VCE Physics Formula Sheet

Original worked revision examples with notes on units and assumptions.

Use the board PDF below for the official sheet. Coverage of examples varies by subject.

Official reference material

Official VCAA Physics formula sheet

What to work out beyond the sheet

Sketch each reference frame and identify the proper quantity before deciding which time or length to divide or multiply by γ.

Formulas and worked examples

Motion · average velocity and acceleration

Formula or reference: $v = \Delta s/\Delta t$. $a = \Delta v/\Delta t$.

Units and conditions: Displacement in m, time in s, velocity in m/s and acceleration in m/s².

Worked example: A displacement of 12 m in 4 s gives average velocity 3 m/s. A velocity increase of 6 m/s in 4 s gives average acceleration 1.5 m/s².

Motion · constant acceleration

Formula or reference: $v = u + at$. $s = ut + at^2/2 = vt - at^2/2 = (u + v)t/2$. $v^2 = u^2 + 2as$.

Units and conditions: Take signed values along one axis. Use m and s.

Worked example: For u = 2 m/s, a = 2 m/s² and t = 3 s, v = 8 m/s and s = 15 m by any of the displacement forms. Also, $8^2 = 2^2 + 2 \times 2 \times 15$.

Forces · Newton’s second law

Formula or reference: $\Sigma F = ma$

Units and conditions: Net force in N, mass in kg and acceleration in m/s².

Worked example: A 3 kg cart with net force 12 N accelerates at 4 m/s² in the direction of that force.

Motion · uniform circular motion

Formula or reference: $v = 2\pi r/T$. $F_{net} = mv^2/r$.

Units and conditions: Period in s, speed in m/s, radius in m and inward net force in N.

Worked example: A 2 kg mass takes 2 s per circle of radius 1 m. Its speed is π m/s and its inward net force is about 19.7 N.

Forces · Hooke’s law

Formula or reference: $F = -kx$

Units and conditions: Displacement in m and stiffness in N/m. The minus sign denotes the restoring direction.

Worked example: For k = 80 N/m and x = +0.10 m, the spring’s restoring force is −8.0 N.

Energy · gravitational potential energy change

Formula or reference: $\Delta E_g = mg\Delta h$ near Earth’s surface

Units and conditions: Mass in kg, height change in m and energy in J.

Worked example: Lifting 2 kg by 3 m increases gravitational potential energy by $2 \times 9.81 \times 3 \approx 58.9$ J.

Energy · kinetic energy

Formula or reference: $E_k = mv^2/2$

Units and conditions: Use mass in kg and speed in m/s to obtain J.

Worked example: A 4 kg object at 3 m/s has kinetic energy 18 J.

Gravity · force and field

Formula or reference: $F_g = Gm_1m_2/r^2$. $g = GM/r^2$.

Units and conditions: Use distance between centres in m. Field strength is in N/kg.

Worked example: If $GM = 36\ m^3/s^2$ and $r = 3$ m, $g = 4$ N/kg and the gravitational force on 2 kg is 8 N.

Motion · impulse

Formula or reference: $F\Delta t = m\Delta v$ for average net force F

Units and conditions: Impulse in N s, mass in kg and velocity in m/s.

Worked example: A 0.25 kg ball changes velocity from +8 to −4 m/s. Its impulse is −3 N s, opposite the initial direction.

Motion · momentum

Formula or reference: $p = mv$

Units and conditions: Momentum in kg m/s, with the same direction as velocity.

Worked example: A 0.50 kg ball moving west at 6 m/s has momentum 3.0 kg m/s west.

Energy · elastic potential energy

Formula or reference: $E_s = kx^2/2$

Units and conditions: Spring stiffness in N/m, extension in metres and energy in joules.

Worked example: Stretching a spring of stiffness 80 N/m by 0.10 m stores 0.40 J.

Relativity · time dilation

Formula or reference: $t = \gamma t_0$, with $\gamma = 1/\sqrt{(1 - v^2/c^2)}$.

Units and conditions: Use consistent speed units. t_0 is the proper time.

Worked example: At $v = 0.60c$, $\gamma = 1.25$. A proper interval of 4.0 μs corresponds to 5.0 μs in the frame in which the clock moves.

Relativity · length contraction

Formula or reference: $L = L_0/\gamma$

Units and conditions: L_0 is measured in the object’s rest frame. Contraction is along the direction of motion.

Worked example: A 10 m object moving at 0.60c measures 10/1.25 = 8 m along its motion.

Relativity · energy

Formula or reference: $E_0 = mc^2$. $E_{total} = E_k + E_0 = \gamma mc^2$. $E_k = (\gamma - 1)mc^2$.

Units and conditions: Use joules or another consistent energy unit across all terms.

Worked example: At $\gamma = 1.25$, an object of rest energy 8.0 J has total energy 10 J and kinetic energy 2.0 J.

Electric fields · charged plates

Formula or reference: $E = V/d$

Units and conditions: Use potential difference in V and plate spacing in m. Field magnitude is in V/m.

Worked example: A 60 V difference across a 0.020 m gap gives 3000 V/m, neglecting edge effects.

Electric fields · energy transfer

Formula or reference: $mv^2/2 = qV$ for a particle starting at rest that gains kinetic energy qV.

Units and conditions: Use J, kg, C and V. Choose the sign or magnitude so qV represents the kinetic energy gained.

Worked example: A particle of mass 1.0×10^{-26} kg gains 8.0×10^{-18} J crossing a potential difference. Its nonrelativistic speed is 4.0×10^4 m/s.

Electric fields · point charge and electric force

Formula or reference: $E = kQ/r^2$. $F = qE$.

Units and conditions: The point-charge field magnitude uses $|Q|$. Use SI units and determine direction separately.

Worked example: If $k|Q| = 36$ N m²/C at $r = 3$ m, $E = 4$ N/C. A +2.0 µC test charge feels 8.0 µN along the field.

Electric forces · Coulomb’s law

Formula or reference: $F = k|q_1q_2|/r^2$

Units and conditions: Use C, m and N. Like charges repel and unlike charges attract.

Worked example: If $k|q_1q_2| = 0.060$ N m² and $r = 0.30$ m, the magnitude is 0.67 N.

Magnetic forces · moving charge

Formula or reference: $F = |q|vB$ when velocity is perpendicular to B.

Units and conditions: Use C, m/s and T to obtain N.

Worked example: A charge of magnitude 2.0 µC moving at 400 m/s across a 0.50 T field feels a force of 4.0×10^{-4} N.

Magnetic forces · current-carrying wire

Formula or reference: $F = nI\ell B$ for n perpendicular active lengths whose forces add.

Units and conditions: Use A, m and T. Count only lengths that contribute in the direction being considered.

Worked example: Three active 0.20 m lengths carrying 2 A in a 0.50 T field contribute 0.60 N.

Magnetic forces · orbit radius

Formula or reference: $r = mv/(|q|B)$ for perpendicular motion.

Units and conditions: Use kg, m/s, C and T to obtain m.

Worked example: If $mv/|q| = 0.12$ T m and $B = 0.40$ T, $r = 0.30$ m.

Circuits · current and power

Formula or reference: $I = V/R$. $P = VI$.

Units and conditions: Use V, Ω, A and W.

Worked example: A 6 Ω resistor across 12 V draws 2 A and dissipates 24 W.

Circuits · resistors in series and parallel

Formula or reference: Series: $R_T = R_1 + R_2 + \ldots$. Parallel: $1/R_T = 1/R_1 + 1/R_2 + \ldots$.

Units and conditions: Resistance in Ω.

Worked example: A 6 Ω and 3 Ω pair gives 9 Ω in series or 2 Ω in parallel.

Electricity · ideal transformer

Formula or reference: $N_1/N_2 = V_1/V_2 = I_2/I_1$

Units and conditions: Turn counts are unitless. Use consistent voltage and current measures.

Worked example: A 400-turn primary and 100-turn secondary take 24 V and 0.50 A on the primary to 6 V and 2 A on the secondary.

Electricity · RMS voltage and current

Formula or reference: $V_{RMS} = V_{peak}/\sqrt{2}$. $I_{RMS} = I_{peak}/\sqrt{2}$ for sinusoids.

Units and conditions: Use V for voltage and A for current.

Worked example: A 20 V peak and 4 A peak give approximately 14.1 V RMS and 2.83 A RMS.

Electricity · induction and magnetic flux

Formula or reference: $\varepsilon = -N\Delta\Phi/\Delta t$. $\Phi = B_{\perp}A$.

Units and conditions: Flux in Wb, area in m^2, normal field in T and EMF in V.

Worked example: If a 20-turn loop's normal field increases by 0.10 T over 0.05 s across area 0.020 m^2, $\Delta\Phi = 0.0020$ Wb per turn and $|\varepsilon| = 0.80$ V.

Electricity · line losses

Formula or reference: $V_{drop} = I_{line}R_{line}$. $P_{loss} = I_{line}^2R_{line}$.

Units and conditions: Use A, Ω, V and W.

Worked example: A 3 A line current through 2 Ω of line resistance drops 6 V and dissipates 18 W.

Waves · wave speed

Formula or reference: $v = f\lambda$

Units and conditions: Speed in m/s, frequency in Hz and wavelength in m.

Worked example: A 2 Hz wave with wavelength 1.5 m travels at 3 m/s.

Waves · interference

Formula or reference: In-phase sources: constructive at path difference $n\lambda$, destructive at $(n + \frac{1}{2})\lambda$.

Units and conditions: n is an integer and the path difference uses the same length unit as λ.

Worked example: For $\lambda = 0.20$ m, path difference 0.40 m is constructive and 0.30 m is destructive.

Waves · fringe spacing

Formula or reference: $\Delta x = \lambda L/d$ when $L \gg d$.

Units and conditions: Use metres for wavelength, screen distance, slit spacing and fringe spacing.

Worked example: For $\lambda = 600$ nm, $L = 2.0$ m and $d = 0.30$ mm, $\Delta x = 0.0040$ m.

Light · photoelectric effect

Formula or reference: $E_{k,max} = hf - \varphi$ when $hf \geq \varphi$.

Units and conditions: Keep photon energy and work function in the same units.

Worked example: A 5.0 eV photon incident on a surface with work function 2.0 eV gives maximum electron kinetic energy 3.0 eV.

Light · photon energy

Formula or reference: $E = hf = hc/\lambda$

Units and conditions: With h in J s, use f in Hz and λ in m to obtain joules.

Worked example: A photon of frequency 5.0×10^{14} Hz has energy about 3.32×10^{-19} J.

Matter and light · wavelength and momentum

Formula or reference: Photon momentum $p = h/\lambda$. De Broglie wavelength $\lambda = h/p$.

Units and conditions: Use h in J s, p in kg m/s and λ in m.

Worked example: A 600 nm photon has $p \approx 1.10 \times 10^{-27}$ kg m/s. A particle with that momentum has a 600 nm de Broglie wavelength.

Units · mass and energy conversions

Formula or reference: 1 tonne = 10^3 kg. 1 kWh = 3.6×10^6 J.

Units and conditions: Match the unit required by the equation before substitution.

Worked example: A mass of 0.40 tonnes is 400 kg. An energy use of 0.50 kWh is 1.8×10^6 J.