一 孤立导体的电容

孤立导体带电荷Q与其电势V的比值

$$C=\frac{Q}{V}$$

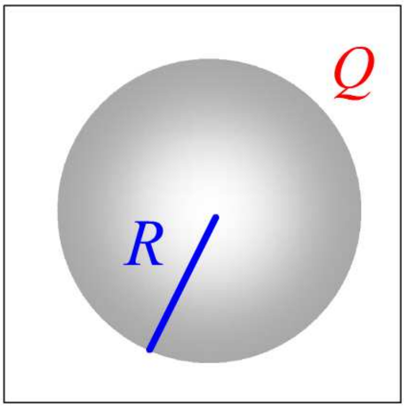
单位： $1\,\mathrm{F}=1\,\mathrm{C/V}$

$$1\,\mathrm{F}=10^{6}\,\mu\mathrm{F}=10^{12}\,\mathrm{pF}$$

例 球形孤立导体的电容

$$V = \frac{Q}{4\pi\varepsilon_0 R}$$

$$C = \frac{Q}{V} = 4\pi\varepsilon_0 R$$



- 地球 $R_{\mathrm{E}} = 6.4\times10^{6}\ \mathrm{m}$, $C_{\mathrm{E}} \approx 7\times10^{-4}\ \mathrm{F}$

二 电容器

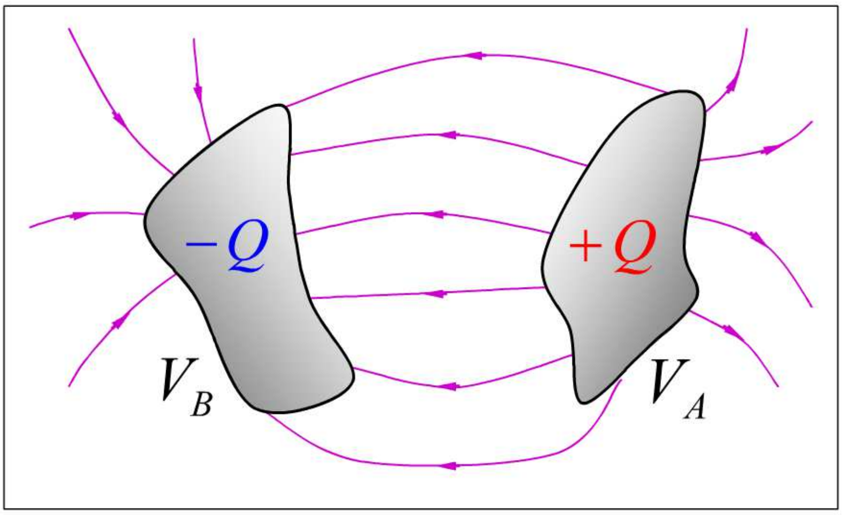
1 电容器分类

按形状：柱型、球型、平行板电容器
按型式：固定、可变、半可变电容器
按介质：空气、塑料、云母、陶瓷等
特点：非孤立导体，由两极板组成

2 电容器电容

$$C=\frac{Q}{V_A-V_B}=\frac{Q}{U}$$

$$U=\int_{AB}\vec{E}\cdot\mathrm{d}\vec{l}$$



电容的大小仅与导体的形状、相对位置、其间的电介质有关，与所带电荷量无关.

3 电容器电容的计算

步骤

$$C=\frac{Q}{V_A-V_B}=\frac{Q}{U}$$

（1）设两极板分别带电$\pm Q$

（2）求两极板间的电场强度$\vec{E}$

（3）求两极板间的电势差U

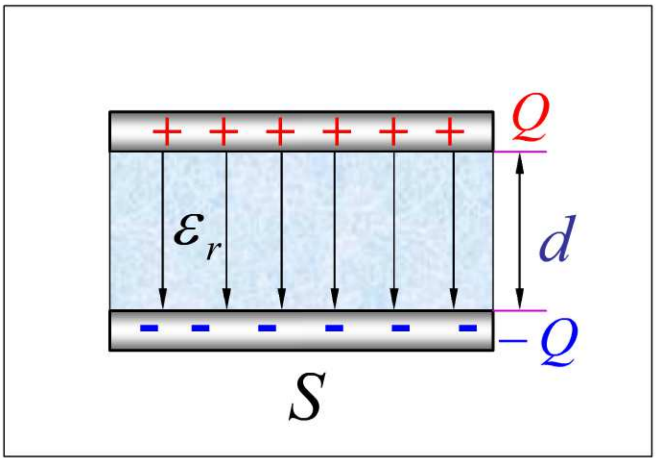
（4）由$C=Q/U$求C

例1 平行平板电容器

解 $E = \dfrac{\sigma}{\varepsilon_0 \varepsilon_r} = \dfrac{Q}{\varepsilon_0 \varepsilon_r S}$

$$U = Ed = \frac{Qd}{\varepsilon_0 \varepsilon_r S}$$

$$C = \frac{Q}{U} = \frac{\varepsilon_0 \varepsilon_r S}{d}$$



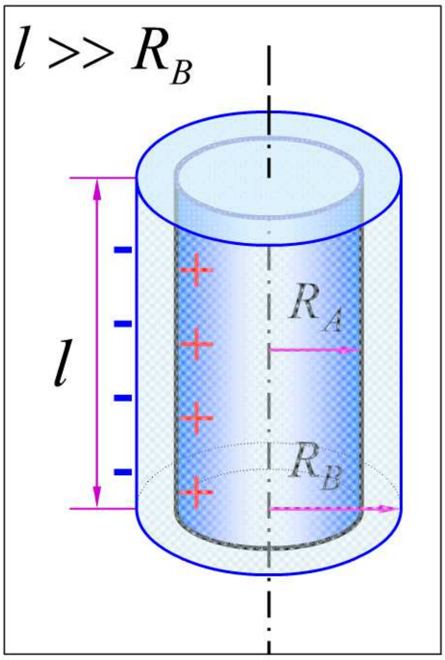
例2 圆柱形电容器

解 设两圆柱面单位长度上分别带电$\pm\lambda$

$$E=\frac{\lambda}{2\pi\varepsilon_0 r}\quad (R_A<r<R_B)$$

$$U=\int_{R_A}^{R_B}\frac{\lambda \mathrm{d}r}{2\pi\varepsilon_0 r}=\frac{Q}{2\pi\varepsilon_0 l}\ln\frac{R_B}{R_A}$$

$$C=\frac{Q}{U}=\frac{2\pi\varepsilon_0 l}{\ln\frac{R_B}{R_A}}$$

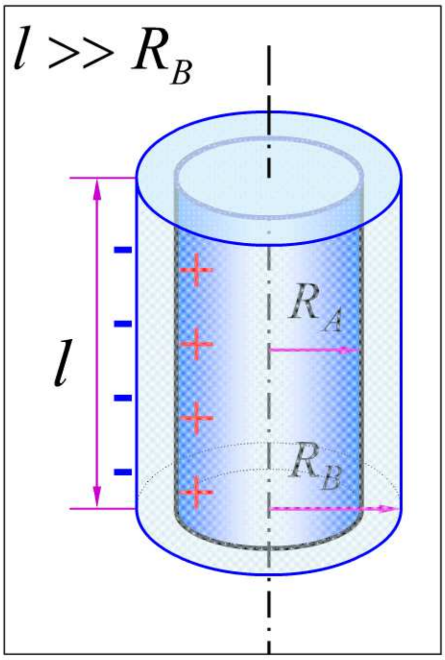


$$C=\frac{Q}{U}=\frac{2\pi\varepsilon_0 l}{\ln\frac{R_B}{R_A}}$$

$$d=R_B-R_A<<R_A$$

$$C\approx\frac{2\pi\varepsilon_0 lR_A}{d}=\frac{\varepsilon_0 S}{d}$$

平行板电容器电容



例3 球形电容器的电容

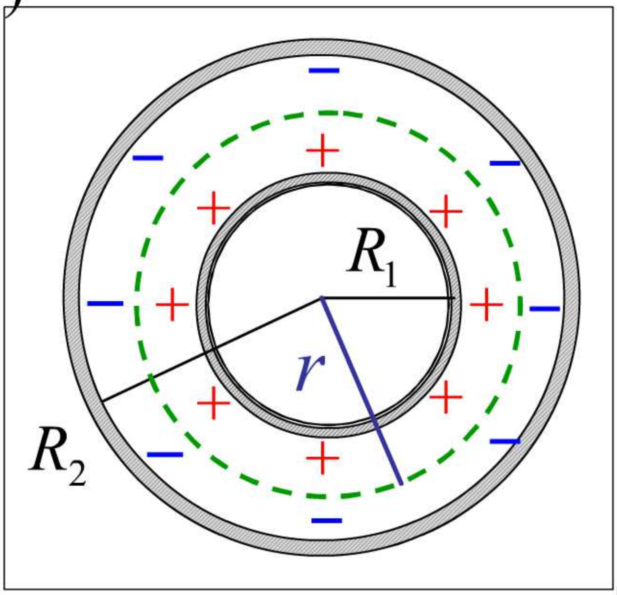
解 设内外球带分别带电$\pm Q$

$$E=\frac{Q}{4\pi\varepsilon_0 r^2}\quad(R_1<r<R_2)$$

$$U=\int\vec{E}\cdot\mathrm{d}\vec{l}$$

$$=\frac{Q}{4\pi\varepsilon_0}\int_{R_1}^{R_2}\frac{\mathrm{d}r}{r^2}$$

$$=\frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$



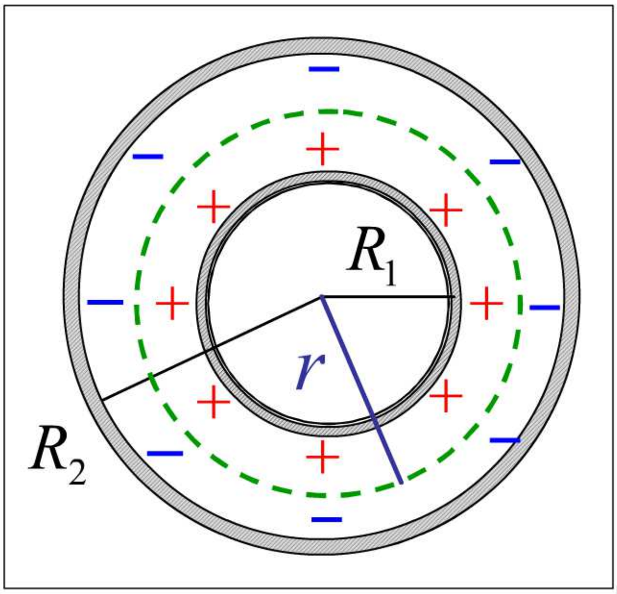
$$U=\frac{Q}{4\pi\varepsilon_0}(\frac{1}{R_1}-\frac{1}{R_2})$$

$$C=\frac{Q}{U}=4\pi\varepsilon_0\frac{R_1R_2}{R_2-R_1}$$

$$R_2\to\infty$$

$$C=4\pi\varepsilon_0R_1$$

孤立导体球电容

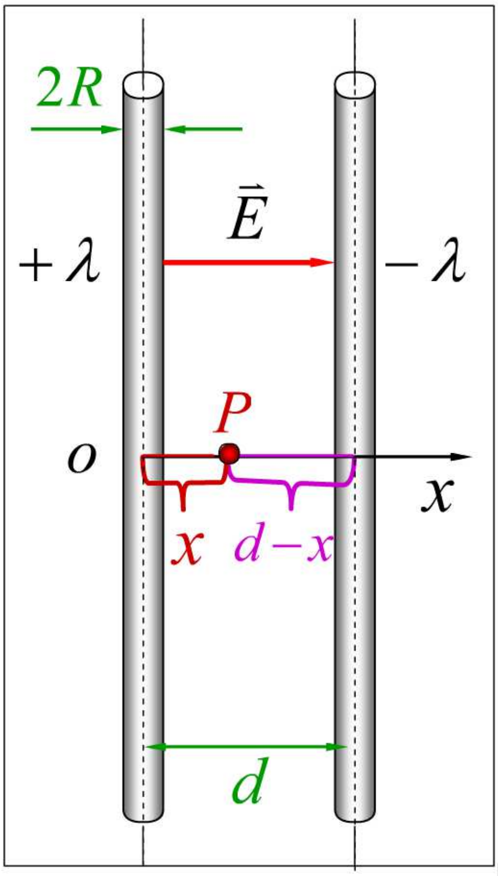


例4 两半径为R的平行长直导线，中心间距为d，且$d>>R$，求单位长度的电容.

解 设两金属线的电荷线密度为$\pm\lambda$

$$E = E_+ + E_-$$

$$= \frac{\lambda}{2\pi\varepsilon_0 x} + \frac{\lambda}{2\pi\varepsilon_0 (d-x)}$$

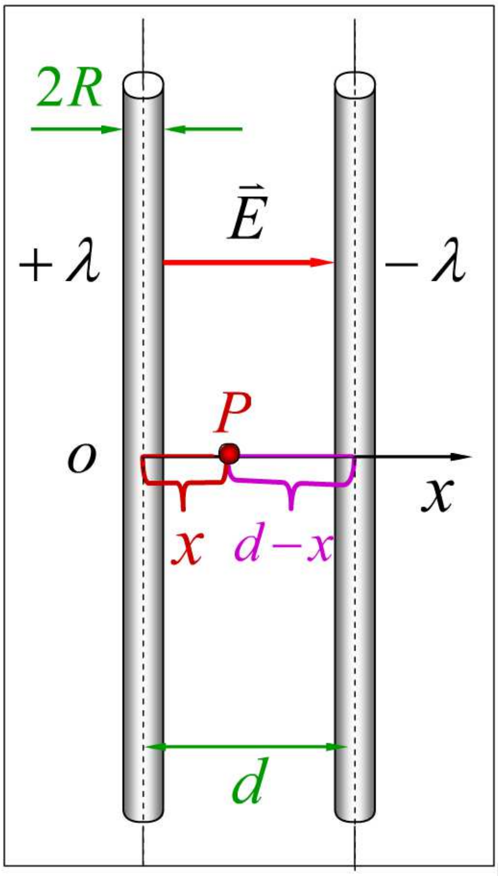


$$U = \int_R^{d-R} E\,\mathrm{d}x$$

$$= \frac{\lambda}{2\pi\varepsilon_0}\int_R^{d-R}\left(\frac{1}{x}+\frac{1}{d-x}\right)\mathrm{d}x$$

$$= \frac{\lambda}{\pi\varepsilon_0}\ln\frac{d-R}{R} \approx \frac{\lambda}{\pi\varepsilon_0}\ln\frac{d}{R}$$

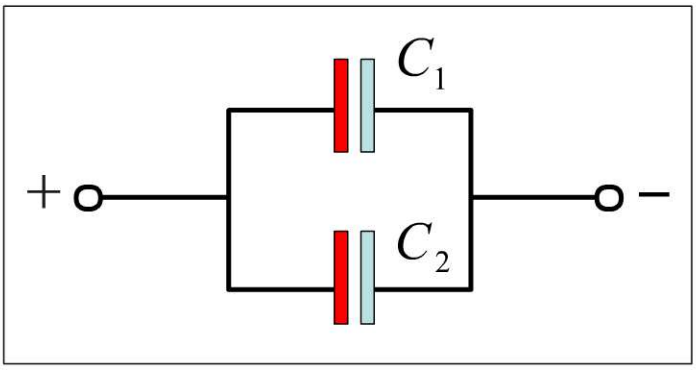
$$C = \frac{\lambda}{U} = \frac{\pi\varepsilon_0}{\ln\dfrac{d}{R}}$$



三 电容器的并联和串联

1 电容器的并联

$$C = C_1 + C_2$$



2 电容器的串联

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$