§3－3 Electric Field Line & Flux
电场线 电通量

1. Electric Field Line 电场线

电场线是用来形象地描述场强分布的空间曲线簇.

a nice way to visualize patterns in electric fields.

1) 规定:

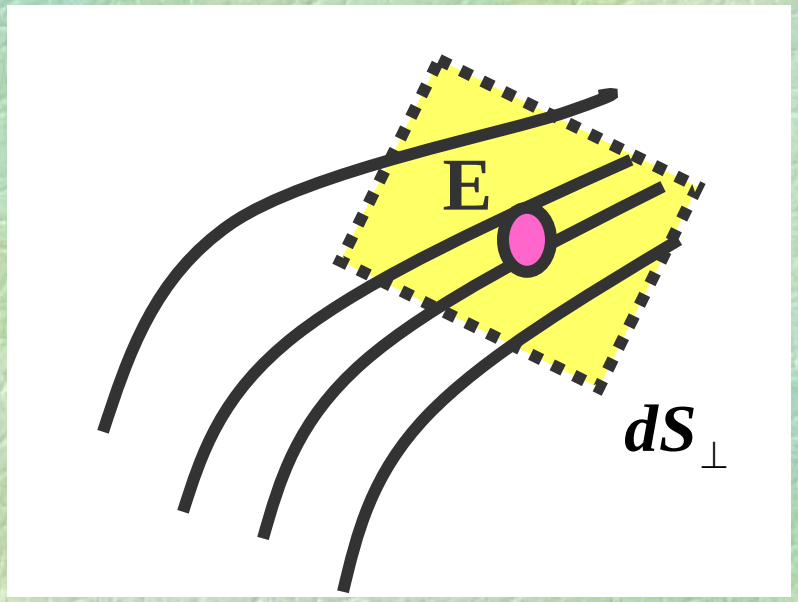
(1)The direction of tangent to a curved field line is the direction of electric field, and (2) the field line is drawn so that the number of lines per unit area, measured in a plane that is perpendicular to the lines, is proportional to the magnitude of $\vec{E}$

1、曲线上每一点的切线方向表示该点处电场强度 $\vec{E}$ 的方向。

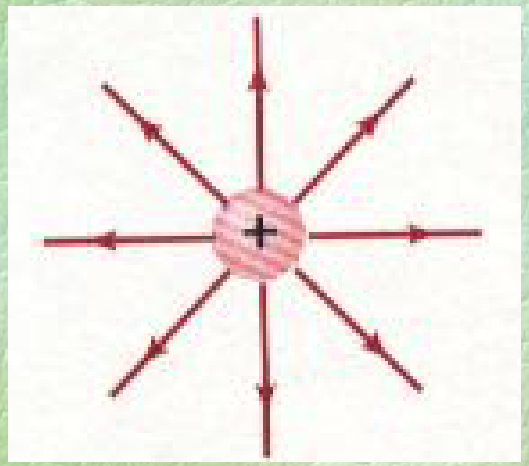
2、通过垂直于电场强度的单位面积的电场线条数，就等于该点处电场强度 $\vec{E}$ 的大小。

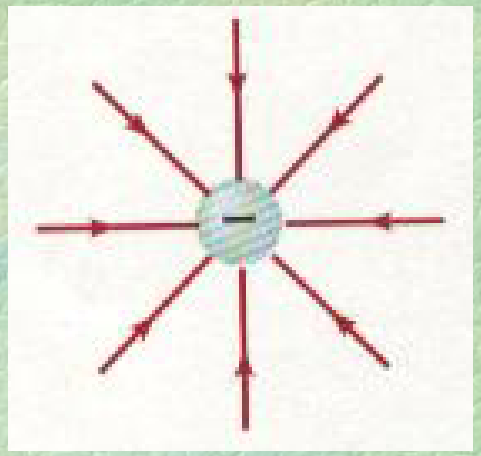
$$\frac{dN}{dS_{\perp}} = E$$

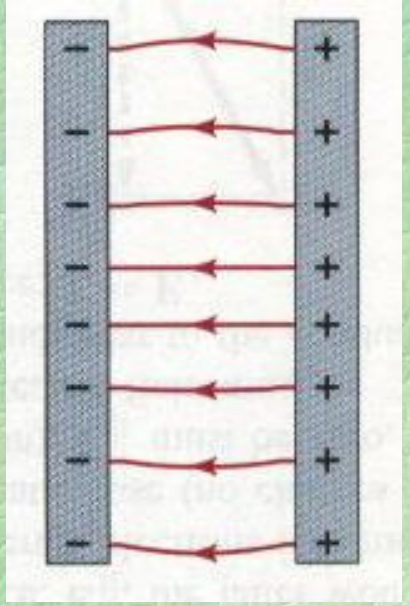
显然，电力线密的空间，电场强。

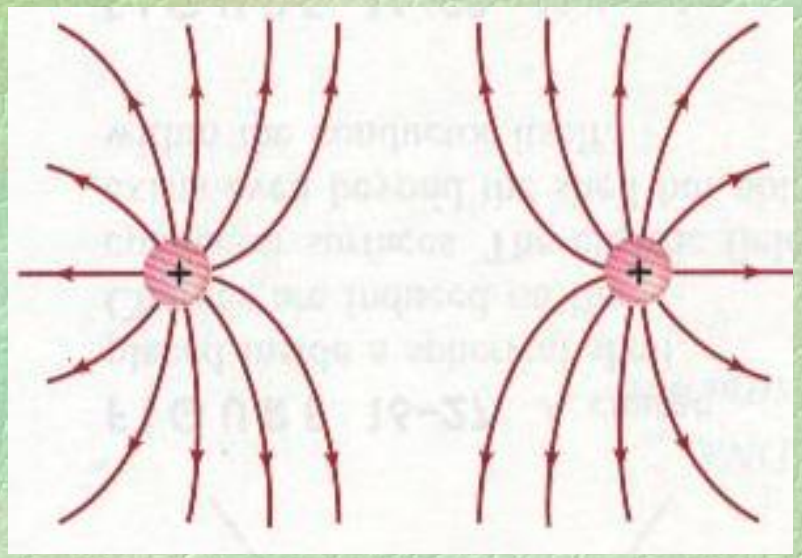


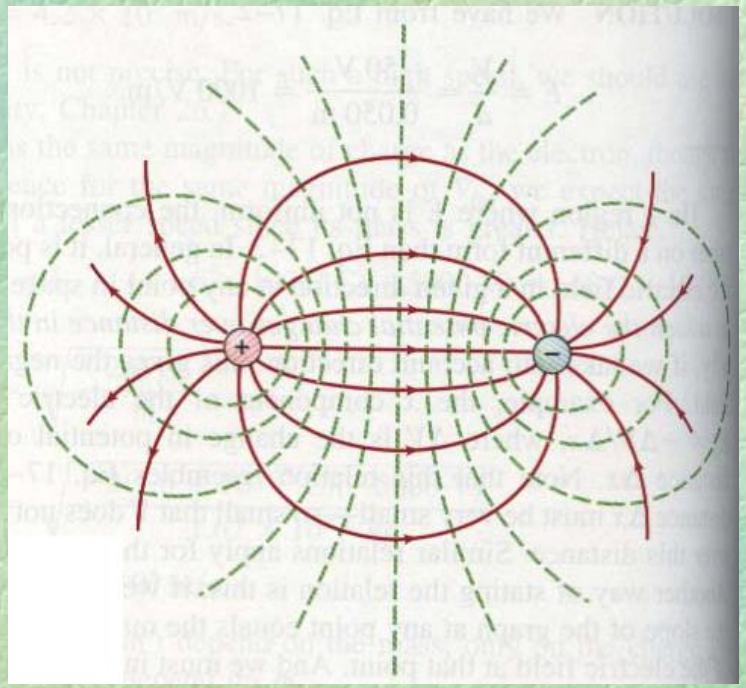
2)典型的电场线图





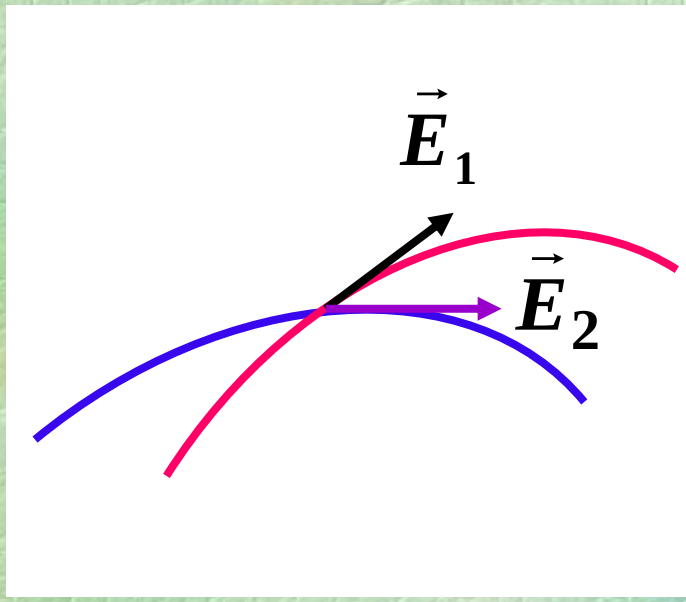






3) 电力线性质：

- 电力线始于正电荷（或无穷远）终止于负电荷，不会在没有电荷处中断(Electric field lines extend away from positive charge and toward negative charge)；
- 两条电力线不会相交；
- 电力线(静电场）不会形成闭合曲线。

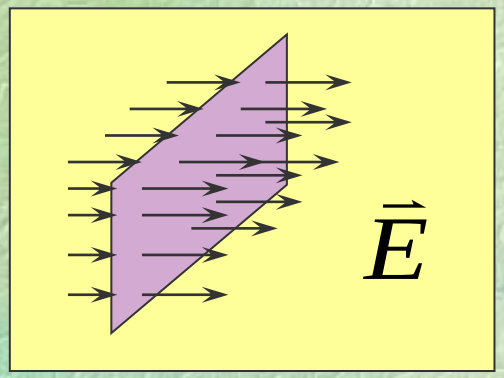


2. Electric Flux 电场强度通量（E通量）Φ_e：

The number of line of electric force through a area A is called the electric flux of this area, labeled by Φ_e

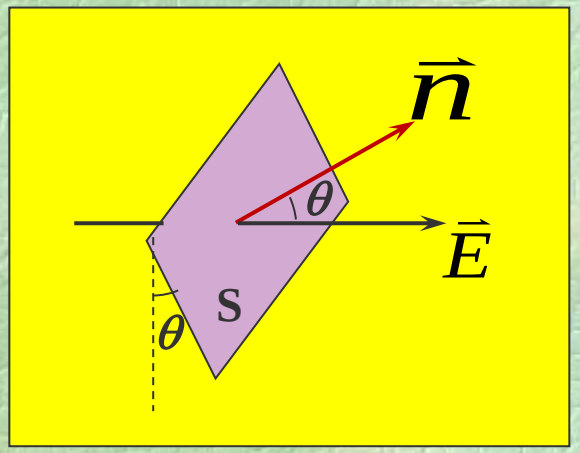
通过电场中任一曲面的电场线条数表示通过这个面的电场强度通量。

1、均匀电场中通过平面S的E通量



$$\Phi_e = ES$$

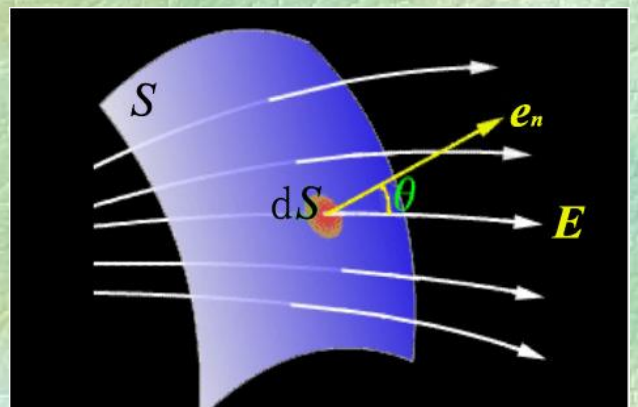
$$\Phi_e = ES\cos\theta = \vec{E}\cdot\vec{S}$$



2、非均匀电场通过任一曲面S的E通量

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

$$\Phi_e = \iint_s d\Phi = \iint_s \vec{E}\cdot d\vec{S}$$

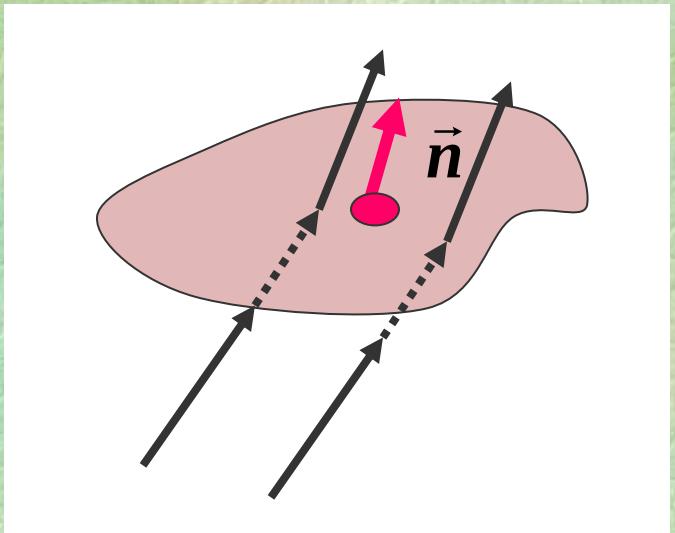


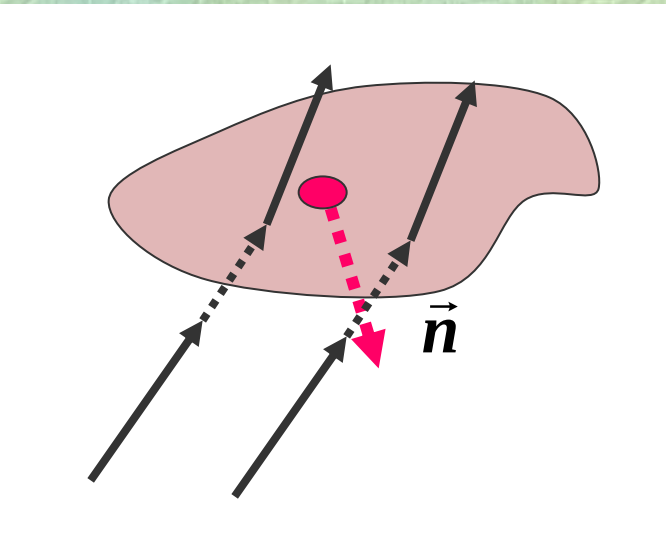
对闭合曲面的E通量：

$$\Phi_e = \oiint_S \vec{E} \cdot d\vec{S}$$

Note

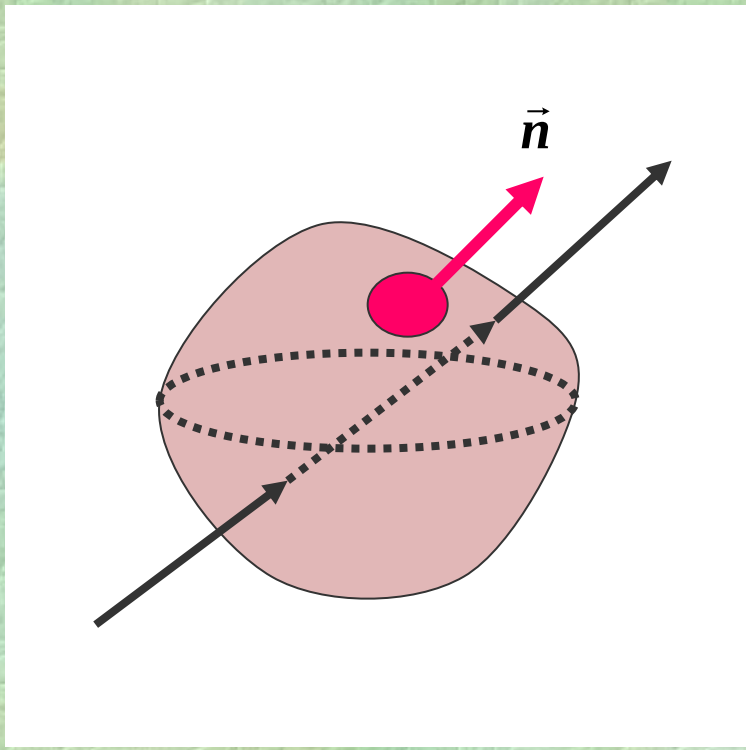
(1) 对于非封闭曲面，法线的定义有两种选择，结果电通量 $\Phi_e > 0$ 或 $\Phi_e < 0$ 。





（2）对于封闭曲面，规定:外法线方向为正

$$\Phi_e = \oiint_S \vec{E} \cdot d\vec{s} = \oiint_S E\cos\theta ds$$



- 当$\theta < 90°$ 时$\Phi_e > 0$：

  电场线穿出闭合曲面。

- 当$\theta > 90°$ 时$\Phi_e < 0$

  电场线穿进闭合曲面。

习题:一均匀带电直线长为d，电荷线密度为$+\lambda$，以导线中点O为球心，R为半径($R>d$)作一球面，如图所示，则通过该球面的电场强度通量为 _____.

带电直线的延长线与球面交点P处的电场强度的大小为 _____，方向_____.