by observer at rest with respect to object;	M07H3 TZ2 G
	the length of an object in its rest frame / length measured by (inertial) observer with respect to whom object is at rest;	M08H3 TZ1 G
rest mass	rest mass is the mass of a body as measured in the body's rest frame / alternative correct and unambiguous definition;	M04H3 TZ1 G
	mass of object in observer's frame of reference; ***or*** mass when not moving; relative to observer;	M04H3 TZ2 G
spacetime	spacetime is four dimensional quantity / three dimensions of space and one of time;	N08H3 G
principle of equivalence	a frame of reference accelerating far from all masses with acceleration a; is completely equivalent to a frame of reference at rest in a gravitational field of field strength equal to a; *Accept "the impossibility of distinguishing gravitational from inertial effects" for full marks.*	M04H3 TZ1 G
	an observer cannot tell the difference between the effect of acceleration (in one direction) and a gravitational field (in the opposite direction); *Accept "It is impossible to distinguish between inertial or gravitational forces"* ***or*** *"there is no way in which gravitational effects can be distinguished from inertial effects" / OWTTE.*	N04H3 G
	it is not possible to distinguish between an accelerating frame and a stationary/inertial frame in a gravitational field; a stationary/inertial frame in a gravitational field is equivalent to an accelerating frame; ***[1 max]***	N05H3 G
	frame of reference far from all masses having acceleration a; is equivalent to frame of reference (at rest) in gravitational field of strength a; ***Or*** impossible to distinguish between accelerating reference frame; and a gravitational field;	M06H3 TZ1 G
black hole	if an object is dense enough it will cause extreme warping of spacetime such that any light leaving the surface will not be able to escape the spacetime surrounding the object	M03H3 G

quantity	definition	reference
	if object is dense/massive enough it will cause severe warping of space-time; such that light entering the space-time surrounding the object cannot escape; *Do not accept "light cannot escape".*	M06H3 TZ1 G
	black hole causes extreme warping of space in its vicinity; extreme warping causes photons/light to curve back into the black hole;	M07H3 TZ1 G
Schwarzschild radius	centre is single point to which all mass would collapse; surface is where the escape speed is equal to *c*; within this surface, mass has "disappeared" from the universe;	M04H3 TZ2 G
	the radius from within which nothing can escape to the outside / the distance from the black hole where the escape speed is equal to the speed of light;	M08H3 TZ1 G