AP Physics C: Electricity and Magnetism

Revision Sheet · 考前速记

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

Electric Charges, Fields, and Gauss's Law

$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}, \quad \frac{1}{4\pi\varepsilon_0} = 9.0 \times 10^9$ 库仑定律

$\vec{E} = \frac{\vec{F}}{q}, \quad \vec{E} = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r^2}\hat{r}$ exploit symmetry: cancel the components that pair off before integrating 电场与连续分布的积分

$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\varepsilon_0}$ 高斯定律

$E_{\text{sheet}} = \frac{\sigma}{2\varepsilon_0}, \quad E_{\text{line}} = \frac{\lambda}{2\pi\varepsilon_0 r}, \quad E_{\text{sphere}} = \frac{Q}{4\pi\varepsilon_0 r^2}$ 由高斯定律得到的标准结果

Gauss only gives E easily with spherical, cylindrical or planar symmetry. Choose the surface so E is constant and parallel to $d\vec{A}$.

Inside a conductor in electrostatic equilibrium $E = 0$; all excess charge sits on the surface.

Electric Potential

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}, \quad V = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r}$ a SCALAR integral, so no components: usually easier than finding E directly 电势

$\Delta V = -\int \vec{E} \cdot d\vec{l}, \quad \vec{E} = -\nabla V$ $E_x = -\partial V/\partial x$: field points down the steepest potential drop 场与电势互求

$U = qV, \quad U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$ 电势能

Route: charge distribution to V by integration, then E by differentiation. It beats the vector integral nearly every time.

Equipotential surfaces are perpendicular to $\vec{E}$; no work is done moving along one.

Conductors and Capacitors

$C = \frac{Q}{V}, \quad C_{\|\text{plate}} = \frac{\kappa\varepsilon_0 A}{d}$ 电容与平行板电容器

$U_C = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{Q^2}{2C}, \quad u_E = \frac{1}{2}\varepsilon_0 E^2$ 电容器储能与能量密度

$C_p = \sum C_i, \quad \frac{1}{C_s} = \sum \frac{1}{C_i}$ 电容的并联与串联

A dielectric κ raises C. At constant Q it lowers V and E; at constant V it raises Q.

Electric Circuits

$I = \frac{dq}{dt}, \quad V = IR, \quad P = IV, \quad R = \frac{\rho L}{A}$ 电流、欧姆定律、功率与电阻率

$\tau = RC, \quad q(t) = Q_f\left(1 - e^{-t/RC}\right), \quad q(t) = Q_0 e^{-t/RC}$ at $t = 0$ an uncharged capacitor acts as a wire; at $t \to \infty$ as a break RC 充放电

$\tau = \frac{L}{R}, \quad I(t) = \frac{\varepsilon}{R}\left(1 - e^{-Rt/L}\right)$ an inductor is the opposite: a break at $t = 0$, a wire at $t \to \infty$ RL 电路

Kirchhoff: $\sum I_{in} = \sum I_{out}$ at a junction, $\sum \Delta V = 0$ round a loop. Assign directions and let a negative answer fix them.

Magnetic Fields and Electromagnetism

$\vec{F} = q\vec{v} \times \vec{B}, \quad \vec{F} = I\vec{L} \times \vec{B}$ 洛伦兹力与安培力

$r = \frac{mv}{qB}, \quad T = \frac{2\pi m}{qB}$ the period does NOT depend on speed: the cyclotron principle 圆周运动半径与周期

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\, d\vec{l} \times \hat{r}}{r^2}$ 毕奥-萨伐尔定律

$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enc}}$ 安培环路定律

$B_{\text{wire}} = \frac{\mu_0 I}{2\pi r}, \quad B_{\text{solenoid}} = \mu_0 n I, \quad B_{\text{loop,centre}} = \frac{\mu_0 I}{2R}$ 标准磁场结果

A magnetic force never does work: $\vec{F} \perp \vec{v}$ always.

Electromagnetic Induction

$\Phi_B = \int \vec{B} \cdot d\vec{A}, \quad \varepsilon = -\frac{d\Phi_B}{dt}$ 磁通量与法拉第定律

$\varepsilon = BLv$ for a rod of length L sliding at v perpendicular to B 动生电动势

$L = \frac{N\Phi_B}{I}, \quad \varepsilon_L = -L\frac{dI}{dt}, \quad U_L = \frac{1}{2}LI^2$ 自感、感生电动势与储能

Lenz's law is energy conservation. The induced current opposes the CHANGE, so pushing a magnet in meets resistance.

Flux changes three ways: B changes, area changes, or the angle changes. Say which one when you justify.

Exam technique

Say WHY the symmetry lets you use Gauss or Ampere before you use it. The justification carries marks.

For RC and RL, describe the two limits ($t = 0$ and $t \to \infty$) first; they anchor the exponential.

Derive symbolically and substitute once. Check a *limiting case (large r, small t) and state the check.*