AP Physics C: Mechanics

Revision Sheet · 考前速记

Learn these by heart before the exam. 考试前把这些内容背熟。

Kinematics

$\vec{v} = \dfrac{d\vec{r}}{dt}, \quad \vec{a} = \dfrac{d\vec{v}}{dt} = \dfrac{d^2\vec{r}}{dt^2}$ differentiate to go down, integrate (with initial conditions) to go back up 速度与加速度的定义

$\vec{v} = \vec{v}_0 + \int \vec{a}\,dt, \quad \vec{r} = \vec{r}_0 + \int \vec{v}\,dt$ 由加速度积分求运动

$v\,dv = a\,dx$ the trick when $a = a(x)$ rather than $a(t)$ 当 a 依赖于 x 时

Constant-a formulas apply ONLY when a is constant. If a depends on t, v or x, you must integrate.

Force and Translational Dynamics

$\sum \vec{F} = m\vec{a} = \dfrac{d\vec{p}}{dt}$ 牛顿第二定律

$F_d = -bv$ or $-cv^2$ terminal velocity is where $\sum F = 0$, so $mg = bv_t$ 阻力

$m\dfrac{dv}{dt} = mg - bv \;\Rightarrow\; v(t) = \dfrac{mg}{b}\left(1 - e^{-bt/m}\right)$ separate variables, integrate, apply $v(0) = 0$ 线性阻力下的落体

$F_G = \dfrac{Gm_1m_2}{r^2}, \quad a_c = \dfrac{v^2}{r}$ 万有引力与向心加速度

Free-body diagram first, choose axes along the motion, then $\sum F = ma$ per axis.

Work, Energy, and Power

$W = \int \vec{F}\cdot d\vec{r}, \quad P = \dfrac{dW}{dt} = \vec{F}\cdot\vec{v}$ 功与瞬时功率

$K = \frac{1}{2}mv^2, \quad W_{\text{net}} = \Delta K$ 动能定理

$F_x = -\dfrac{dU}{dx}, \quad \Delta U = -\int \vec{F}\cdot d\vec{r}$ force is MINUS the slope of the potential-energy curve 保守力与势能

$U_g = -\dfrac{GMm}{r}, \quad U_s = \frac{1}{2}kx^2$ the $-GMm/r$ form (zero at infinity) is the Physics C one, not mgh 引力势能与弹性势能

On a $U(x)$ graph: minima are stable equilibria, maxima unstable; turning points are where $E = U$.

Linear Momentum

$\vec{p} = m\vec{v}, \quad \vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$ 动量与冲量

$\vec{r}_{cm} = \dfrac{\sum m_i\vec{r}_i}{\sum m_i}, \quad \vec{r}_{cm} = \dfrac{1}{M}\int \vec{r}\,dm$ 质心

With no external force the centre of mass keeps moving at constant velocity, whatever happens inside.

Elastic collision conserves p AND K; perfectly inelastic conserves only p and the bodies stick.

Torque and Rotational Dynamics

$\vec{\tau} = \vec{r}\times\vec{F}, \quad \tau = rF\sin\theta, \quad \sum\tau = I\alpha$ 力矩与转动定律

$I = \int r^2\,dm$ 转动惯量的积分定义

$I_{\text{disc}} = \frac{1}{2}MR^2, \quad I_{\text{rod,cm}} = \frac{1}{12}ML^2, \quad I_{\text{sphere}} = \frac{2}{5}MR^2$ 常见转动惯量

$I = I_{cm} + Md^2$ 平行轴定理

Rolling without slipping: $v_{cm} = R\omega$ and friction does no work (the contact point is instantaneously at rest).

Energy and Momentum of Rotating Systems

$K_{\text{rot}} = \frac{1}{2}I\omega^2, \quad K_{\text{total}} = \frac{1}{2}Mv_{cm}^2 + \frac{1}{2}I_{cm}\omega^2$ 转动动能与滚动总动能

$\vec{L} = \vec{r}\times\vec{p} = I\vec{\omega}, \quad \vec{\tau} = \dfrac{d\vec{L}}{dt}$ 角动量

Angular momentum is conserved when the net external torque is zero, even in a collision that loses energy.

Kepler 2 is just conservation of L: equal areas in equal times.

Oscillations

$\dfrac{d^2x}{dt^2} = -\omega^2x \;\Rightarrow\; x(t) = A\cos(\omega t + \varphi)$ recognise this differential equation and you have the period immediately 简谐运动方程

$\omega_s = \sqrt{\dfrac{k}{m}}, \quad \omega_p = \sqrt{\dfrac{g}{L}}, \quad \omega_{\text{phys}} = \sqrt{\dfrac{mgd}{I}}$ 弹簧、单摆与复摆

$E = \frac{1}{2}kA^2, \quad v_{\max} = A\omega, \quad a_{\max} = A\omega^2$ 简谐运动的能量与极值

To prove SHM: show the restoring force (or torque) is proportional to $-x$ (or $-\theta$), then read ω^2 off the coefficient.

Exam technique

Set up the integral or differential equation explicitly. Physics C awards the setup, so write $\int$ with its limits before evaluating.

Check limits: does your answer behave sensibly as $t\to\infty$, $m\to 0$, or $r\to\infty$? Say so; examiners credit it.

Symbols before numbers. Derive an algebraic result, then substitute once at the end.