# 电磁学

## 一、静电场

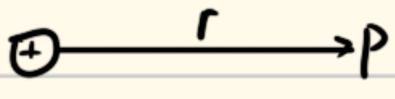
1. 库仑定律：$\vec{F_{21}} = k\frac{q_1 q_2}{r^2}\vec{e_{12}} = -\vec{F_{12}}$ （真空、点电荷、静止）

$k = 8.99\times10^9\ N\cdot m^2/C^2$　　$k = \frac{1}{4\pi\varepsilon_0}$　　$\varepsilon_0 = 8.854\times10^{-12}\ C^2/(N\cdot m^2)$ 真空介电常数

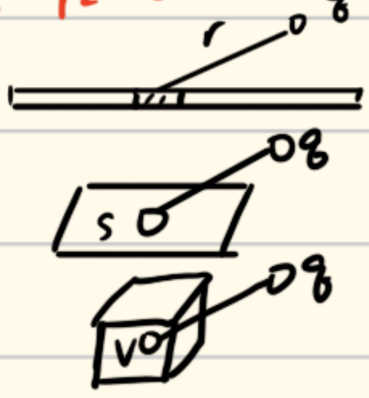
2. 电场强度：试探点电荷 $q_0$ 在电场中受力 F，$F/q_0$ 与场点的位置有关

$\vec{E}(P) \equiv \lim_{q_0\to 0}\frac{\vec{F}}{q_0}$　　空气击穿强度 $3\times10^6$ v/m　晴天大地表面 100 v/m

点电荷 q 在 P 点场强 $\vec{E} = \frac{\vec{F}}{q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\vec{e_r}$




$d\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r^2}\vec{e_r}$

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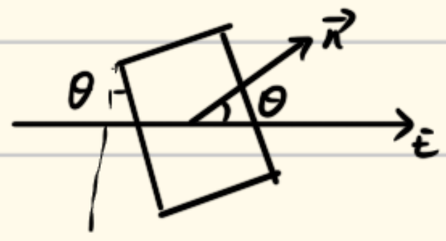
|---|---|---|---|
| 线状带电体 | 线密度 $\lambda = \frac{dq}{dl}$ | $d\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{\lambda dl}{r^2}\vec{e_r}$ | $\vec{E} = \int_l \frac{1}{4\pi\varepsilon_0}\frac{\lambda dl}{r^2}d\vec{e_r}$ |
| 面状带电体 | 面密度 $\sigma = \frac{dq}{ds}$ | $d\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{\sigma ds}{r^2}\vec{e_r}$ | $\vec{E} = \int_s \frac{1}{4\pi\varepsilon_0}\frac{\lambda ds}{r^2}d\vec{e_r}$ |
| 体分布带电体 | 体密度 $\rho = \frac{dq}{dv}$ | $d\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{\rho dv}{r^2}\vec{e_r}$ | $\vec{E} = \int_v \frac{1}{4\pi\varepsilon_0}\frac{\rho dv}{r^2}d\vec{e_r}$ |

求场强实际上考的是微积分

3. 电通量：$\Phi_E = \vec{E}\cdot\vec{S}$　$(\vec{S} = S\cdot\vec{n})$




$d\Phi_E = E\,ds\cos\theta = \vec{E}\cdot d\vec{S}$

穿过任意 S 面通量 $\Phi_E = \int_S \vec{E}\cdot d\vec{S}$

场线穿出闭合曲面时 $\Phi_E$ 为正，反之为负

4. 高斯定理：穿过任意闭合曲面 S 的电通量，正比于 S 所围电荷的净值

$\oint_S \vec{E}\cdot\vec{S} = \frac{1}{\varepsilon_0}\int dq$　　散度 $\nabla\cdot\vec{E} = \frac{\rho}{\varepsilon_0}$

旋度 $\nabla\times\vec{E} = 0$

5. 静电场环路定理

1）点电荷在电场中运动电场作功

$dA = \vec{F}\cdot d\vec{l} = q_0\vec{E}\,d\vec{l} = q_0 E\,dl\cos\theta = q_0 E\,dr$

$A_{ab} = \int_a^b q_0\vec{E}\,dr = \int_{r_a}^{r_b}\frac{q_0 q}{4\pi\varepsilon_0 r^2}dr = \frac{q_0 q}{4\pi\varepsilon_0}\left(\frac{1}{r_a}-\frac{1}{r_b}\right)$

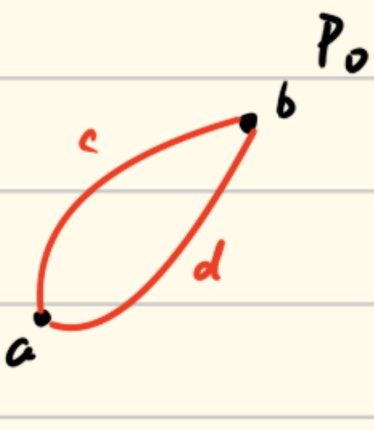
作功与路径无关

2）环路定理

$\int_{a(c)}^{b}\vec{E}\cdot d\vec{l} = \int_{a(d)}^{b}\vec{E}\cdot d\vec{l}$

$\Rightarrow \int_{a(c)}^{b}\vec{E}\cdot d\vec{l} + \int_{b(d)}^{a}\vec{E}\cdot d\vec{l} = 0$

$\Rightarrow \oint_L \vec{E}\cdot d\vec{l} = 0$




静电场是有源无旋场

6. 电势能

$W_P - W_{P_0} = \int_P^{P_0} q_0\vec{E}\cdot d\vec{l} = -(W_{P_0} - W_P) = -\Delta W$

选 $P_0$ 为参照点，P 点势能，$W_P = A_{PP_0} = q_0\int_P^{P_0}\vec{E}\cdot d\vec{l}$

7. 电势（势场）　沿电场线方向电势减小

移动单位正电荷电场力所做的功

$U_P = \frac{W_P}{q_0} = \int_P^{P_0}\vec{E}\cdot d\vec{l}$

电势差：$U_a - U_b = \int_a^{P_0}\vec{E}\,d\vec{l} - \int_b^{P_0}\vec{E}\,d\vec{l} = \int_a^b\vec{E}\,d\vec{l}$