Cambridge IGCSE · Physics 0625

Physics 0625 formulas and definitions

All 213 formulas, facts and definitions to learn, by syllabus topic. Formulas the exam gives you are left out.

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1 Motion, forces and energy

1.1 Physical quantities and measurement techniques

Length measured from a mark other than zero = end reading − start reading

Time interval = later reading − earlier reading, with $1\ \text{min} = 60\ \text{s}$

Volume of a box shape: $V = l \times w \times h$

Volume by displacement: $V = V_2 - V_1$

One of many: $\text{size of one} = \dfrac{\text{total measured}}{\text{number of items}}$

Period of a pendulum: $T = \dfrac{\text{time for } n \text{ oscillations}}{n}$

Mean $= \dfrac{\text{sum of the readings}}{\text{number of readings}}$

Extended only: resultant of a and b at right angles: $R = \sqrt{a^2 + b^2}$

Extended only: direction: $\tan\theta = \dfrac{b}{a}$, angle measured from the direction of a

1.2 Motion

Speed: $v = \dfrac{s}{t}$, so $s = vt$ and $t = \dfrac{s}{v}$

Average speed $= \dfrac{\text{total distance travelled}}{\text{total time taken}}$

Distance–time graph: gradient = speed

Speed–time graph: area under the graph = distance travelled

Distance at a steady change from u to v: $s = \dfrac{u+v}{2} \times t$ (the trapezium area)

Acceleration of free fall: $g \approx 9.8\ \text{m/s}^2$

Extended only: acceleration $a = \dfrac{\Delta v}{\Delta t}$, in m/s²

Extended only: speed–time graph: gradient = acceleration

Extended only: deceleration = negative acceleration

1.3 Mass and weight

Gravitational field strength: $g = \dfrac{W}{m}$ (force per unit mass)

Weight: $W = mg$; mass: $m = \dfrac{W}{g}$

g is equal to the acceleration of free fall

Units: mass in kg, weight in N, g in N/kg; $1000\ \text{g} = 1\ \text{kg}$

1.4 Density

Density: $\rho = \dfrac{m}{V}$ (mass per unit volume)

Rearranged: $m = \rho V$, $V = \dfrac{m}{\rho}$

Volume of a cuboid = length $\times$ width $\times$ height

Volume by displacement = reading with object $-$ reading without

Units: g/cm³ or kg/m³; 1 g/cm³ $= 1000$ kg/m³

Density of water $= 1.0$ g/cm³ $= 1000$ kg/m³ (given in the question when needed)

Floats if $\rho_{\text{object}} < \rho_{\text{liquid}}$; sinks if $\rho_{\text{object}} > \rho_{\text{liquid}}$

1.5 Forces

Resultant along a line: add forces in the same direction, subtract forces in opposite directions

Extension = stretched length $-$ unstretched length

Extended only: spring constant $k = \dfrac{F}{x}$ (force per unit extension), in N/m or N/cm

Extended only: $F = ma$ (F is the resultant force, same direction as a)

Moment = force $\times$ perpendicular distance from the pivot, in N m

Principle of moments: sum of clockwise moments = sum of anticlockwise moments

Equilibrium: no resultant force **and** no resultant moment

Weight $W = mg$ (from Mass and weight)

1.6 Momentum

Extended only: momentum $p = mv$ (a vector, in kg m/s)

Extended only: change in momentum $\Delta p = mv - mu$, with signs for direction

Extended only: impulse $= F\Delta t = \Delta(mv)$, in N s

Extended only: resultant force $F = \dfrac{\Delta p}{\Delta t}$

Extended only: conservation: total momentum before = total momentum after (no external force)
Extended only: stream of material: F = mass per second × change in velocity
1 N s = 1 kg m/s
$F = ma$ and $a = \dfrac{v - u}{t}$ (from Forces and Motion)

1.7 Energy, work and power

Work done $W = Fd = \Delta E$ (force × distance moved in the direction of the force)
Power $P = \dfrac{W}{t}$ and $P = \dfrac{\Delta E}{t}$; so $\Delta E = Pt$
Extended only: kinetic energy $E_k = \frac{1}{2}mv^2$
Extended only: change in gravitational potential energy $\Delta E_p = mg\Delta h$
Extended only: efficiency = $\dfrac{\text{useful energy output}}{\text{total energy input}} (\times 100\%)$
Extended only: efficiency = $\dfrac{\text{useful power output}}{\text{total power input}} (\times 100\%)$
Extended only: falling from rest with no air resistance: $v = \sqrt{2g\Delta h}$ (from $\frac{1}{2}mv^2 = mg\Delta h$)
Wasted energy = total input − useful output
Units: energy and work in J (kJ, MJ); power in W (kW, MW); 1 W = 1 J/s; 1 kWh = 3.6×10^6 J

1.8 Pressure

Pressure $p = \dfrac{F}{A}$ (force per unit area); so $F = pA$ and $A = \dfrac{F}{p}$
Force from a mass: weight $W = mg$
Extended only: change in pressure in a liquid $\Delta p = \rho g \Delta h$; so $\rho = \dfrac{\Delta p}{g\Delta h}$ and $\Delta h = \dfrac{\Delta p}{\rho g}$
Extended only: total pressure = atmospheric pressure $+ \rho g h$
Density $\rho = \dfrac{m}{V}$ (for the mass of liquid in a tank)
Units: 1 Pa = 1 N/m²; 1 kPa = 1000 Pa; 1 N/cm² = $10\,000$ Pa; 1 m² = $10\,000$ cm²

2 Thermal physics

2.1 Kinetic particle model of matter

$T\ (\text{in K}) = \theta\ (\text{in } ^\circ\text{C}) + 273$; so $\theta = T - 273$
Absolute zero = 0 K = -273 °C: the particles have the least kinetic energy
Pure ice melts at 0 °C (273 K); pure water boils at 100 °C (373 K) at standard atmospheric pressure

A temperature change of 1 °C is a change of 1 K

Pressure $p = \dfrac{F}{A}$ (force per unit area)

Extended only: $pV = \text{constant}$ for a fixed mass of gas at constant temperature, so $p_1V_1 = p_2V_2$

Extended only: p against V is a curve; p against $\dfrac{1}{V}$ is a straight line through the origin

2.2 Thermal properties and temperature

Extended only: $c = \dfrac{\Delta E}{m\,\Delta\theta}$, so $\Delta E = mc\,\Delta\theta$ (c in J/(kg °C))

Energy from a heater: $\Delta E = Pt$, and $P = VI$, so $\Delta E = VIt$

Extended only: in mixing, energy lost by the hot object $=$ energy gained by the cold one (no losses)

Density $\rho = \dfrac{m}{V}$, so $m = \rho V$ (for water, 1 cm³ has a mass of 1 g)

Pure water melts at 0 °C and boils at 100 °C at standard atmospheric pressure

Expansion: gas $>$ liquid $>$ solid; mass constant, density decreases

2.3 Transfer of thermal energy

Conduction: solids (best in metals); convection: liquids and gases only; radiation: needs no medium, crosses a vacuum

Density $\rho = \dfrac{m}{V}$: heating a fluid increases V at constant m, so ρ decreases and the warm fluid rises

Dull black: best absorber and best emitter, worst reflector; shiny white or silver: worst absorber and emitter, best reflector

Extended only: rate of emission increases with surface temperature and with surface area

Extended only: constant temperature $\iff$ rate of energy received $=$ rate of energy transferred away

Extended only: rate received $>$ rate lost $\Rightarrow$ temperature rises; rate received $<$ rate lost $\Rightarrow$ temperature falls

Area of one face of a square sheet $= s^2$; surface area of a cube $= 6s^2$

3 Waves

3.1 General properties of waves

$v = f\lambda$ (speed in m/s, frequency in Hz, wavelength in m)

$f = \dfrac{\text{number of waves}}{\text{time taken}}$, or $f = \dfrac{1}{\text{time for one wave}}$

Speed $= \dfrac{\text{distance}}{\text{time}}$ (for how long a wave takes to travel somewhere)

Transverse: vibration at right angles to the direction of travel (light and all EM waves, water waves, S-waves)

Longitudinal: vibration parallel to the direction of travel (sound, P-waves)
Reflection: angle of incidence = angle of reflection; speed, frequency and wavelength unchanged
Refraction: speed and wavelength change, frequency does not; water waves are slower in shallow water
Diffraction: wavelength unchanged; **Extended only:** most spreading when the gap is about one wavelength

3.2 Light

Angle of incidence = angle of reflection (both measured from the normal)
Angle from the normal = 90° − angle from the surface
Plane-mirror image: same size, same distance behind the mirror, virtual, upright, laterally inverted
Extended only: $n = \dfrac{\text{speed of light in air}}{\text{speed of light in the material}}$
Extended only: $n = \dfrac{\sin i}{\sin r}$ (i in air, r in the material)
Extended only: $n = \dfrac{1}{\sin c}$, so $c = \sin^{-1}\left(\dfrac{1}{n}\right)$
Extended only: speed of light in a vacuum = 3.0×10^8 m/s (about the same in air)
$v = f\lambda$ (for the frequency or wavelength of light)
TIR: light in the slower material heading for the faster one, and $i > c$
Ray rules: parallel → through F; through the centre → straight on; through F → parallel
Spectrum: red, orange, yellow, green, blue, indigo, violet (frequency increases, wavelength decreases)

3.3 Electromagnetic spectrum

Order (increasing frequency): radio, microwaves, infrared, visible, ultraviolet, X-rays, gamma
All e-m waves travel at the same speed in a vacuum
Extended only: speed of e-m waves in a vacuum $c = 3.0 \times 10^8$ m/s, about the same in air
$v = f\lambda$, so $\lambda = \dfrac{v}{f}$ and $f = \dfrac{v}{\lambda}$
distance = speed × time (halve the time for there and back)
$f = \dfrac{1}{T}$ (frequency from the period)
Prefixes: k = 10^3, M = 10^6, G = 10^9; mm = 10^{-3}, μm = 10^{-6}, nm = 10^{-9}
Uses and harmful effects of each region (the tables above)

3.4 Sound

speed = distance ÷ time, $v = \dfrac{d}{t}$

Echo (there and back): $2d = vt$, so $d = \frac{vt}{2}$
Wave equation $v = f\lambda$, so $\lambda = \frac{v}{f}$ and $f = \frac{v}{\lambda}$
$f = \frac{1}{T}$ (frequency from the period)
Human hearing: about 20 Hz to $20\,000$ Hz
Ultrasound: sound above 20 kHz ($20\,000$ Hz)
Speed of sound in air: 330–350 m/s
Extended only: speed in water about 1500 m/s; solids faster than liquids, liquids faster than gases
Amplitude ↑ ⇒ louder; frequency ↑ ⇒ higher pitch
Extended only: compression → wavelength: $\lambda = 2\times$ (compression-to-rarefaction distance)
Prefixes: k $= 10^3$, M $= 10^6$; 1 cm $= 0.01$ m; per minute ÷ 60 = per second

4 Electricity and magnetism

4.1 Simple phenomena of magnetism

Like poles repel; unlike poles attract
A magnet attracts unmagnetised magnetic materials with either pole; only repulsion proves a magnet
Magnetic materials: iron, steel, nickel, cobalt; copper, aluminium and non-metals are non-magnetic
Induced magnetism: the near end becomes the opposite pole, so it is attracted
Soft iron: temporary magnet (easily magnetised and demagnetised); steel: permanent magnet
Magnetic field: a region in which a magnetic pole experiences a force
Field direction: the direction of the force on an N pole; lines go from N to S outside the magnet
A compass needle's N end points along the field direction
Extended only: closer field lines mean a stronger field; strongest at the poles
Extended only: magnetic forces are due to interacting magnetic fields
Weight and force: $W = mg$, with $g = 9.8$ N/kg (for balance questions)

4.2 Electrical quantities

Like charges repel; unlike charges attract
Charging by friction: only electrons move; gaining electrons makes an object negative, losing them makes it positive
Conductors have free electrons; insulators do not

Extended only: electric field: a region in which an electric charge experiences a force; direction = direction of the force on a positive charge

Extended only: $I = \frac{Q}{t}$ (charge Q in coulombs)

Extended only: conventional current: $+$ to $-$; electrons: $-$ to $+$

e.m.f.: electrical work done by a source in moving unit charge around a complete circuit

p.d.: work done by unit charge passing through a component

Extended only: $E = \frac{W}{Q}$ and $V = \frac{W}{Q}$ ($1\ \text{V} = 1\ \text{J/C}$)

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

Longer wire: more resistance; thicker wire: less resistance

Extended only: $R \propto L$ and $R \propto \frac{1}{A}$; $A \propto d^2$ for a round wire

$P = IV$

$E = IVt$

$P = I^2R$ and $P = \frac{V^2}{R}$ (from $P = IV$ and $V = IR$)

Energy (kW h) = power (kW) $\times$ time (h); 1 kW h $= 3.6 \times 10^6$ J

Ammeter in series; voltmeter in parallel

4.3 Electric circuits

$V = IR$ (p.d. = current × resistance)

$P = IV$ and $E = IVt$ (power in W, energy in J, t in s)

$Q = It$ (charge in C)

Series: same current everywhere

Series resistances: $R = R_1 + R_2 + \ldots$

Series cells: e.m.f.s add (a reversed cell subtracts)

Parallel: source current $>$ current in any branch

Parallel: combined resistance $<$ the smallest resistor

Extended only: junction: $I = I_1 + I_2$ (total in = total out)

Extended only: series: $V = V_1 + V_2 + \ldots$

Extended only: parallel: same p.d. across every branch

Extended only: two in parallel: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$, or $R = \frac{R_1 R_2}{R_1 + R_2}$

Extended only: potential divider: $\frac{R_1}{R_2} = \frac{V_1}{V_2}$

Units: 1 kΩ $= 1000\ \Omega$; 1 mA $= 0.001$ A; energy in kWh = power in kW × time in hours

4.4 Electrical safety

$P = IV$, so the current in an appliance is $I = \frac{P}{V}$ (power in W, not kW)

Currents of appliances on one lead or fuse add: $I_{\text{total}} = I_1 + I_2 + \ldots$

Fuse rating (or trip setting): the **smallest** value **above** the normal current (the next one up if it is only just above), and no more than the cable's rating

The switch and the fuse go in the **live** wire

Metal case → **earthed**; insulating case (double-insulated) → **no earth wire**, but still a **fuse**

Fuse: melts when the current is too large → protects the **cables** from **overheating** (fire)

Earth wire + fuse together → protect the **user** from **shock** when the case becomes live

4.5 Electromagnetic effects

Transformer: $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

Extended only: 100%-efficient transformer: $I_p V_p = I_s V_s$

Power: $P = IV$

Extended only: power lost in cables: $P = I^2 R$

Step-up: $N_s > N_p$, so $V_s > V_p$; step-down: $N_s < N_p$, so $V_s < V_p$

Frequency of a generator's a.c. = revolutions per second; period $= \frac{1}{\text{frequency}}$

Right-hand grip rule: thumb along the current, fingers show the field

Solenoid end with the current anticlockwise = N pole; clockwise = S pole

Extended only: left-hand rule (force): First finger Field, seCond finger Current, thuMb Motion

Extended only: right-hand rule (induced current): thumb motion, first finger field, second finger induced current

Induced e.m.f. bigger with: faster movement, stronger magnet, more turns

Turning effect on a coil bigger with: more turns, bigger current, stronger magnet

5 Nuclear physics

5.1 The nuclear model of the atom

Relative charges: proton $+1$, neutron 0, electron -1

Nuclide notation ${}^{A}_{Z}\mathrm{X}$: A = nucleon number (top), Z = proton number (bottom)

Number of neutrons $N = A - Z$

Neutral atom: number of electrons $= Z$

Ion: charge = protons − electrons (lose electrons → positive, gain → negative)

Isotopes: same Z, different A (different number of neutrons)

Extended: relative charge on a nucleus $= +Z$; relative mass of a nucleus $\approx A$

Extended: neutron ${}^{1}_{0}\mathrm{n}$, proton ${}^{1}_{1}\mathrm{p}$ or ${}^{1}_{1}\mathrm{H}$, alpha particle ${}^{4}_{2}\mathrm{He}$, beta particle ${}^{0}_{-1}\mathrm{e}$

Extended: in a nuclide equation, top numbers balance and bottom numbers balance

Extended: fission and fusion: products have less mass than reactants; the lost mass is released as energy

5.2 Radioactivity

Count rate $= \dfrac{\text{number of counts}}{\text{time}}$, in counts/s or counts/minute

Corrected count rate = measured count rate − background count rate (Extended)

Number of half-lives $n = \dfrac{\text{time}}{\text{half-life}}$

Amount left after n half-lives $= \text{starting amount} \times \left(\frac{1}{2}\right)^{n}$ (for mass, number of nuclei or corrected count rate)

Fraction decayed $= 1 - \left(\frac{1}{2}\right)^{n}$

Neutrons $= A - Z$ (nucleon number − proton number)

$\alpha = {}^{4}_{2}\mathrm{He}$, $\beta = {}^{0}_{-1}\mathrm{e}$, $\gamma = {}^{0}_{0}\gamma$ (Extended)

α-decay: A falls by 4, Z falls by 2; β-decay: A same, Z rises by 1; γ: no change (Extended)

In β-decay: neutron → proton + electron (Extended)

Charge on $\alpha = +2 \times 1.6 \times 10^{-19} = +3.2 \times 10^{-19}$ C (Extended)

6 Space physics

6.1 The Earth and the Solar System

Time for light to travel a distance: $t = \dfrac{d}{c}$, with $c = 3.0 \times 10^{8}$ m/s

Speed of light in km/s: 3.0×10^5 km/s $= 0.30 \times 10^6$ km/s
Average orbital speed $v = \dfrac{2\pi r}{T}$, r = average orbit radius, T = orbital period (Extended)
Rearranged: $T = \dfrac{2\pi r}{v}$, $r = \dfrac{vT}{2\pi}$ (Extended)
Gravitational field strength $g = \dfrac{W}{m}$ (force per unit mass, N/kg)
Density $\rho = \dfrac{m}{V}$, so $m = \rho V$ (Extended, planetary data)
Temperature: θ in °C $= T$ in K -273
Fraction of an orbit completed $= \dfrac{\text{time}}{\text{orbital period}}$; angle turned $= \text{fraction} \times 360^\circ$

6.2 Stars and the Universe

Speed of light in space $c = 3.0 \times 10^8$ m/s; distance $d = c \times t$, time $t = \dfrac{d}{c}$
1 light-year $= 9.5 \times 10^{15}$ m $= 9.5 \times 10^{12}$ km (Extended)
1 year $= 365 \times 24 \times 3600 = 3.15 \times 10^7$ s (about 3.2×10^7 s)
Hubble constant $H_0 = \dfrac{v}{d}$, so $v = H_0 d$ and $d = \dfrac{v}{H_0}$ (Extended)
$H_0 = 2.2 \times 10^{-18}$ per second (s^{-1}) (Extended)
Age of the Universe $\approx \dfrac{d}{v} = \dfrac{1}{H_0} = 4.5 \times 10^{17}$ s $\approx 1.4 \times 10^{10}$ years (Extended)