

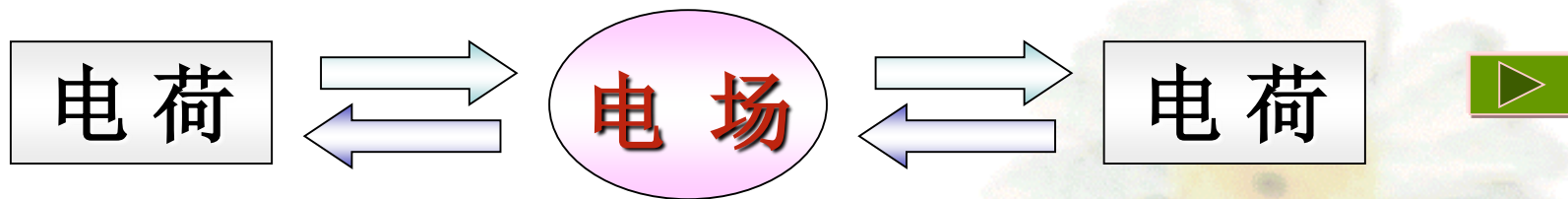


云南省职工业务技能大赛——

“高教社杯” 高等师范院校

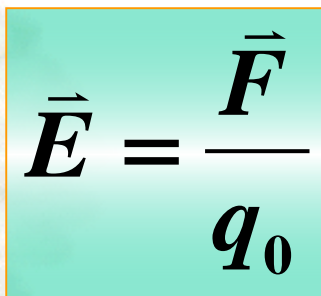
物理学教师教学技能大赛决赛





- 给电场中的电荷施以力的作用

电场具有“力”的性质 引入  电场强度



The equation $\vec{E} = \frac{\vec{F}}{q_0}$ is displayed inside a light green rectangular box. The vector \vec{E} is on the left, followed by an equals sign, then the vector \vec{F} over the scalar q_0 . The background features a faint, light-colored flower.

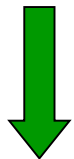
若**已知电荷分布**，则空间各点的**场强**可以求出。

方法：

任选 **dq**

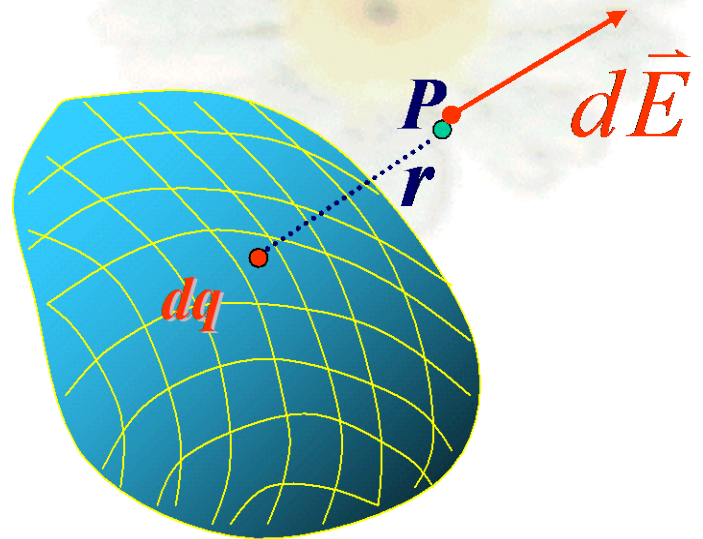


求出 **$d\vec{E}$**



$$\vec{E} = \int d\vec{E}$$

$$d\vec{E} = \frac{dq}{4\pi\epsilon_0 r^2} \vec{e}_r$$

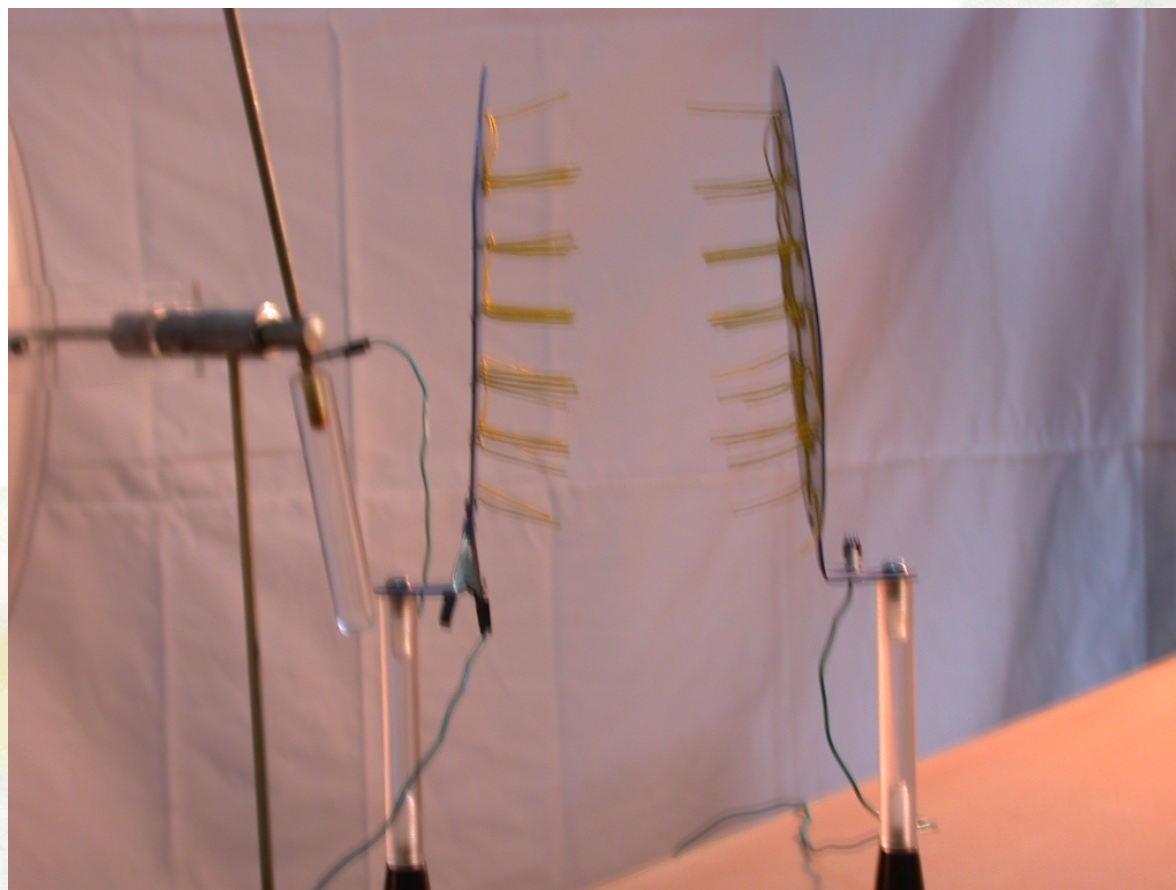


问题：

如何形象化地把客观存在的静电场中的**场强分布**描绘出来？

§ 1-3 电场线

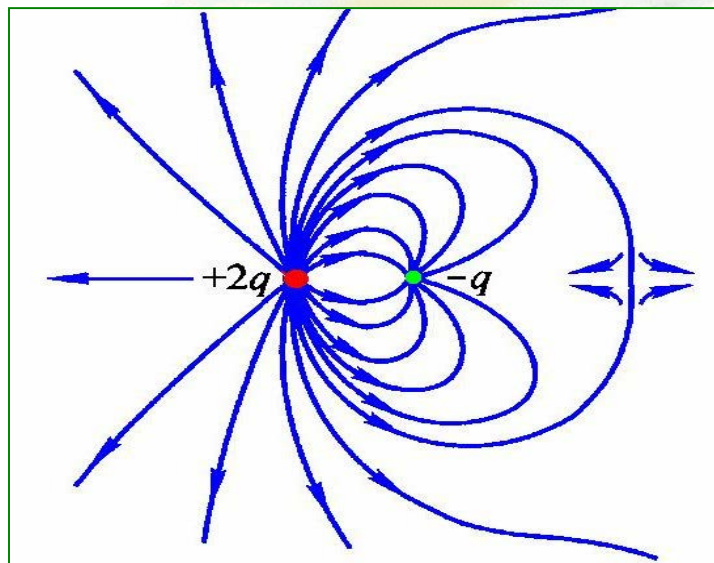
电通量



一、 电场线

◆为了**形象化**地把客观存在的电场表示出来，引入电场线这一辅助工具。

1、 定义

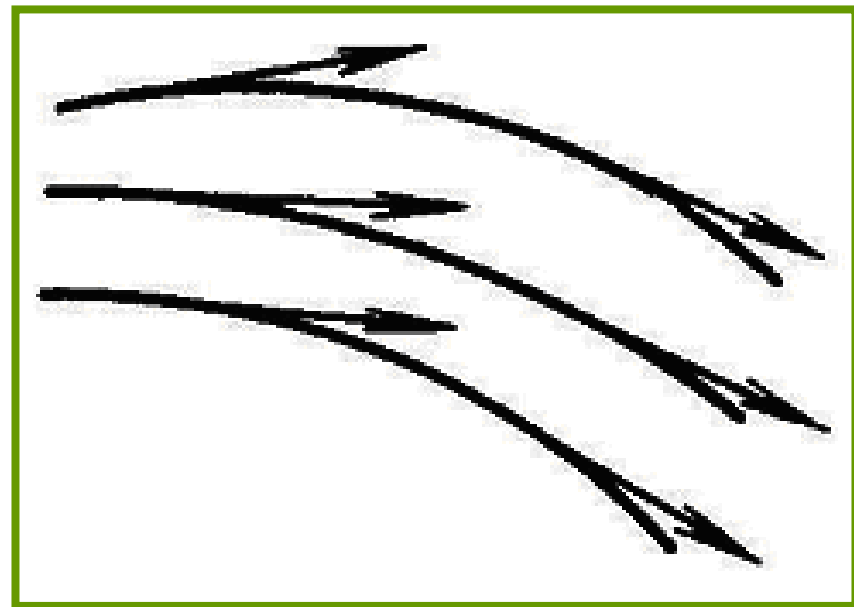
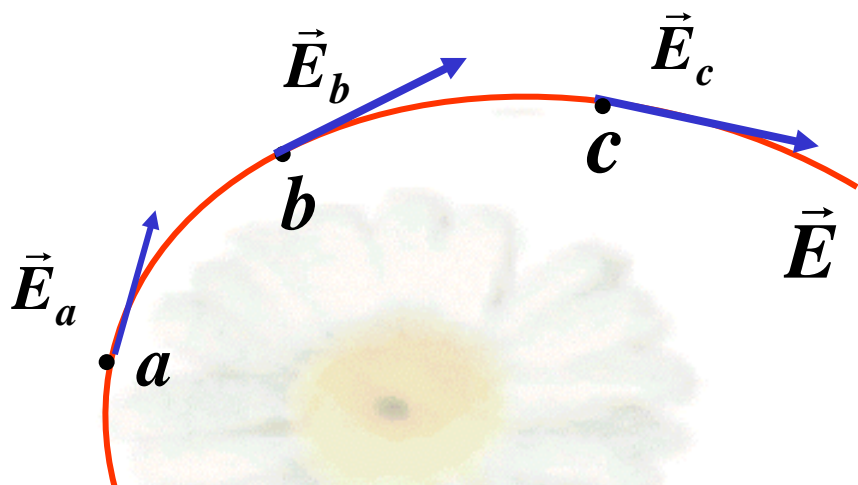


电场线是为了**形象描绘**电场中的场强分布

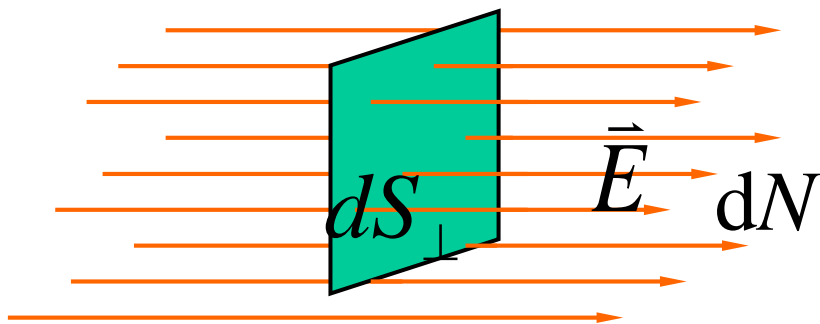
而引入的**假想曲线**

2. 规定

1) 电场线上每一点切线方向为该点的场强方向



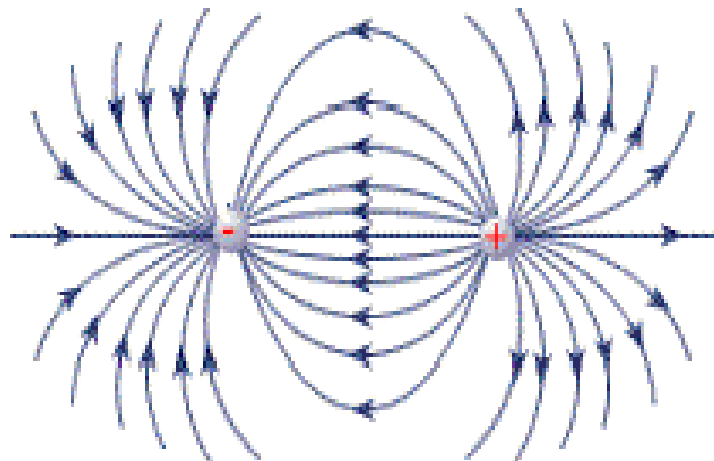
2) 通过垂直于电场方向单位面积电场线条数为该点电场强度的大小。



$$E = \frac{dN}{dS_{\perp}}$$

即：电场中某点的电场强度大小等于该点的
电场线数密度

电场线密集，场强大
电场线稀疏，场强小

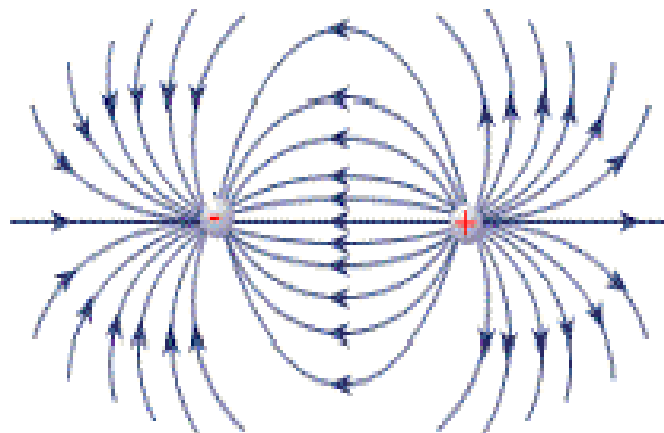
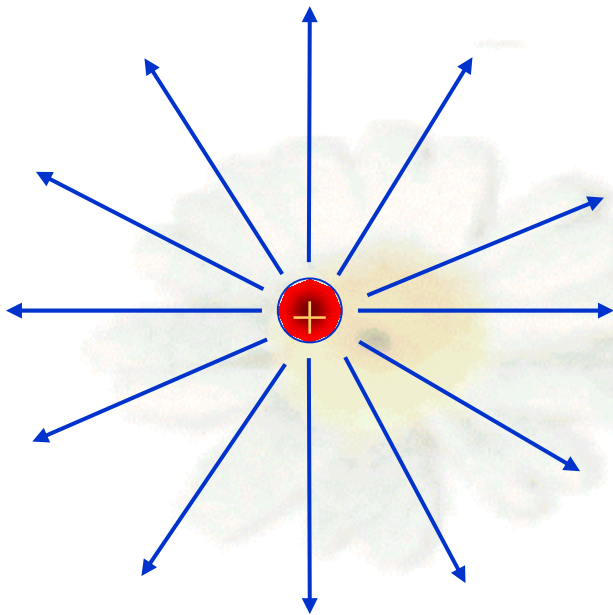


等量异种电荷的电场。

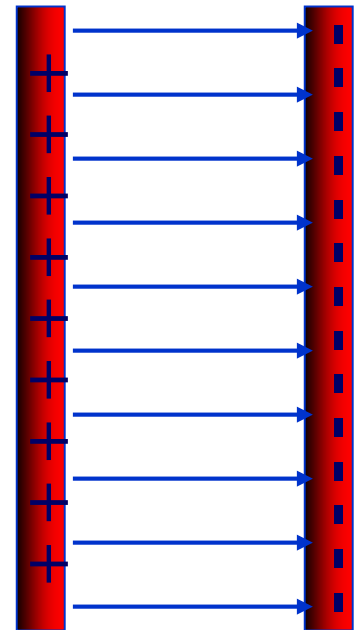
3、几种常见电场线

4. 特性

- 1) 电场线始于正电荷, 止于负电荷或来自无穷远, 去向无穷远
- 2) 静电场电场线是非闭合曲线。
- 3) 任意两条电场线不会相交。



等量异种电荷的电场。

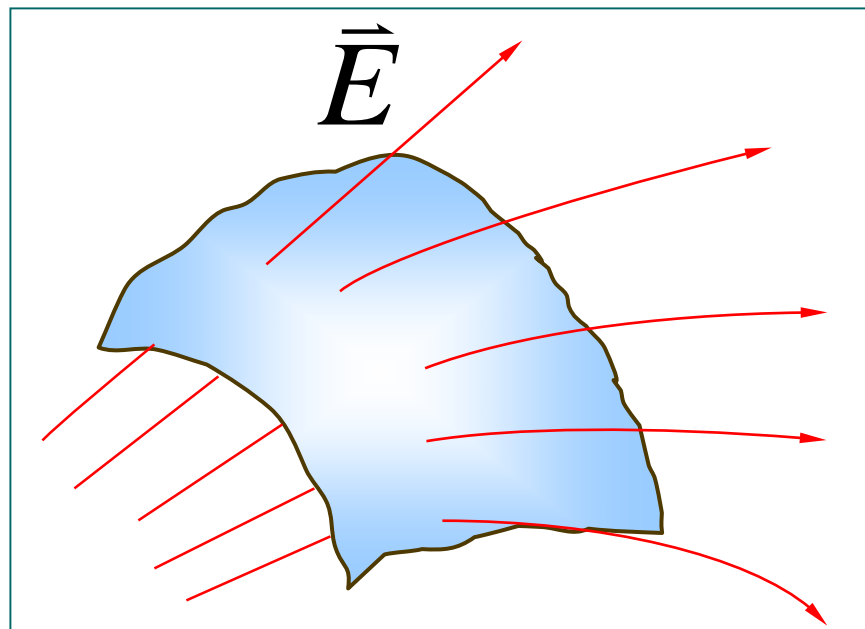
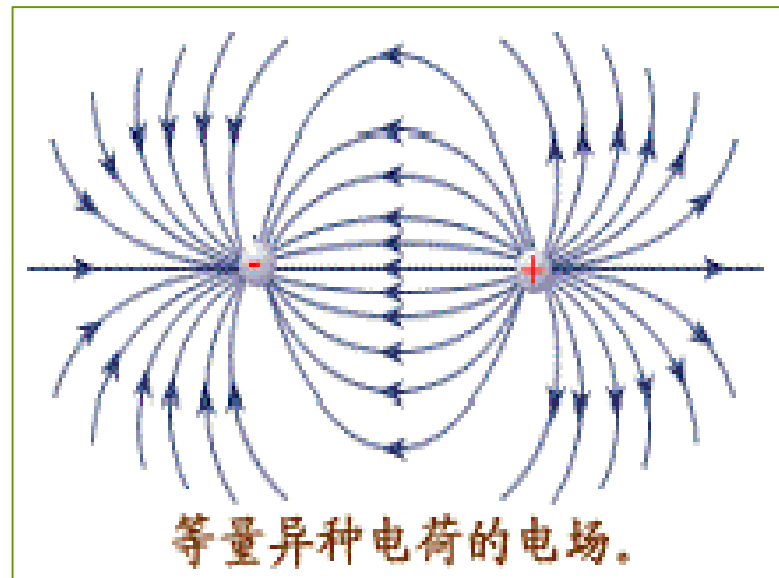


二、电通量

1、定义

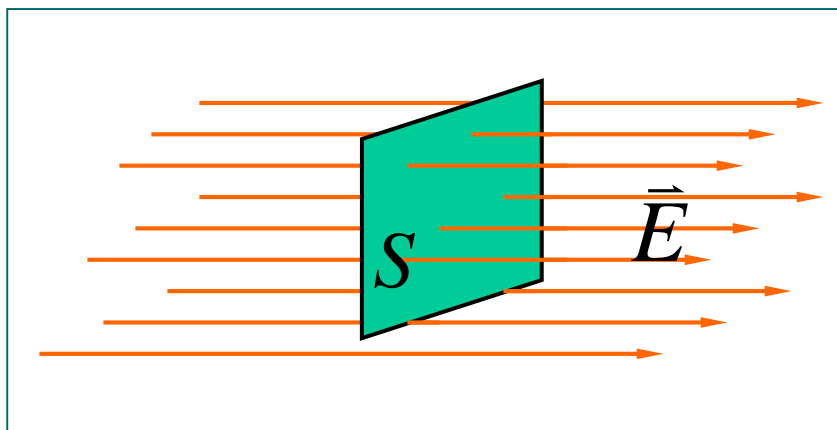
通过电场中任意曲面的
电场线的数目，称为通过
该曲面的电通量，
用 Φ_e 表示。

$$\phi_e = ?$$

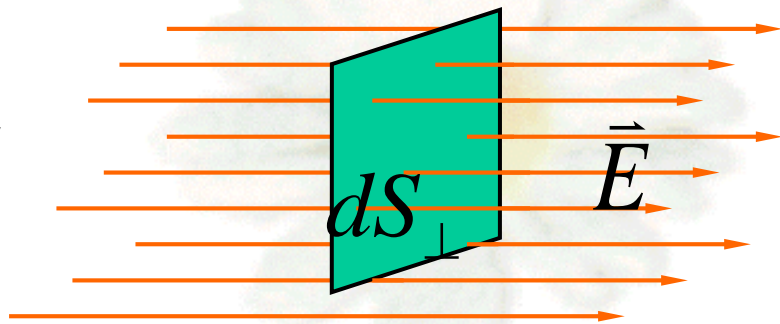


2、计算

(1) 在匀强电场中, 若 $\vec{E} \perp S$



$$\phi_e = ES$$



$$E = \frac{dN}{dS_{\perp}}$$



$$dN = E dS_{\perp}$$

$$d\phi_e$$

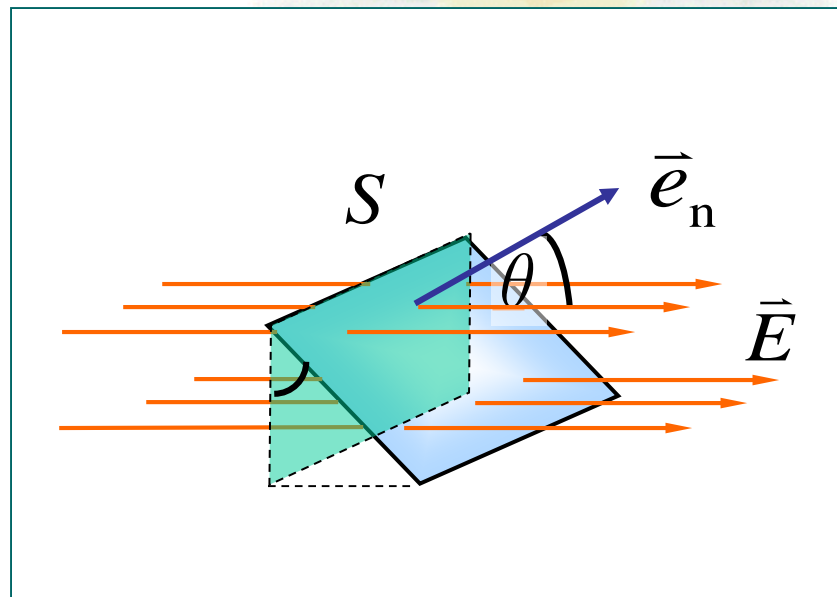
2、计算

(2) 匀强电场，
 \vec{E} 与平面夹角 θ 。

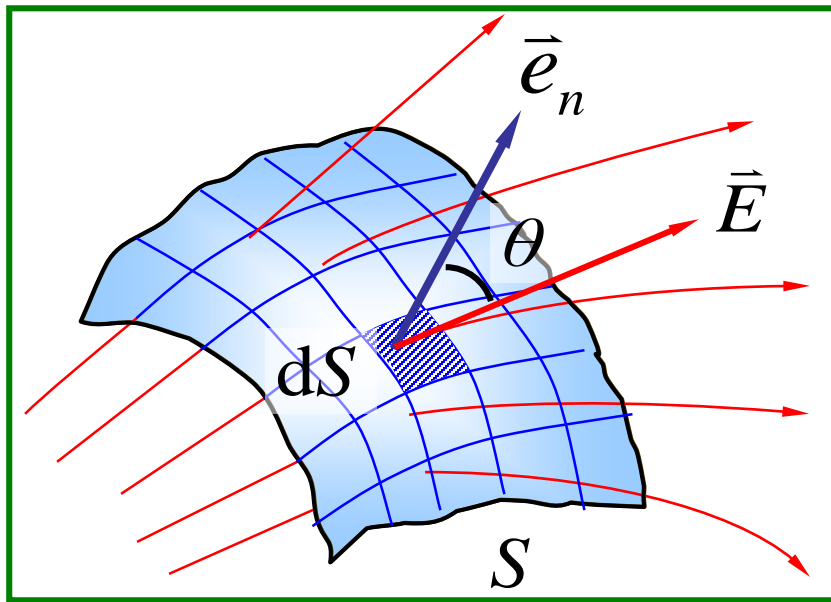
$$\phi_e = ES \cos \theta$$

面积矢量： $\vec{S} = S\vec{e}_n$

$$\phi_e = \vec{E} \cdot \vec{S}$$



(3) 非匀强电场，任意曲面 S 的电通量.



$$d\phi_e = E \cos \theta dS = \vec{E} \cdot d\vec{S}$$

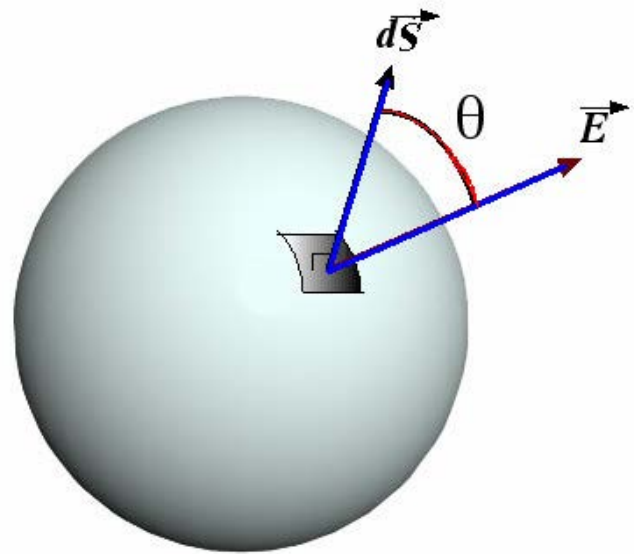
$$\phi_e = \int d\phi_e = \int_S \vec{E} \cdot d\vec{S}$$

(4) 闭合曲面的电通量

$$\phi_e = \oint_S \vec{E} \cdot d\vec{S}$$

规定:

法线的**正方向**为指向
闭合曲面的**外侧**。

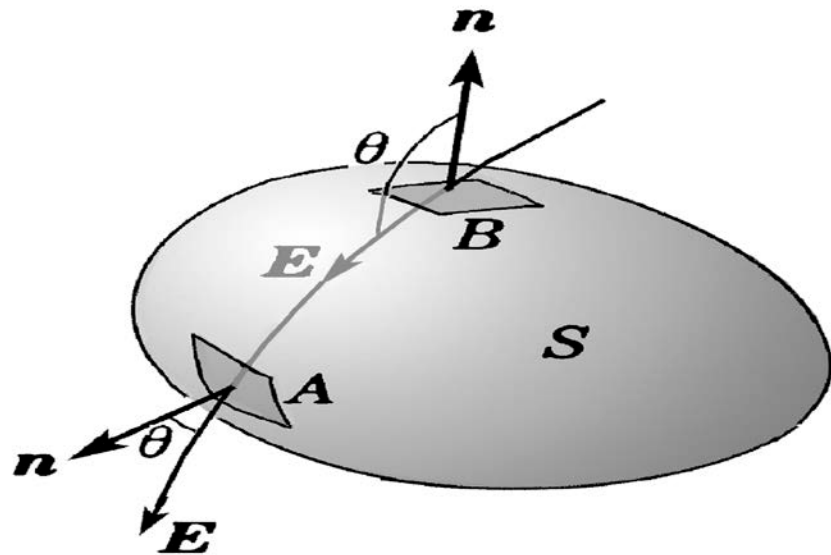


穿入处: $\theta > \frac{\pi}{2}$, $d\phi_e < 0$

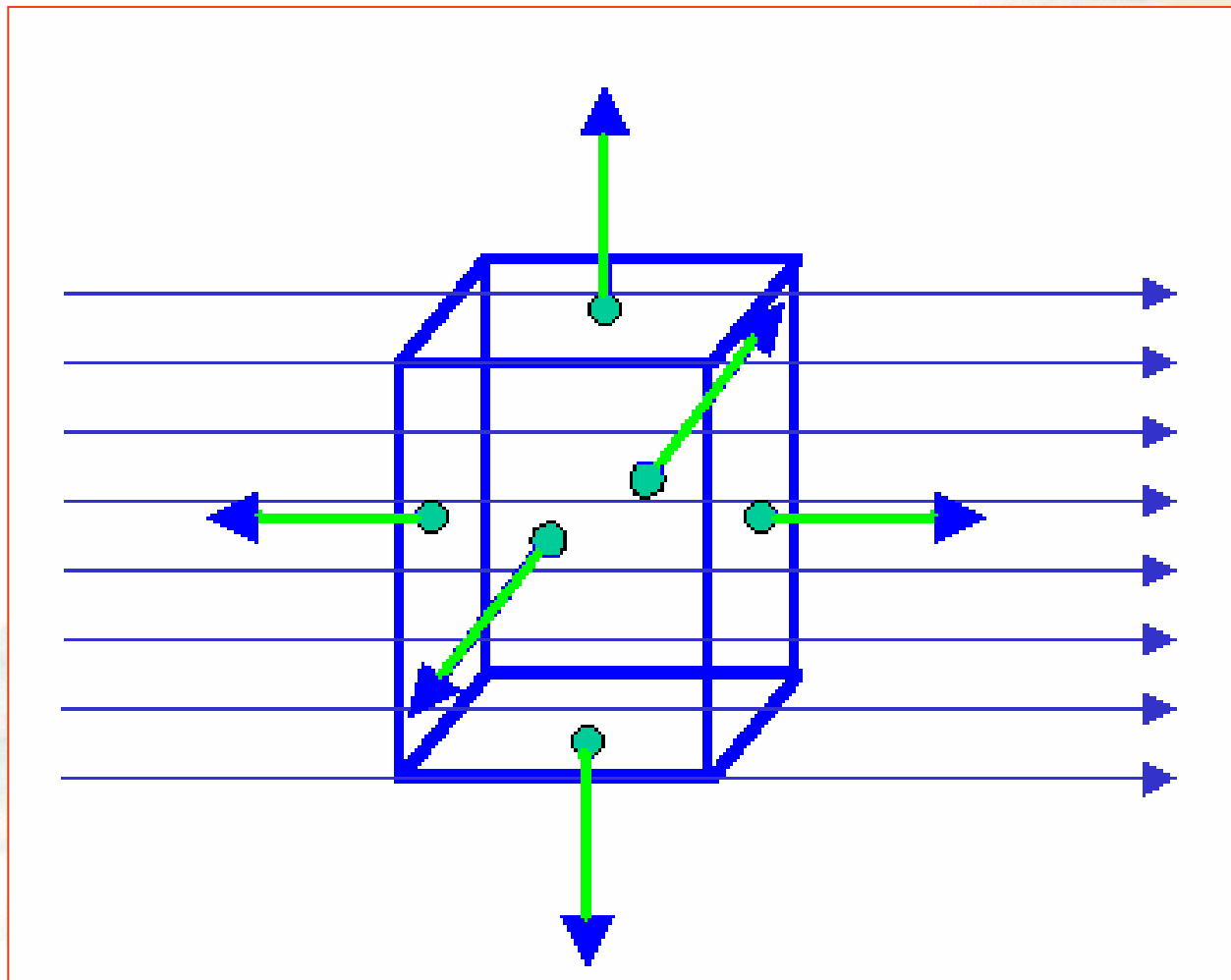
穿出处: $\theta < \frac{\pi}{2}$, $d\phi_e > 0$

若: $N_{\text{入}} = N_{\text{出}}$

则: $\phi_e = 0$



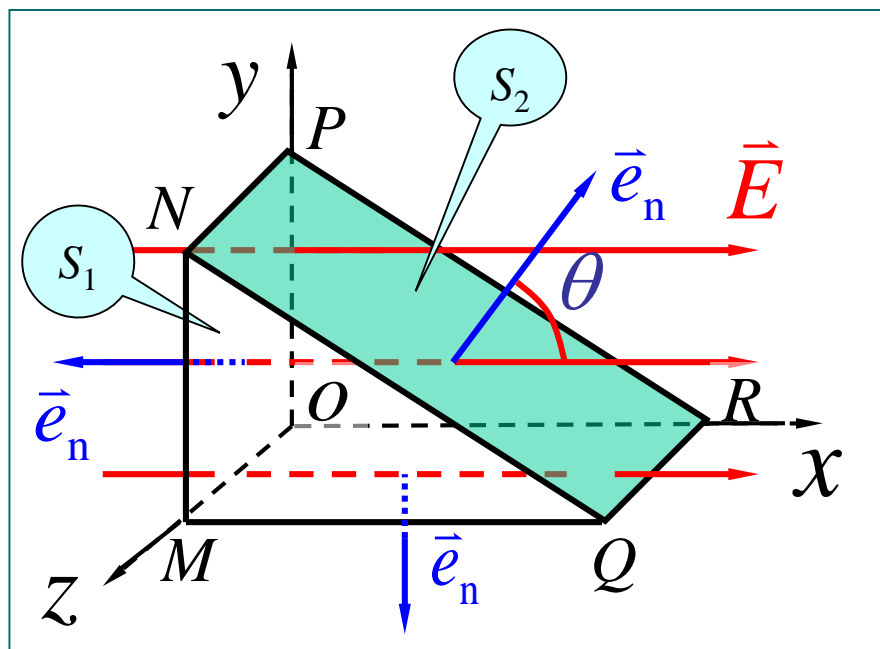
若： $N_{\lambda} = N_{\text{出}}$ 则： $\phi_e = 0$

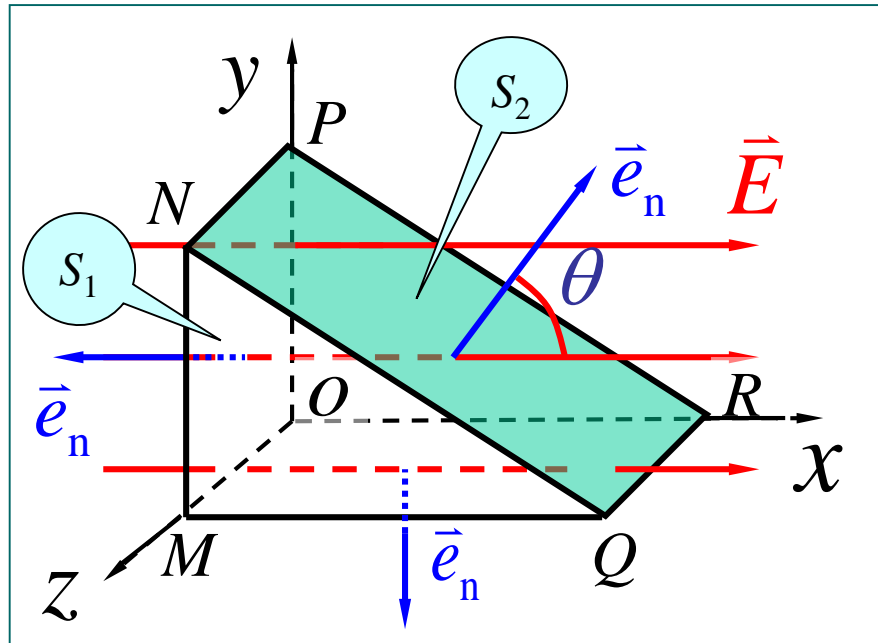


例1 三棱柱体放置在如图所示的匀强电场中，求通过此三棱柱体的电场强度通量。

解

$$\begin{aligned}\Phi_e &= \sum_{i=1}^5 \Phi_{ei} \\ &= \Phi_{e1} + \Phi_{e2}\end{aligned}$$





$$\Phi_{e1} = ES_1 \cos \pi = -ES_1$$

$$\Phi_{e2} = ES_2 \cos \theta = ES_1$$

$$\Phi_e = \sum_{i=1}^5 \Phi_{ei} = 0$$

例2：点电荷 q 位于球心处，求通过球面的电通量

$$d\phi_e = \vec{E} \cdot d\vec{S}$$

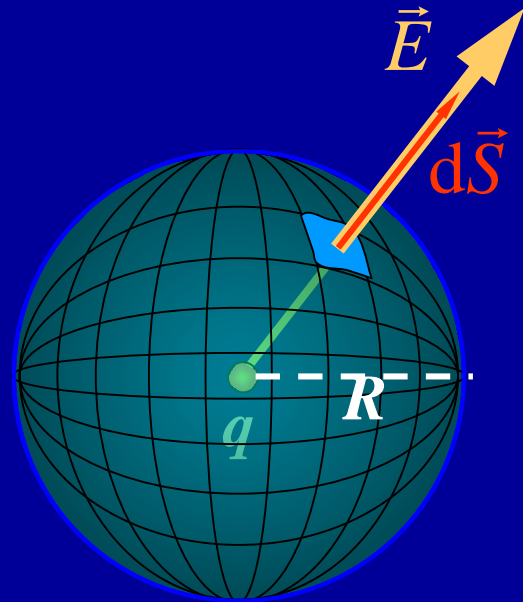
$$= E dS$$

$$= \frac{q}{4\pi\epsilon_0 R^2} dS$$

$$\phi_e = \oint_S \vec{E} \cdot d\vec{S}$$

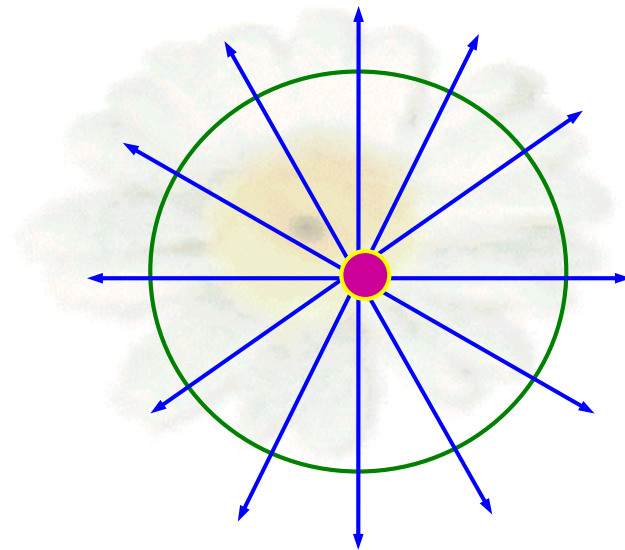
$$= \oint_S E dS$$

$$= \frac{q}{4\pi\epsilon_0 R^2} \cdot 4\pi R^2 = \frac{q}{\epsilon_0}$$



点电荷在球面的球心处

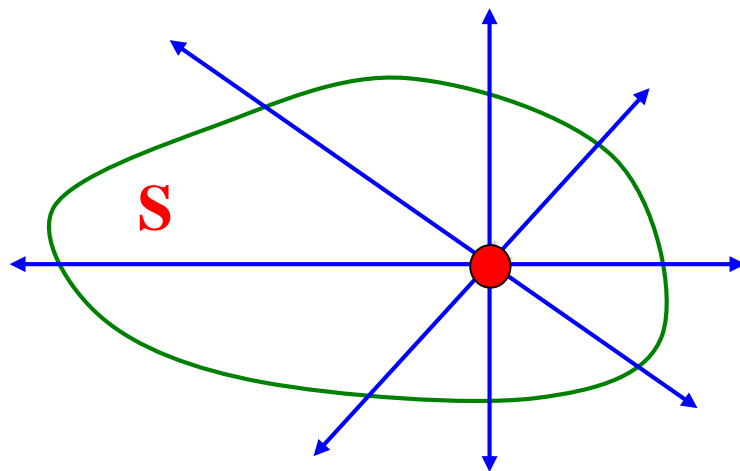
$$\phi_e = \oint_S \vec{E} \cdot d\vec{S} = \frac{q}{\epsilon_0}$$



思考问题1:

点电荷在任意形状的闭合曲面内

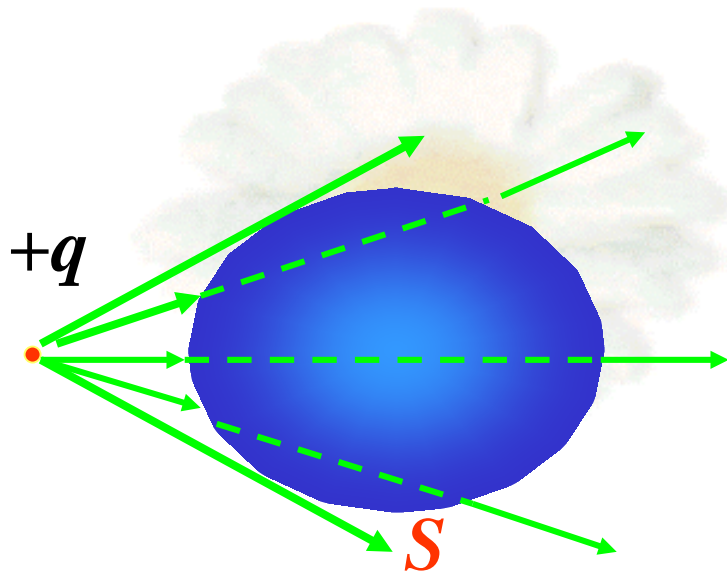
$$\phi_e = \oint_S \vec{E} \cdot d\vec{S} = ?$$



思考问题2:

点电荷在闭合曲面外,
通过闭合曲面的电通量?

$$\phi_e = \oint_S \vec{E} \cdot d\vec{S} = ?$$



思考问题3:

多个电荷存在,
通过任意闭合曲面的电通量?

$$\phi_e = \oint_S \vec{E} \cdot d\vec{S} = ?$$

