AP Physics C: Mechanics

Formula Sheet · 公式表

The Physics C sheet gives the equations in their calculus form, which is where the difficulty moves: knowing which quantity is the derivative or integral of which, and when the constant- acceleration shortcuts are simply illegal. This booklet is that map. 公式表给出微积分形式，难点在于判断何时可用匀加速公式、何时必须积分。

The derivative and integral chain

Position, velocity, acceleration — $v = dx/dt$ and $a = dv/dt = d^2x/dt^2$; going back, $\Delta x = \int v\,dt$ and $\Delta v = \int a\,dt$. On a graph, slope differentiates and area integrates.

When suvat is legal — Only when a is constant. Given $a(t)$, $a(x)$ or a force that varies, integrate instead. A question that gives you acceleration as a function of anything is telling you not to use the shortcut.

The chain-rule trick — When acceleration depends on position rather than time, write $a = v\,dv/dx$ and separate variables. This one substitution solves the majority of the harder mechanics free-response parts.

Work as an integral — $W = \int \vec{F} \cdot d\vec{r}$, which reduces to $Fd\cos\theta$ only for a constant force. For a spring it gives $\frac{1}{2}kx^2$, and for gravity at astronomical distances $-GMm/r$.

Force from potential energy — $F = -dU/dx$: the force is the negative slope of the potential-energy curve. Equilibrium is where the slope is zero, stable where the curve is concave up.

Momentum, centre of mass, and systems

Impulse — $\vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$ – the area under a force-time graph, which is why those graphs appear so often.

Centre of mass — $x_{cm} = \frac{1}{M}\sum m_i x_i$, or $\frac{1}{M}\int x\,dm$ for a continuous body. With no external force, the centre of mass keeps moving exactly as it was, whatever the internal explosion does.

Variable mass — A rocket problem is not $F = ma$ with a changing m. Work from momentum conservation for the system including the ejected mass.

Rotation

Moment of inertia — $I = \sum m_i r_i^2$ or $\int r^2\,dm$. Set up dm in terms of a linear density and integrate over the correct variable; that setup is where the points are.

Parallel-axis theorem — $I = I_{cm} + Md^2$. It is on the sheet; what is not is that you must first have I about the centre of mass, and d is the perpendicular distance between the axes.

Rolling without slipping — $v = \omega R$ and $a = \alpha R$ hold only in this case, and then friction does no work. Rolling kinetic energy is $\frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$ – both terms, always.

Angular momentum — $L = I\omega$ for a rigid body, and $L = mvr_\perp$ for a particle about a point. Conserved when the net external torque about that point is zero – state the point.

Oscillation and gravitation

The SHM test — A system oscillates simple-harmonically when the equation of motion reduces to $d^2x/dt^2 = -\omega^2 x$. Deriving that form from the forces is the standard free-response task; the period then follows as $T = 2\pi/\omega$.

Spring and pendulum — $\omega = \sqrt{k/m}$ for a spring; $\omega = \sqrt{g/L}$ for a simple pendulum in the small-angle approximation, which must be stated.

Orbits and energy — $U = -GMm/r$, and a bound circular orbit has total energy $-GMm/2r$. Escape speed comes from setting total energy to zero, not from a memorised formula.

Kepler"s third law — It follows in two lines from setting gravity equal to mv^2/r – derive it rather than recalling it, because the exam often asks for exactly that derivation.

Habits that earn points

Answer symbolically first and substitute numbers last. Physics C rubrics award the symbolic expression, and a symbolic answer can be dimension-checked; a number cannot.

Check limits: does your expression behave sensibly as a mass goes to zero, a length to infinity, or an angle to zero? Examiners award this reasoning explicitly in “justify” parts.

State the system and the axis before writing any conservation statement. Angular momentum conserved “about the pivot” is a different claim from conserved “about the centre of mass”, and only one of them may be true.