CIE IGCSE physics equations 2016

Topic	Quantity	Symbol equation (whenever applicable)	Description	Other info e.g. ways to use them (other than plug in numbers)
General physics	Density	$\rho = m / V$	density = mass / volume	Units are often in kg m^{-3}, but g cm^{-3} is also commonly encountered. 1000 kg m^{-3} Is equivalent to 1 g cm^{-3}.
Kinematics / motion	Speed		speed = distance / time	The most common unit for speed is m s^{-1}.
Kinematics / motion	Velocity	$v = s / t$	velocity = displacement / time	The most common unit for velocity is m s^{-1}. The difference between distance and displacement is that distance = path length while displacement = change in position.
Kinematics / motion	Displacement -time graph		finding velocity	• Average velocity = connect two points on graph and work out gradient. • Instantaneous velocity = draw tangent line at a point and work out gradient.
Kinematics / motion	Acceleration	$a = (v - u) / t$	acceleration = change in velocity / time	The most common unit for acceleration is m s^{-2}.
Kinematics / motion	Velocity-time graph		Finding acceleration and displacement	• Average acceleration = connect two points on graph and work out gradient. • Instantaneous acceleration = draw tangent line at a point and work out gradient. • Displacement = area under curve. Treat area below the time-axis as negative displacement.
Force	Force	$F = ma$	Newton's 2nd law says that net force = mass × acceleration	The unit for force is the Newton (N). Forces that contribute to the resultant force often include external driving force, drag, friction, tension, reaction force, weight, and spring force.
Force	Spring constant	$F = kx$	Force = spring constant × extension	This is called Hooke's law. Here we are assuming that the spring hasn't exceeded its limit of proportionality.
Force	Force-extension graph		Force-extension graph	• Gradient = spring constant (k), unit = N m^{-1}. • Point where graph starts to curve = limit of proportionality (material may still be elastic but won't obey Hooke's law when deformed) • Limit of elasticity = the point beyond which material is permanently deformed and won't return to its original shape even if force removed • Area under graph (= $\frac{1}{2}kx^2$, not needed for exam) = spring elastic energy stored
Force	Weight	$W = mg$	Weight = mass × gravitation field strength	For objects near the Earth's surface, g = 10 m s^{-2}.
Force	Momentum	$p = mv$	Momentum = mass × velocity	
Force	Impulse	Impulse = $mv - mu$	Impulse = change in momentum	Be aware of appropriately assigning negative signs during situations where there is a change in direction e.g. rebounding.
Force	Impact force	$F = \frac{(mv - mu)}{t}$	Impact force = impulse / time	
Force	Conservation of momentum	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$	Total momentum before an event e.g. collision = total momentum afterwards.	If the collision is inelastic and the two objects are joined, then the equation becomes $m_1u_1 + m_2u_2 = (m_1 + m_2)v$ where v is the common velocity.

Energy	Work done	W = Fs	Work done (energy transferred by an external force) = Force × distance travelled ALONG the direction of movement	Work done by a force on an object can result in…… i) an increase in KE, ii) an increase in GPE, iii) an increase in elastic PE, iv) energy dissipated by friction (Friction x distance travelled) ……or a combination of all these.
Energy	Kinetic energy	$KE = \frac{1}{2} mv^2$	Energy of an object due to its motion	
Energy	Gravitational potential energy	GPE = mgΔh	Energy change of an object due to the change in its position within a constant gravitational field	Change in position is pretty much always just change in height or altitude.
Energy	Conservation of energy	$mg\Delta h = \frac{1}{2} mv^2$	Gain (or loss) of gravitational potential energy = loss (or gain) of kinetic energy	There are many other kinds of energy conversion, but PE to KE is the most common type of calculation-required energy conversion on exam papers.
Energy	Power	P = E / t	Power = energy transferred per unit time	
Energy	Efficiency	Efficiency = (output / input) × 100%	Efficiency = (output / input) x 100%	The output and input can be in terms of either energy, power, or even Voltage.
Force	Moment	Moment = F × d	Moment = force × perpendicular distance from the pivot	
Force	Conservation of moment	$F_1 \times d_1 = F_2 \times d_2$	Sum of all anticlockwise moment = sum of all clockwise moment	When this happens, an object is said to be in rotational equilibrium.
Pressure	Mechanical pressure	P = F / A	Mechanical pressure = force / contact area	The unit of pressure is the Pascal. 1 Pa = 1 N m^{-2}.
Pressure	Liquid pressure	P = ρgΔh	Pressure at bottom of liquid = density × gravity × difference in height	
Pressure	Hydraulics	$F_1/A_1 = F_2/A_2$	Pressures on either side of a hydraulic system are the same	
Wave	Frequency, period	f = 1 / T and T = 1 / f	Frequency = 1 / Period Period = 1 / Frequency	Period is usually the more readily available quantity -- can be read off diagrams.
Wave	Speed	v = f × λ or c = f × λ	Speed of wave = frequency × wavelength	In 1 period, a wave will travel 1 wavelength. Speed of electromagnetic waves in vacuum all equals to 3×10^8 m/s. Speed of sound in air is about 330 m/s.
Wave	Refraction	n = sin i / sin r	Refractive index = sine(incident angle) / sine(refracted angle)	These notations and symbols apply when light travels from air into a higher-density medium. The more general way to use this is n = sin(bigger angle) / sin(smaller angle) – this equation is applicable even when light is travelling in the other direction. The path of light will be the same regardless of direction of travel.

Wave	Refraction	n = 1 / sin c	Refractive index = 1 / sine(critical angle)	This equation applies only when light tries to emerge from a dense medium and enter a less dense medium, typically air. If an incident angle exceeds c then total internal reflection takes place. If incident angle < c then the ray can mostly undergo refraction, even though a tiny amount of internal reflection will still occur.
Wave	Refraction	$n = c_{air} / c_{medium}$	Refractive index is the ratio of speed of light in air vs. speed of light in the medium of interest.	Keep in mind that when waves undergo refraction, speed changes (decrease), wavelength changes (decreases) and frequency DOESN'T CHANGE.
Wave	Reflection	i = r	Angle of incidence = angle of reflection	
Wave	Thin lens	M = v / u	Magnification = lens-image distance / lens-object distance magnification	
Wave	Thin lens	$M = h_i/h_o$	Magnification = image size / object size	
Wave	Thin lens	1/f = 1/u + 1/v	1/focal length = 1/u + 1/v, with u and v as denoted above	This equation will not be formally tested, but is nevertheless a convenient tool for you to accurately pre-determine the position of the image before you actually draw the ray diagram. A negative value for v indicates a virtual image.
Wave	Speed of sound using pulse-echo technique	v = 2d / t	speed of sound = 2 × distance / time	This is a twist on the classic v = d / t. The 2 in front of the d is due to the sound travelling a round trip -- reflection off a surface as an echo before arriving the detector placed next to the source.
Heat	Thermal capacity	Q = CΔT	Thermal energy = heat capacity × change in temperature	
Heat	Specific heat capacity	Q = mcΔT	Thermal energy = mass × specific heat capacity × change in temperature	Specific heat capacity is a property of a substance while thermal capacity is not. We can describe the heat capacity of a heater or a beaker or an apparatus set, but specific heat capacity applies to substances like water, aluminium, carbon dioxide and copper. Also, the sign of Q tells us if energy is absorbed (ΔT > 0, the substance warms so Q > 0) or released (ΔT < 0, the substance cools so Q < 0) by the substance. Finally, the ΔT in this equation can be in degree-Celsius or in Kelvin, because a difference of 1 degree Celsius is the same as a difference of 1 Kelvin.
Heat	Specific latent heat	Q = mL	Thermal energy = mass × specific latent heat	There are two types of latent heats: i) Latent heat of fusion, L_f: energy involved during a solid--liquid phase change. For example, the value for L_f of ice is 334000 J / kg, meaning that it takes 334000 J to melt 1 kg of ice into water with temperature staying constant (at 0 ºC). ii) Latent heat of vaporization, L_v: energy involved during a liquid-gas phase change. For example, the value for L_v of water is 2260000 J / kg, meaning that it will take 2260000 J to completely boil 1 kg of water with temperature staying constant (at 100 ºC).

Heat	Absolute zero	K = C + 273	The temperature in Kelvin = temperature in Celsius + 273	0 K is also known as absolute zero, the temperature at which all molecular motions stop and all molecules have zero kinetic energy.
Heat	Ideal gas law	$P_1V_1/T_1 = P_2V_2/T_2$	For a constant amount of ideal gas subjected to various conditions, the product of PV divided by T is constant	This is the general gas law that features varying P, V and T. If any of these values are held constant, however, then either of the following gas laws can be used. Keep in mind that the temperature has to be in Kelvin in order for the ideal gas law (or variations thereof) to be applied.
Heat	Boyle's law	$P_1V_1 = P_2V_2$	For a fixed amount of ideal gas kept at constant temperature, pressure and volume are inversely proportional to each other.	This applies to constant-temperature situations, for example, compressing a syringe of gas, or filling balloons with a cylinder of pressurized gas.
Heat	Charles' law	$V_1/T_1 = V_2/T_2$	For a fixed amount of ideal gas kept at constant pressure, temperature and volume are directly proportional to each other.	This applies to constant-pressure situations, for example, warming a gas in a flexible container (balloon or syringe) against a constant external pressure, or warming a vessel of gas connected to a mercury manometer / barometer.
Heat	Pressure law	$P_1/T_1 = P_2/T_2$	For a fixed amount of ideal gas kept at the same volume, pressure and temperature are directly proportional to each other.	This applies to constant-volume transformations, such as heating or cooling a gas in a rigid (metal or glass) container.
Electricity	Current	I = Q / t	Current is defined to be the rate of flow of charge.	Charge is a fundamental property of matter and is measured in Coulombs. Current is measured in Amps (Amperes).
Electricity	Voltage	V = work done / Q	Voltage is work (electrical energy) done, on or by the charge, per unit charge	Voltage is measured in Volts. The term voltage is often used loosely, and can refer to either...... EMF (electromotive force) = energy <u>per unit charge</u> SUPPLIED TO the charge in driving the charges a complete loop around the circuit, or...... Potential difference = energy per unit charge transferred (LOST) to (dissipated at) circuit components that have resistance
Electricity	Resistance	R = V / I	Resistance = Voltage across a circuit component / current through the circuit component	Resistance is measured in Ohms. Ohm's law is a special case of V = IR with R being constant, resulting in V being directly proportional to I. Typical conductors that obey Ohm's law would be a metal wire maintained at <u>constant temperature</u>.
Electricity	Resistivity	R = ρL/A	Resistance = resistivity × length / cross-section area	Resistance is directly proportional to length and inversely proportional to cross-section area. Resistivity (ρ) is a property of materials. Good conductors have low resistivities, and vice versa.

<table>
<tr><td>Electricity</td><td>2 resistors in series</td><td colspan="2">$R_{total} = R_1 + R_2$
I is constant and equals to EMF / $(R_1 + R_2)$
EMF is shared in a ratio that's directly proportional to resistance:
EMF = $V_1 + V_2 = IR_1 + IR_2$ so $V_1/R_1 = V_2/R_2$</td><td>Because I is constant, the more resistive component of the two will dissipate a greater share of the EMF and dissipate more power.</td></tr>
<tr><td>Electricity</td><td>2 resistors in parallel</td><td colspan="2">$1/R_{total} = 1/R_1 + 1/R_2$
Current in main loop = $I_1 + I_2$
EMF = $V_1 = V_2$</td><td>Because both branches will be subjected to the same Voltage, the more resistive component of the two will experience a lower current and will dissipate less power.</td></tr>
<tr><td>Electricity</td><td>Electrical power</td><td>P = IV</td><td>Power = Voltage × current</td><td>This can be used to calculate……

Power delivered by battery = EMF × current through the battery, or

Power dissipated at circuit components = Voltage across the component × current through the component.</td></tr>
<tr><td>Electricity</td><td>Electrical energy</td><td>E = IVt</td><td>Energy = Voltage × current × time</td><td>This is simply a combination of P = energy / time and P = IV.</td></tr>
<tr><td>Electricity</td><td>Logic gates</td><td>Truth table (1 = high voltage or current output, and 0 = low voltage or current output)</td><td colspan="2">
NOT gate
<table><tr><th>Input</th><th>Output</th></tr><tr><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td></tr></table>
OR gate
<table><tr><th>Input 1</th><th>Input 2</th><th>Output</th></tr><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td></tr></table>
AND gate
<table><tr><th>Input 1</th><th>Input 2</th><th>Output</th></tr><tr><td>1</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>0</td><td>0</td><td>0</td></tr></table>
NOR gate
<table><tr><th>Input 1</th><th>Input 2</th><th>Output</th></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td></tr></table>
NAND gate
<table><tr><th>Input 1</th><th>Input 2</th><th>Output</th></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td><td>1</td></tr></table>
</td></tr>
<tr><td>Electricity</td><td>Transformer</td><td>$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$</td><td>In a transformer, voltage output-input ratio = number of loops in output (secondary coil) / number of loops in the primary coil. Current, on the other hand, is inversely proportional to the number of loops in the coils.</td><td></td></tr>
<tr><td>Nuclear physics</td><td>Atomic number</td><td></td><td>Atomic number = Number of protons</td><td></td></tr>
<tr><td>Nuclear physics</td><td>Mass number</td><td></td><td>Mass number = Number of protons + number of neutrons</td><td></td></tr>
<tr><td>Nuclear physics</td><td>Isotopes</td><td></td><td>Isotopes are atoms with the same atomic number but different mass number (due to different number of neutrons).</td><td></td></tr>
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Nuclear physics	Alpha decay equation		In an alpha-decay, an alpha particle (${}^{4}_{2}He$) is emitted. The original nucleus experiences a decrease in proton number of 2 and a decrease in mass number of 4.	An example would be ${}^{44}_{20}Ca \rightarrow {}^{40}_{18}Ar + {}^{4}_{2}He$. Note how the proton and mass numbers are conserved during the decay.
Nuclear physics	Beta decay equation		In a beta decay, a neutron converts itself into a proton and an electron. The proton stays put inside the nucleus while the ejected electron is called a beta particle. The nucleus experiences an increase of proton number by one, while the mass number stays the same (11p + 13n becoming 12p + 12n – still 24 nucleons in total). The notation for the electron is ${}^{0}_{-1}\beta$.	An example would be ${}^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + {}^{0}_{-1}\beta$. Note how the proton and mass numbers are conserved during the decay.
Nuclear physics	Decay curve		Finding half-life of an isotope from a decay curve	The half-life of a radioactive isotope is the time taken for the activity of a radioactive sample to decay to half the original value. Nuclear decays follow a constant half-life pattern -- in this graph the half-life can be determined to be 7 seconds.