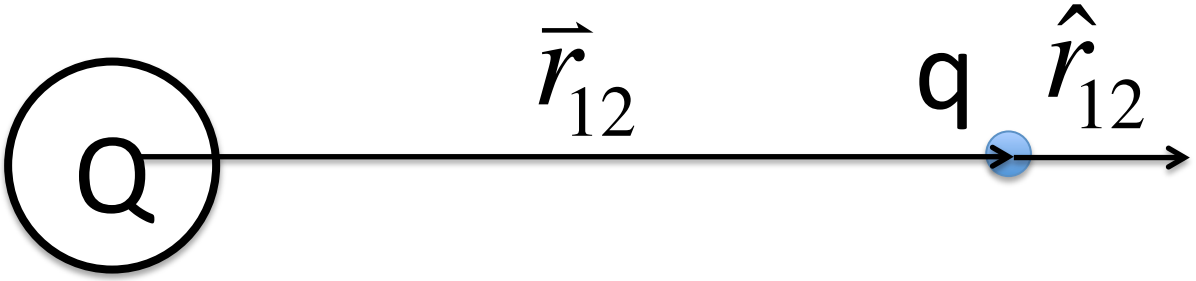
Electric Field

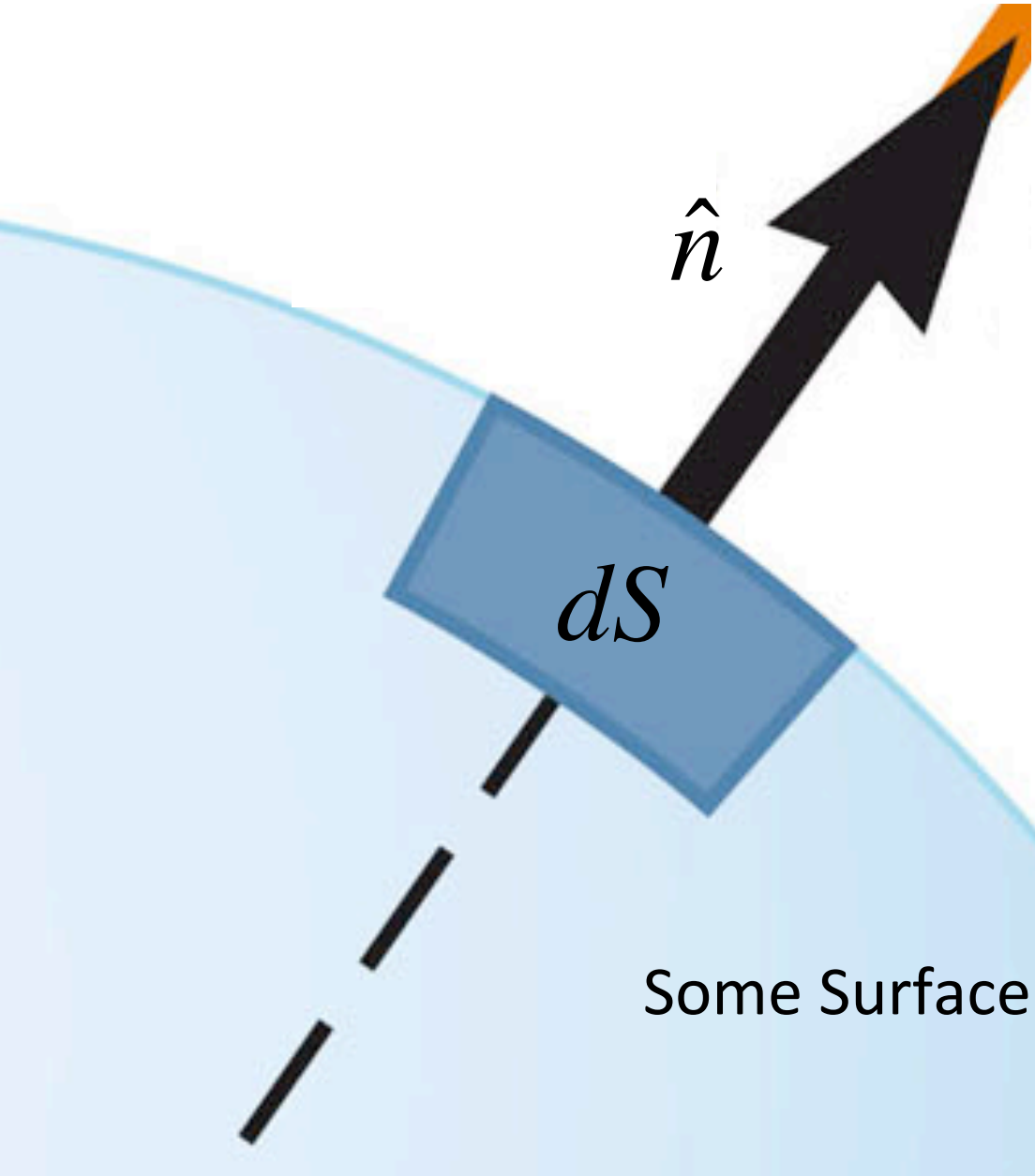


Force on q by Q $\vec{F}_{Qq} = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{\left|\vec{r}_{12}\right|^2}\hat{r}_{12}$

$$\vec{E} = \frac{\vec{F}_{Qq}}{q} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{\left|\vec{r}_{12}\right|^2}\hat{r}_{12}$$

$\vec{E} \sim \hat{r}_{12}$ $\quad\quad$ $\left|\vec{E}\right| \sim Q$ $\quad\quad$ $\left|\vec{E}\right| \sim \frac{1}{\left|\vec{r}_{12}\right|^2}$

Comment on notation and electric flux

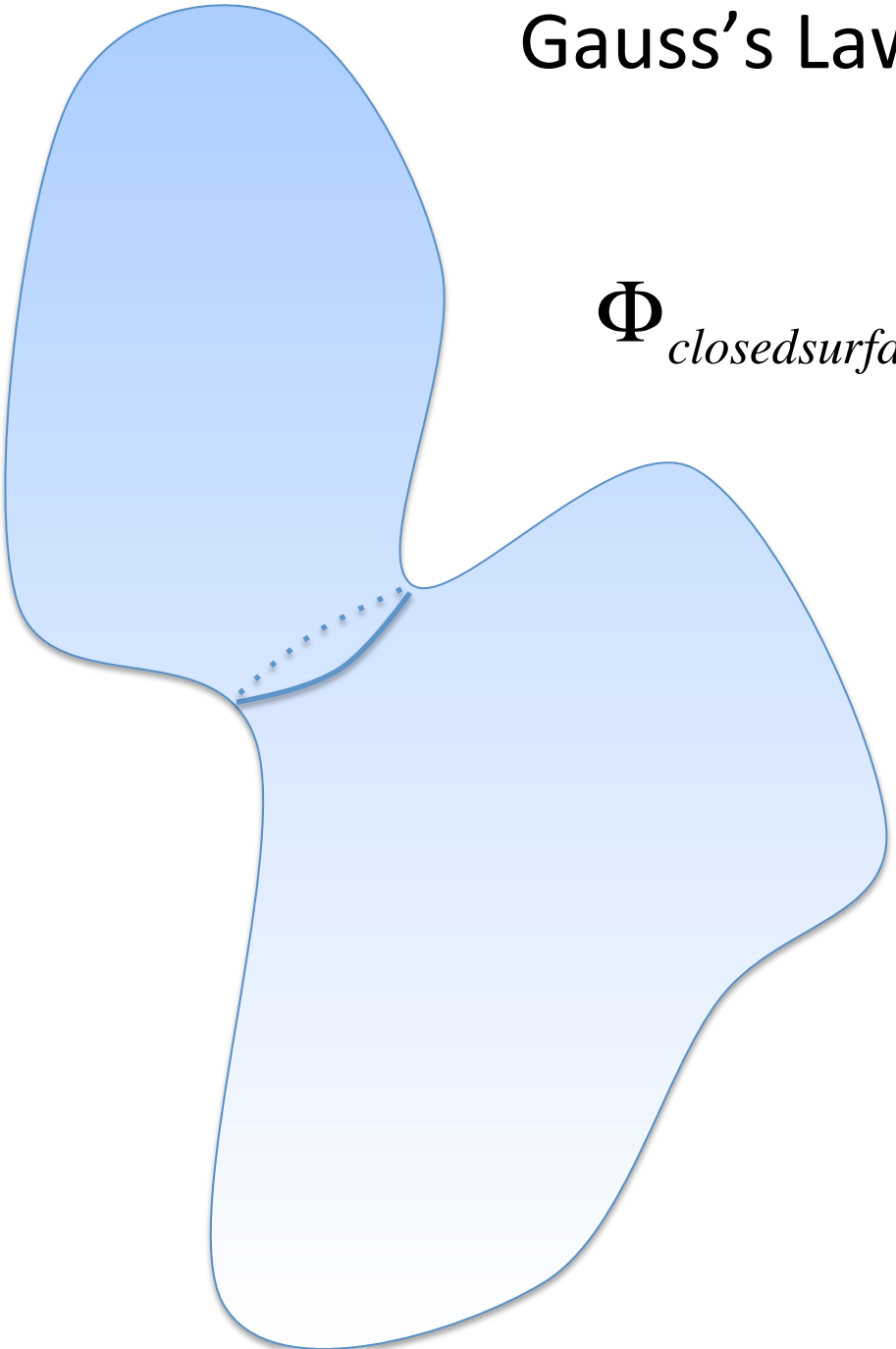


$$dS\hat{n} = d\vec{A}$$

$$d\Phi = \vec{E} \cdot \hat{n} dS$$

$$d\Phi = \vec{E} \cdot d\vec{A}$$

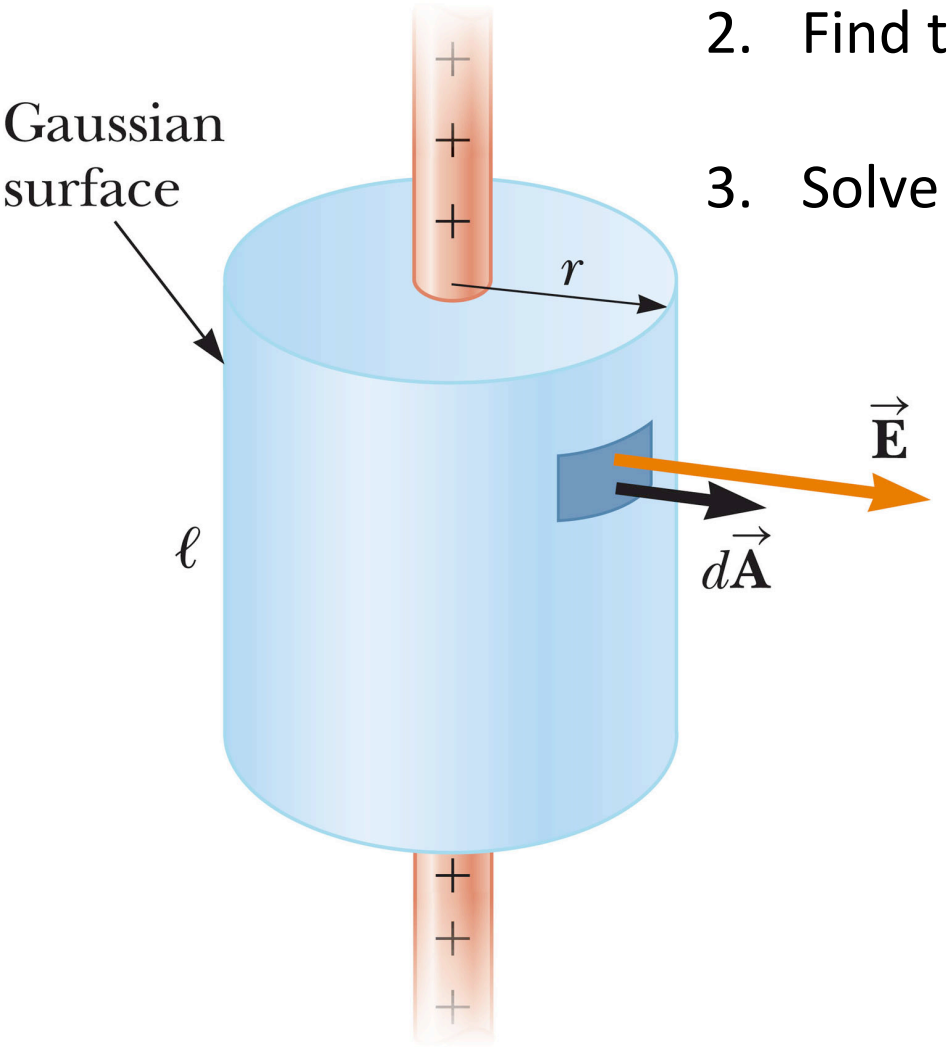
Gauss's Law



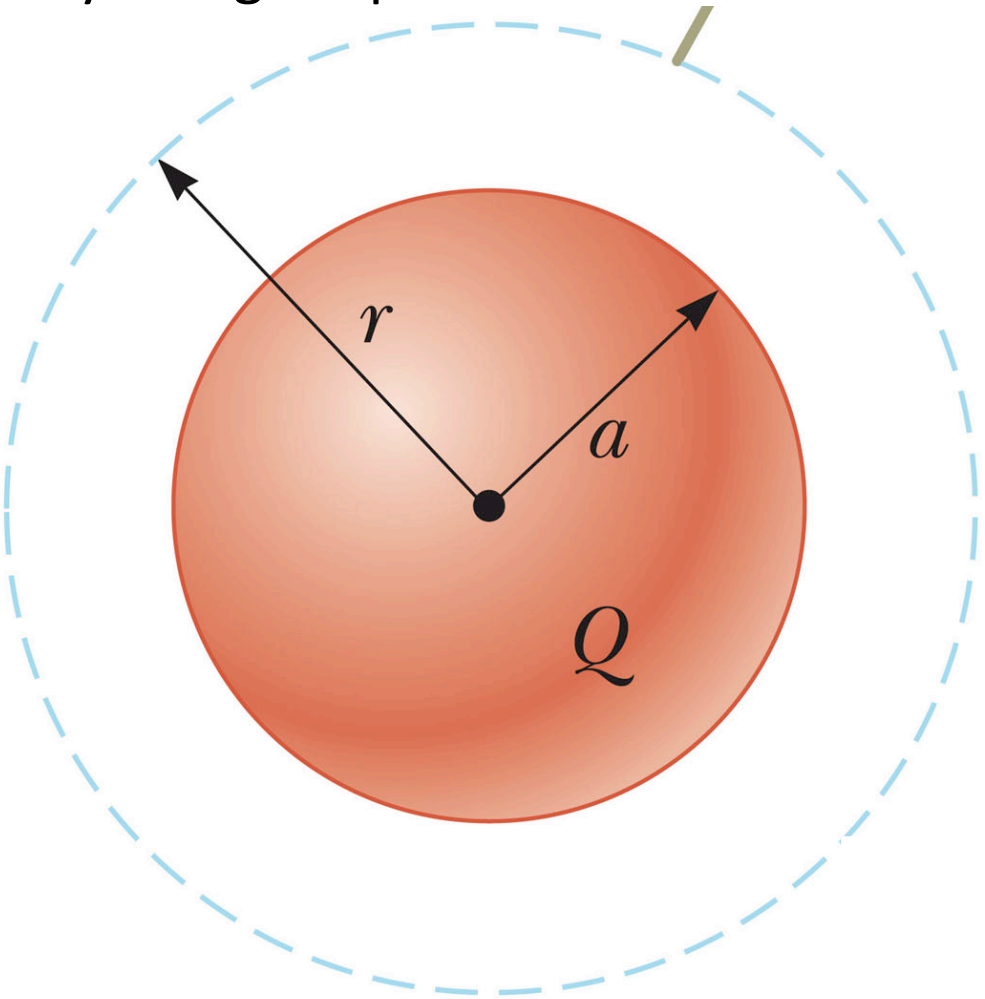
$$\Phi_{closedsurface} = \oint_{surface} \vec{E} \cdot d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$$

Using Gauss's Law (to find electric field)

1. Define a closed surface (Gaussian surface)
2. Find the enclosed charge
3. Solve algebra to get the electric field

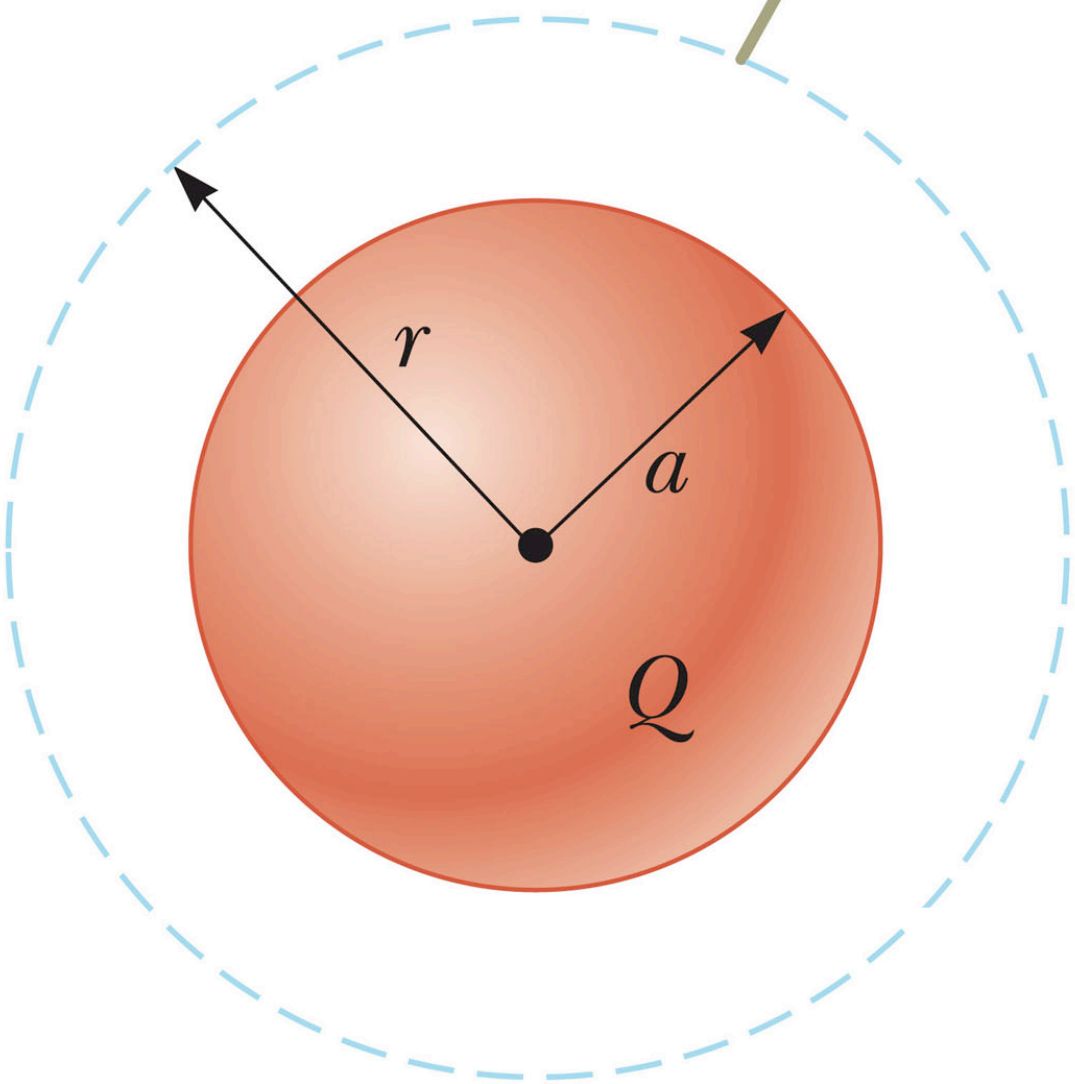


Example: Uniformly charged sphere: find electric field everywhere



- Charge distribution: spherical symmetry = electric field: spherical symmetry
- Spherical symmetry:

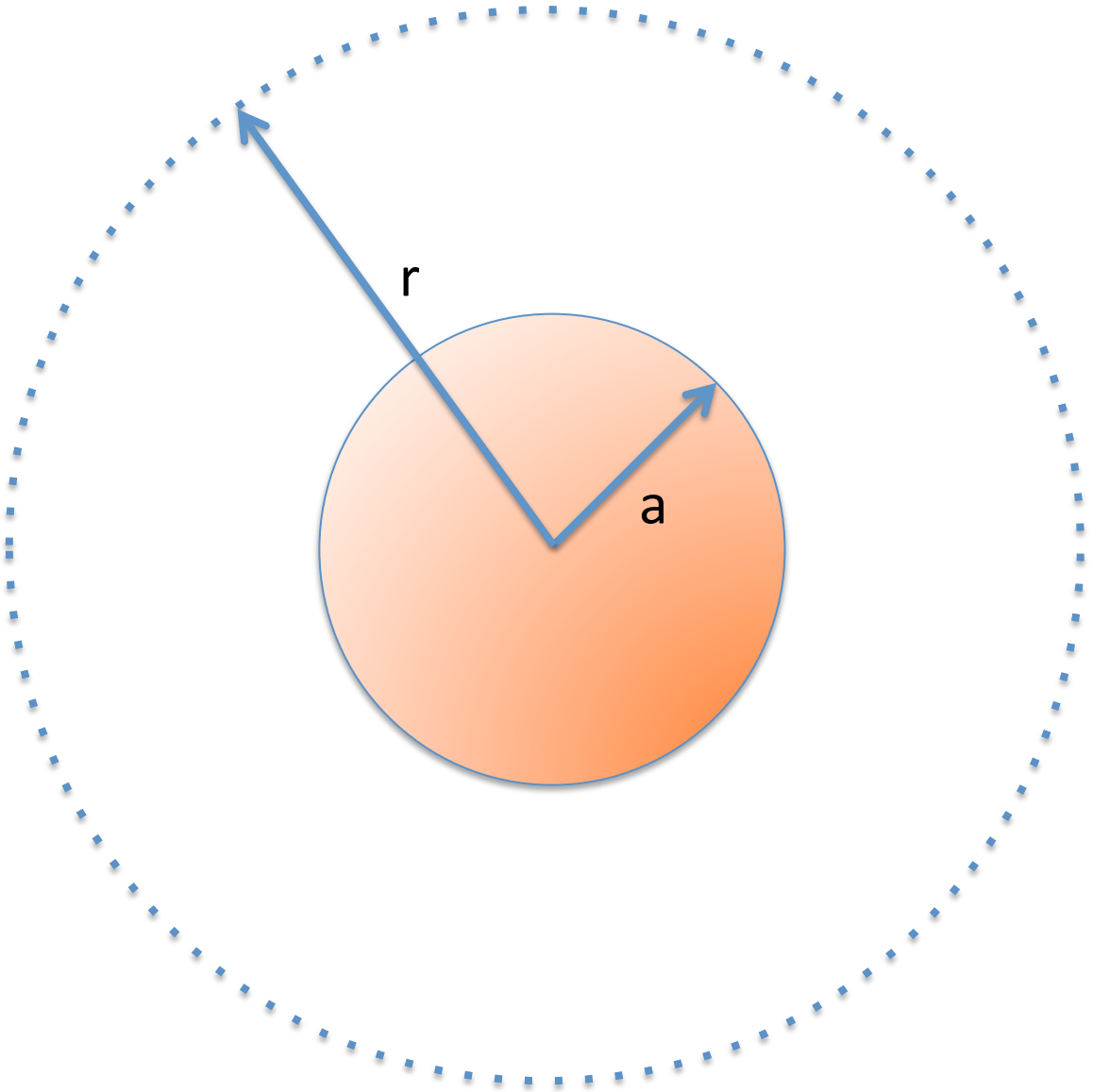
$$\vec{E} \sim E(r)\hat{r}$$



Spherical symmmetry means the Gaussian surface must be spherical

Case 1: r>a

Enclosed Charge = Q



$$\Phi = \frac{Q}{\varepsilon_0}$$

$$\Phi = E(r)4\pi r^2$$

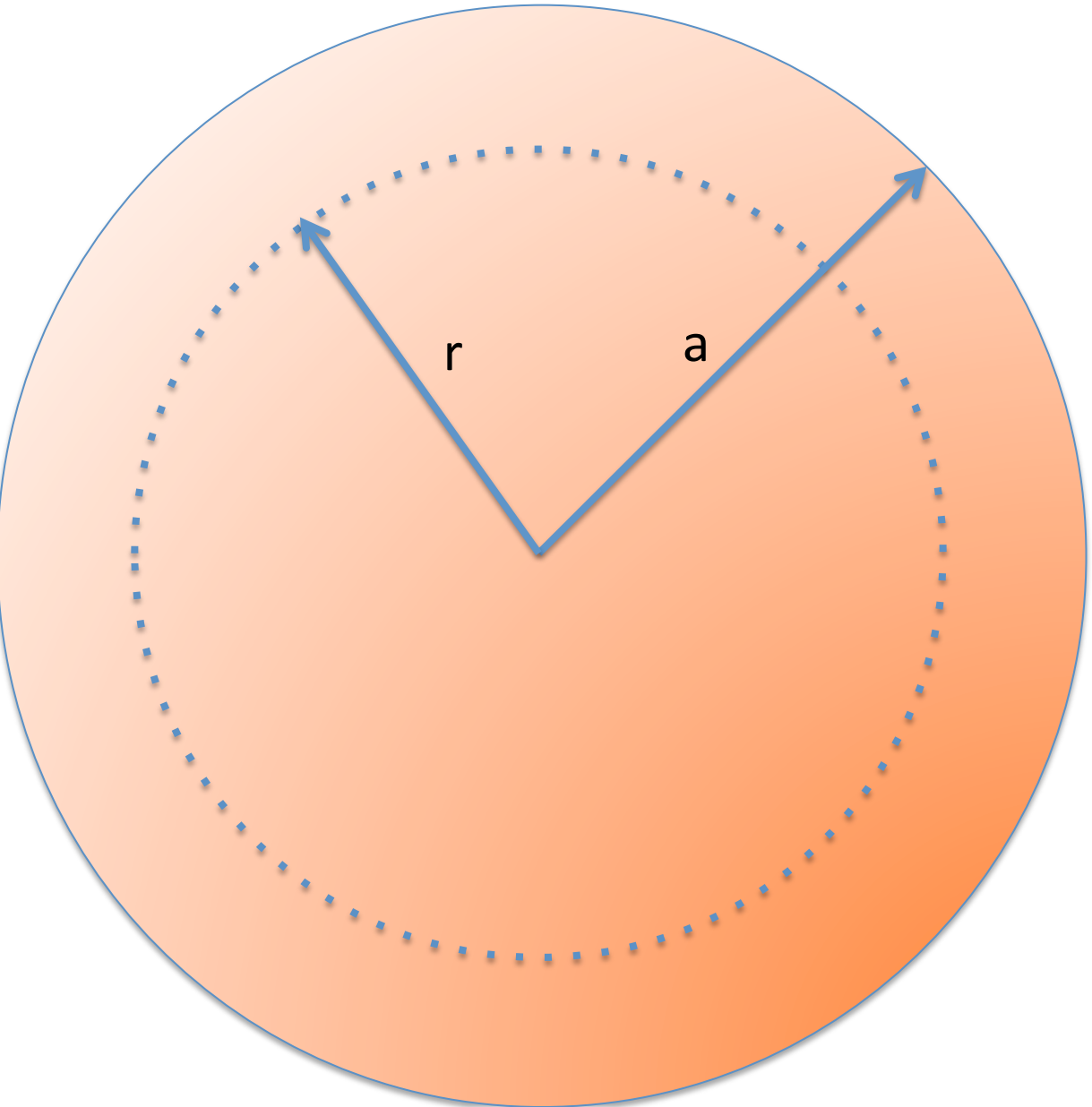
$$E(r)4\pi r^2 = \frac{Q}{\varepsilon_0}$$

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

$$\vec{E}(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}$$

Case : r<a

Enclosed Charge = ?

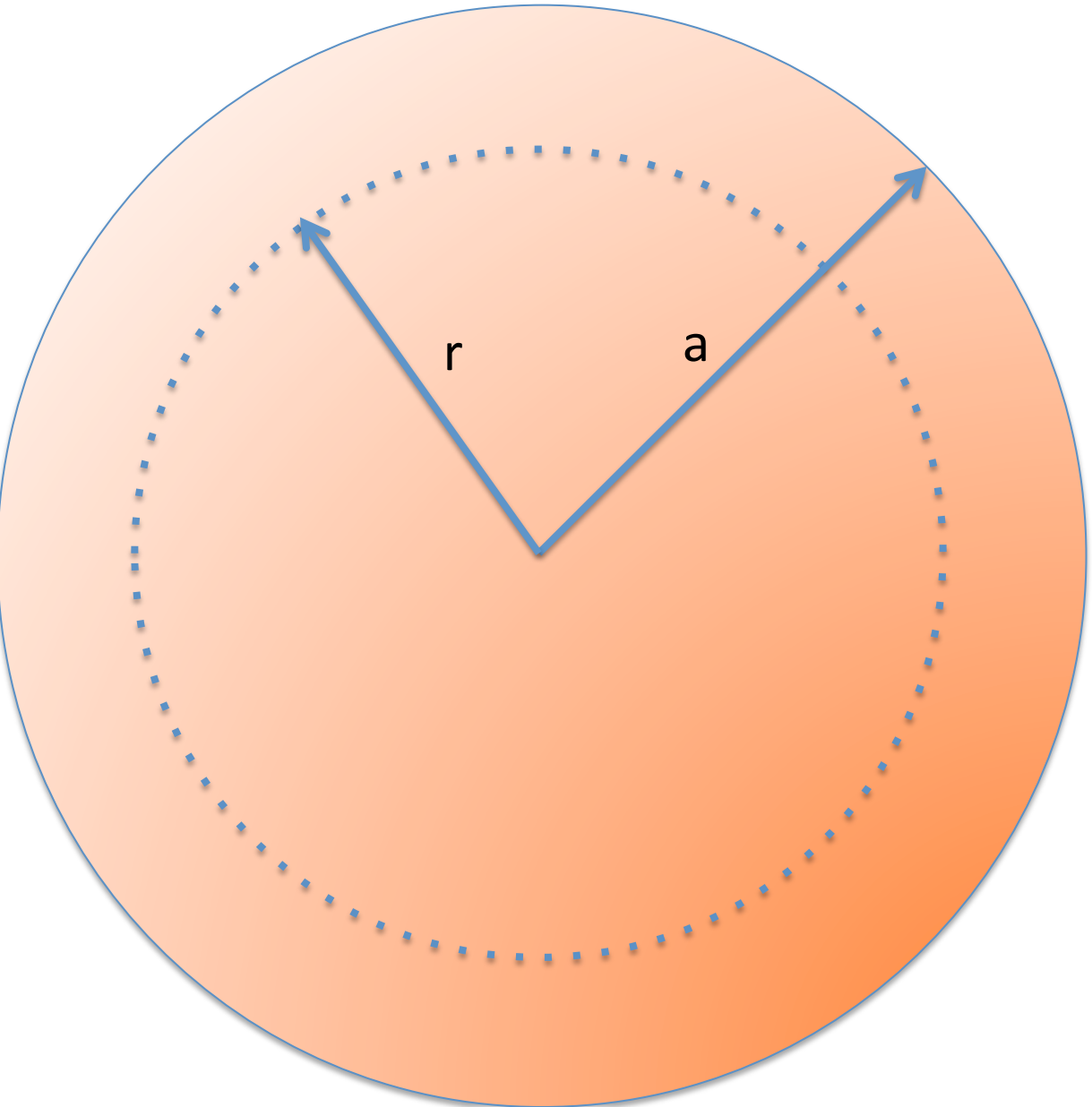


$$\rho = Q / (\frac{4\pi a^3}{3})$$

$$Q_{enclosed} = \rho \frac{4\pi r^3}{3}$$

$$Q_{enclosed} = Q \frac{r^3}{a^3}$$

Case : r<a



$$\Phi = \frac{Q}{\varepsilon_0}\frac{r^3}{a^3}$$

$$\Phi = E(r)4\pi r^2$$

$$E(r)4\pi r^2 = \frac{Q}{\varepsilon_0}\frac{r^3}{a^3}$$

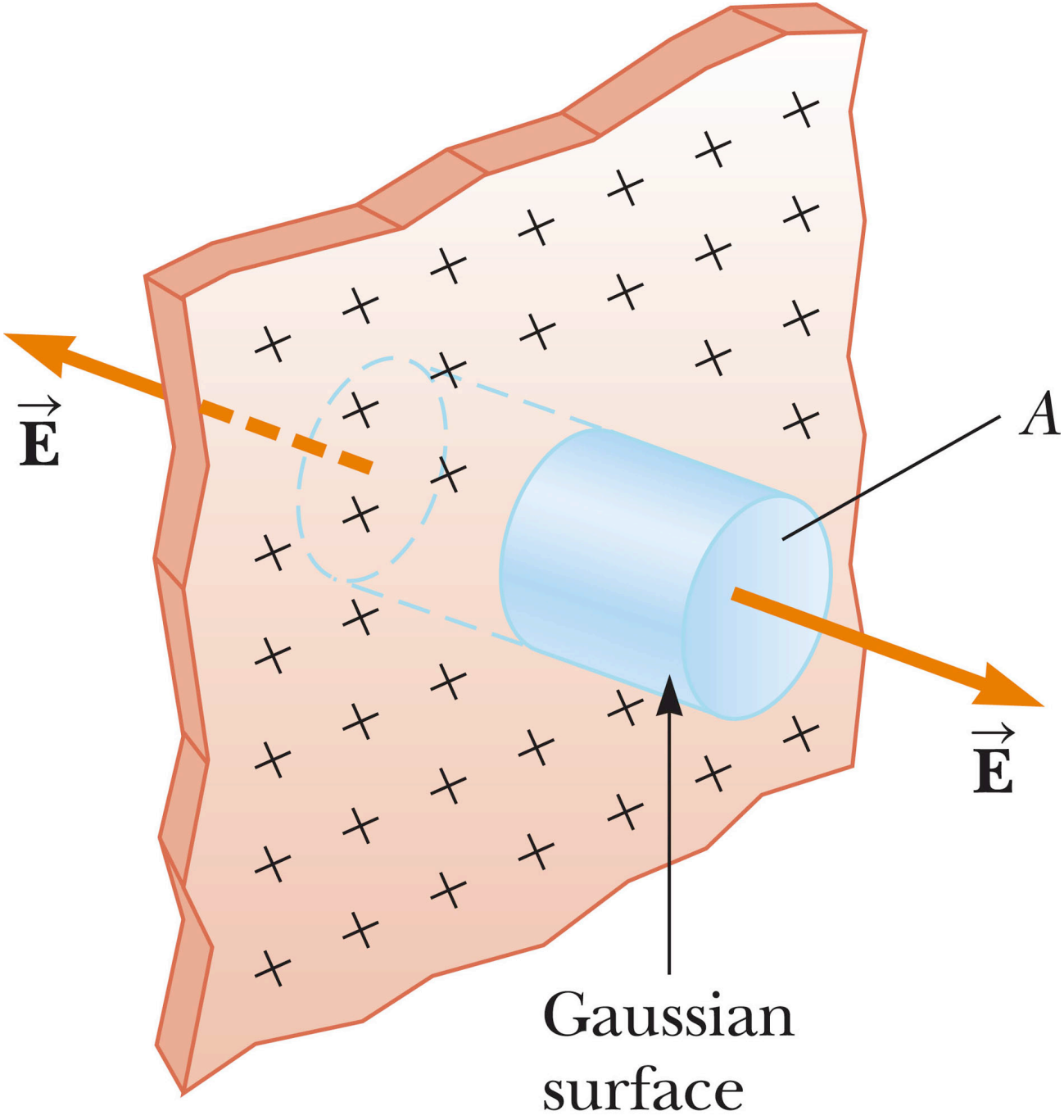
$$E(r) = \frac{1}{4\pi r^2}\frac{Q}{\varepsilon_0}\frac{r^3}{a^3}$$

$$\vec{E}(r) = \frac{1}{4\pi\varepsilon_0}\frac{Qr}{a^3}\hat{r}$$

Infinite Charged Plane

Sheet charge density: (C/m^2) σ

Draw electric field in the Doc Cam


$\vec{\mathbf{E}}$
A
$\vec{\mathbf{E}}$
Gaussian
surface

Discussion on the metal surfaces