

Unit 3 AOS 1 Formula Sheet - Motion

Constants

Acceleration due to gravity at Earth's surface	$g = 9.81 \text{ m s}^{-2}$
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Newton's laws of motion

Velocity; acceleration (vectors)	$v = \frac{\Delta x}{\Delta t}; a = \frac{\Delta v}{\Delta t}$	$\Delta x = s$ = displacement/change in position (m) Δt = time (s) v = velocity (m s^{-1}) Δv = change in velocity (m s^{-1}) a = acceleration (m s^{-2})
Equations for constant acceleration	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $s = vt - \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(u + v)t$	v = final velocity (m s^{-1}) u = initial velocity (m s^{-1}) a = acceleration (m s^{-2}) s = displacement (m) t = time (s)
Newton's second law	$F_{\text{net}} = ma$	F_{net} = net force (N) m = mass (kg) a = acceleration (m s^{-2})
Period of object moving in a circular path*	$T = \frac{1}{f}$	T = period (s) f = frequency (Hz or s^{-1})
Velocity of object moving in a circular path	$v = \frac{2\pi r}{T}$	v = velocity (m s^{-1}) r = radius (m) T = period (s)
Centripetal force	$F_{\text{net}} = \frac{mv^2}{r} = \frac{4\pi^2 rm}{T^2}$	F_{net} = net force/centripetal force (N) m = mass (kg) v = velocity (m s^{-1}) r = radius (m) T = period (s)
Centripetal acceleration*	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$	a = centripetal acceleration (m s^{-2}) v = velocity (m s^{-1}) r = radius (m) T = period (s)
Angle of banked track*	$\tan(\theta) = \frac{v^2}{rg}$	θ = banking angle from horizontal ($^\circ$) v = velocity (m s^{-1}) r = radius (m)
Design speed of banked track*	$v = \sqrt{rg \tan(\theta)}$	v = velocity (m s^{-1}) r = radius (m) θ = banking angle from horizontal ($^\circ$)
Minimum velocity (top, inside circle) or maximum velocity (top, outside circle) to stay in contact with track*	$v = \sqrt{rg}$	v = velocity (m s^{-1}) r = radius (m)
Range of projectile with symmetrical trajectory *	$R = \frac{u^2 \sin(2\theta)}{g}$	R = range/horizontal displacement (m) u = initial velocity (m s^{-1}) θ = angle of firing above horizontal ($^\circ$)

Relationships between force, energy and mass

Hooke's Law (springs)	$F_s = -k\Delta x$ Note: negative sign denotes direction	F_s = force by the spring (N) k = spring constant (N m ⁻¹) Δx = change in spring length by extension or compression (m)
Elastic potential energy	$E_s = \frac{1}{2}k\Delta x^2$ OR: area under force-extension (or force-compression) graph	E_s = elastic potential energy (J) k = spring constant (N m ⁻¹) Δx = change in spring length by extension or compression (m)
Kinetic energy	$E_k = \frac{1}{2}mv^2$	E_k = kinetic energy (J) m = mass (kg) v = speed (m s ⁻¹)
Gravitational potential energy	$E_g = mg\Delta h$ Note: only use when close to Earth's surface, where g can be considered a constant.	E_g = gravitational potential energy (J) m = mass (kg) Δh = change in vertical height (m)
Momentum (vector)	$p = mv$	p = momentum (kg m s ⁻¹) m = mass (kg) v = velocity (m s ⁻¹)
Impulse (vector)	$I = \Delta p = m\Delta v = F_{av}\Delta t$ OR: area under force-time graph	I = impulse (N s) Δp = change in momentum (m s ⁻¹) m = mass (kg) Δv = change in velocity (m s ⁻¹) F_{av} = average force (N) Δt = time (s)
Conservation of momentum*	$\sum p_i = \sum p_f$ Two objects colliding and remaining separate: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ Two objects colliding and joining together: $m_1u_1 + m_2u_2 = (m_1 + m_2)v$	$\sum p_i$ = sum of initial momenta (kg m s ⁻¹) $\sum p_f$ = sum of final momenta (kg m s ⁻¹) v = final velocity (m s ⁻¹) u = initial velocity (m s ⁻¹) m = mass (kg)
Work done*	$W = \Delta E = Fscos(\theta)$ Note: only use if force is constant OR: area under force-distance graph (if force not constant)	W = work done (J) ΔE = change in energy (J) F = force (N) s = displacement (m) θ = angle between displacement and force (°)
Power*	$P = \frac{W}{t}$	P = power (W) W = work done (J) t = time (s)
Elastic collision*	$\sum E_{k(i)} = \sum E_{k(f)}$ Note: for an inelastic collision, $\sum E_{k(i)} > \sum E_{k(f)}$	$\sum E_{k(i)}$ = sum of initial kinetic energies (J) $\sum E_{k(f)}$ = sum of final kinetic energies (J)

* Indicates formulae that are not included in the official VCAA formula sheet

Unit conversions

1 m s ⁻¹ = 3.6 km h ⁻¹			
p=pico=10 ⁻¹²	n=nano=10 ⁻⁹	μ=micro=10 ⁻⁶	m=milli=10 ⁻³
k=kilo=10 ³	M=mega=10 ⁶	G=giga=10 ⁹	T=tera=10 ¹²