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真空中的静电场

一、电荷、电场

1.电荷　2.电场

3.物质电结构理论

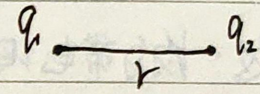
4.电荷守恒

5.电荷量子化　$e=1.6\times10^{-19}C$

6.电荷的相对论不变性

二、库仑定律

点电荷　$F=\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$（$k=\frac{1}{4\pi\varepsilon_0}$ 但不写成 k）



三、~~电力线~~ 电场强度($\vec{E}$)

试验电荷（可视为点电荷，充分小）

$$\vec{E}=\frac{\vec{F}}{q}$$

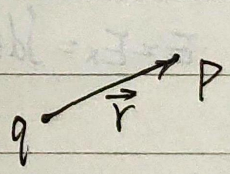
匀强电场

场强叠加原理

$$\vec{F}=\vec{F_1}+\vec{F_2}+\cdots+\vec{F_n}+\cdots$$

$$\vec{E}=\vec{E_1}+\vec{E_2}+\cdots+\vec{E_i}+\cdots=\sum_{i=1}^{n}\vec{E_i}$$

点电荷场强分布



$$\vec{F}=\frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r^2}\left(\frac{\vec{r}}{r}\right)$$

$$\vec{E}=\frac{\vec{F}}{q_0}=\frac{q}{4\pi\varepsilon_0 r^2}\left(\frac{\vec{r}}{r}\right)$$

$$\vec{E}=\sum_{i=1}^{n}\frac{q_i}{4\pi\varepsilon_0 r_i^2}\left(\frac{\vec{r_i}}{r_i}\right)$$

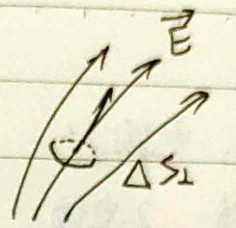
$$d\vec{E}=\frac{dq}{4\pi\varepsilon_0 r^2}\left(\frac{\vec{r}}{r}\right)$$

$$\vec{E}=\int d\vec{E}=\int\frac{dq}{4\pi\varepsilon_0 r^2}\left(\frac{\vec{r}}{r}\right)$$

$$dq=\begin{cases}\lambda dl\\ \sigma ds\\ \rho dv\end{cases}$$

四. 电力线，电通量

电力线数密度.



$$\vec{E} = \frac{\Delta N}{\Delta S_\perp}$$

连续性. 不闭合 两条电力线不相交.

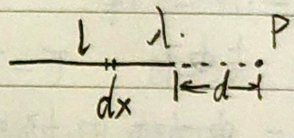
$$d\varphi_m = E\,ds\cos\alpha = \vec{E}\,d\vec{s}$$

$$\varphi_m = \int_s d\varphi_m = \int_s \vec{E}\,d\vec{s}$$

$$\begin{cases} d\varphi_m = \vec{E}\,d\vec{s} \\ \varphi_m = \int_s d\varphi_m = \int_s \vec{E}\,d\vec{s}. \end{cases}$$

例题：均匀带电细棒，长为l.

距棒一端 d处P点.

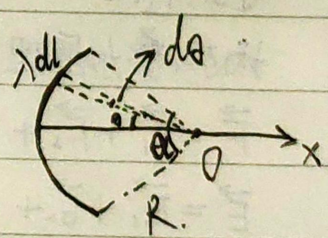


解：取细棒上 dx (线元).

$dq = \lambda dx$.

$$dE = \frac{\lambda dx}{4\pi\varepsilon_0 x^2} \Rightarrow \vec{E} = \int_d^{d+l} \frac{\lambda dx}{4\pi\varepsilon_0 x^2} =$$

例题：带电圆弧. ★



解：$dq = \lambda dl = \lambda R d$

$$d\vec{E} = \frac{dq}{4\pi\varepsilon_0 R^2} = \frac{\lambda R d\theta}{4\pi\varepsilon_0 R^2} = \frac{\lambda d\theta}{4\pi\varepsilon_0 R}$$

$$E = E_x = \int dE_x = \int_{-\frac{\alpha}{2}}^{\frac{\alpha}{2}} \frac{\lambda R d\theta}{4\pi\varepsilon_0 R^2}\cos\theta = \frac{\lambda}{2\pi\varepsilon_0 R}\sin\frac{\alpha}{2}.$$

五. 高斯定理

$$\varphi_e = \oint_s \vec{E}\,d\vec{s} = \frac{1}{\varepsilon_0}\left(\Sigma q_{in内}\right).$$

$$\varphi_e = \oint_s \vec{E}\,d\vec{s} = \frac{1}{\varepsilon_0}\int_Q dq.$$

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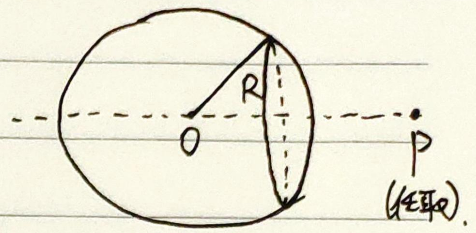
☆例：均匀带电球面.（P183）.

☆例：均匀带电圆环（P177）.



均匀带电球面R，Q

$\Phi_e = \oint_S \vec{E} d\vec{s} = \oint_S E ds = E \oint_S ds$

$= E \cdot 4\pi r^2 = \frac{1}{\varepsilon_0} Q$

$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ $(r > R)$.

$E = 0$ $(r < R)$.

☆例：均匀带电球体.（P184）.

可看成由无穷个带电球面组成.

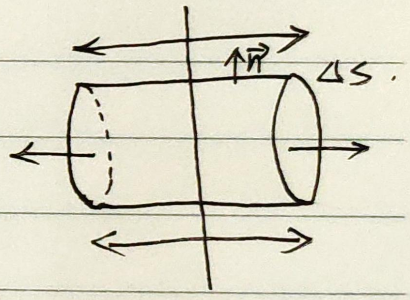
$r > R$，$\Phi_e = \oint_S \vec{E} d\vec{s} = E\, 4\pi r^2 = \frac{1}{\varepsilon_0} Q$.

$E = \frac{Q}{4\pi\varepsilon_0 r^2}$ $(r > R)$.

$r < R$，$\Phi_e = \oint_S \vec{E} d\vec{s} = E 4\pi r^2 = \frac{1}{\varepsilon_0}\left(\frac{Q}{\frac{4}{3}\pi R^3} \cdot \frac{4}{3}\pi r^3\right)$.

$E = \frac{Q}{4\pi\varepsilon_0 R^3} r$.

☆例：无限大均匀带电平面（P186）.



$\Phi_e = \oint_S \vec{E} d\vec{s} = E\Delta s + E\Delta s$.

$= 2E\Delta s$.

$= \frac{1}{\varepsilon_0} \sigma \Delta s$.

$\therefore E = \frac{\sigma}{2\varepsilon_0}$ ※

☆例：无限长均匀带电直线.（P185）.

☆例：无限长均匀带电圆柱面.