PHY-112
Principles of Physics-II
Akiful Islam (AZW)
Spring-24 | Class-5 and 6

Gauss's Law and $\vec{E}$-fields

- The total Φ_E passing through a closed surface is proportional to the total electric charge Q_{enc} enclosed within that surface

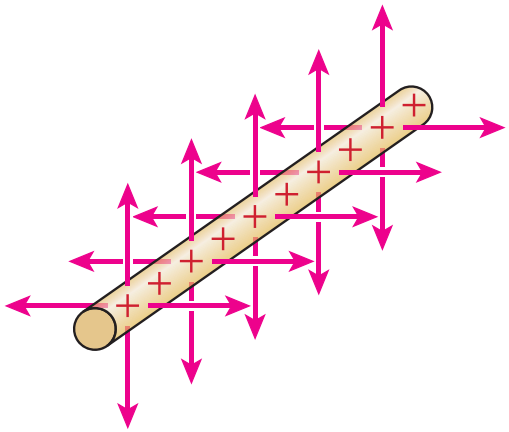
$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{\text{enclosed}}}{\varepsilon_0}. \qquad \text{(Integral Form)}$$

- The Divergence of $\vec{E}$-fields through a closed surface are directly proportional to the charge distribution within that surface

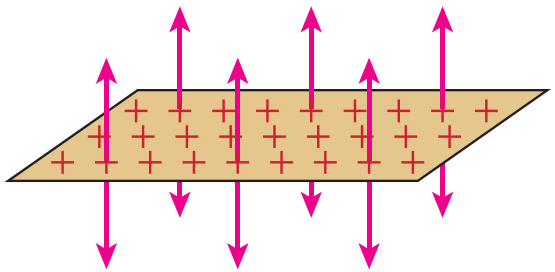
$$\vec{\nabla} \cdot \vec{E} = \frac{\rho_{\text{enclosed}}}{\epsilon_0}. \qquad \text{(Differential Form)}$$

Suitable Gaussian Surfaces for 3 Key $\vec{E}$ Field Sources

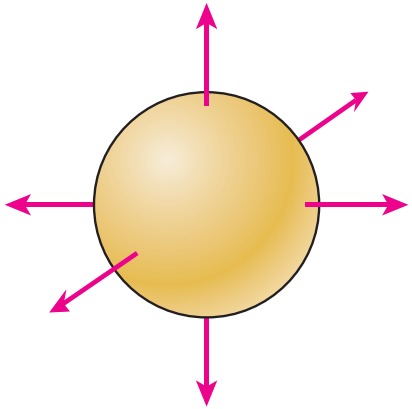
Cylindrical symmetry



Planar symmetry

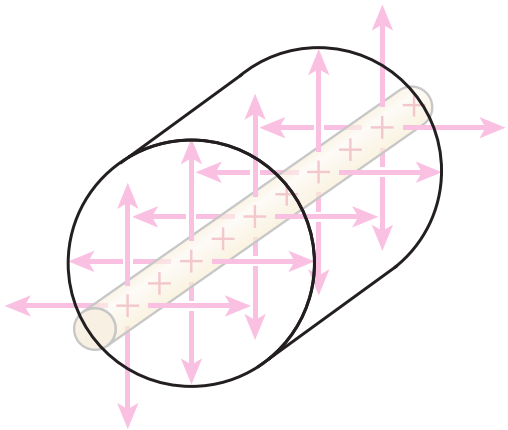


Spherical symmetry

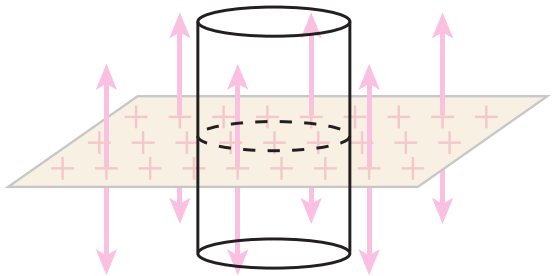


Suitable Gaussian Surfaces for 3 Key $\vec{E}$ Field Sources

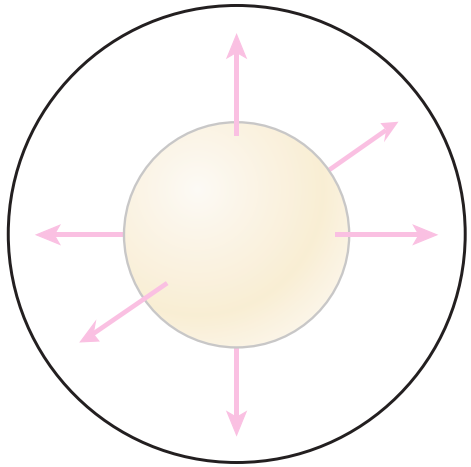
Cylindrical symmetry



Planar symmetry



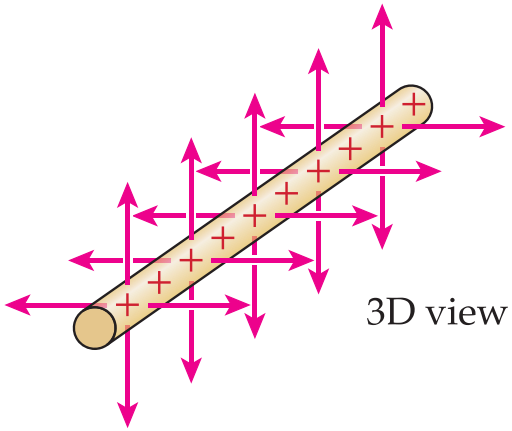
Spherical symmetry



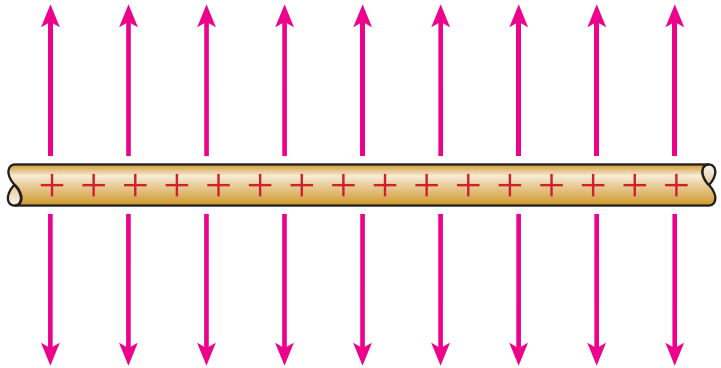
Suitable Gaussian Surfaces for 3 Key $\vec{E}$ Field Sources

- Line Charge $\longrightarrow$ Current Wire $\longrightarrow$ Long Cylindrical
- Surface Charge $\longrightarrow$ Capacitors $\longrightarrow$ Wide Cylindrical
- Volume Charge $\longrightarrow$ Electrodes/Shell Charges $\longrightarrow$ Spherical

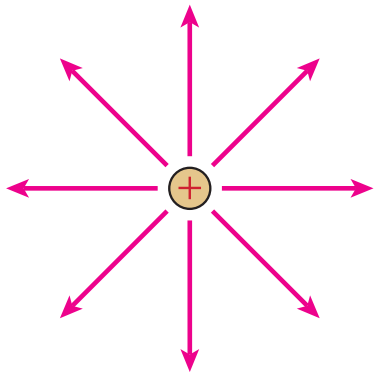
$\vec{E}$ Field for an Infinitely long Line Charge



3D view

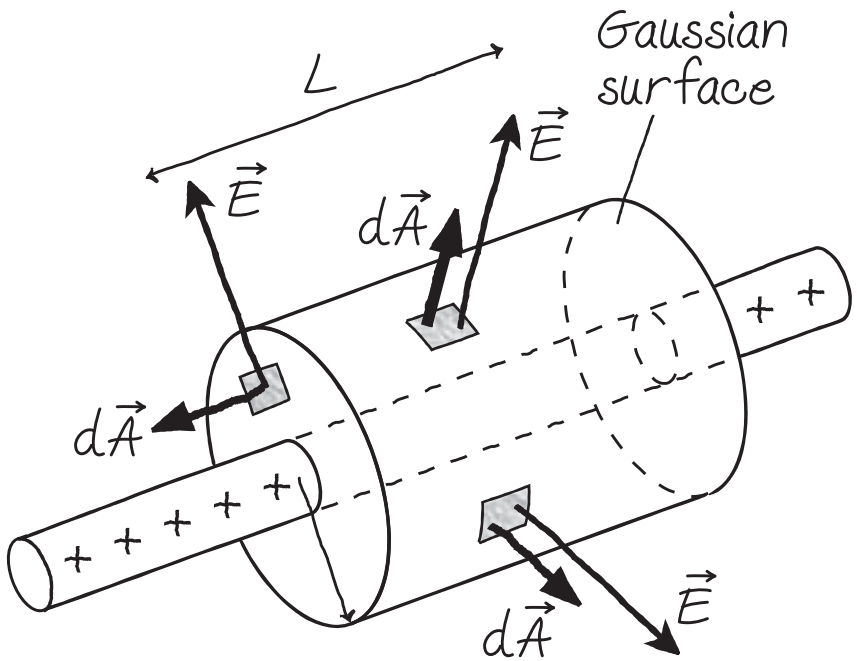


Side view



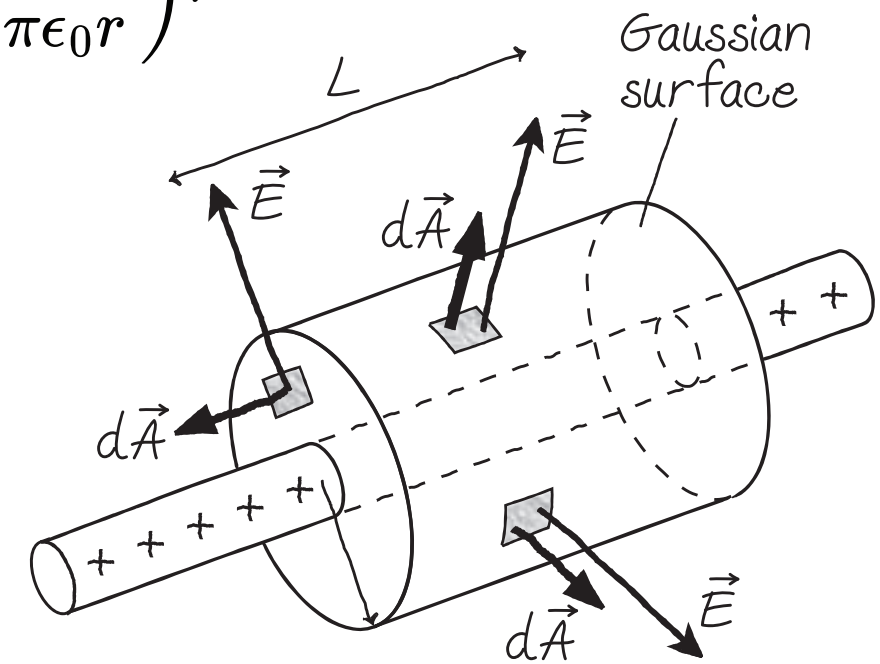
End view

$\vec{E}$ Field for an Infinitely long Line Charge

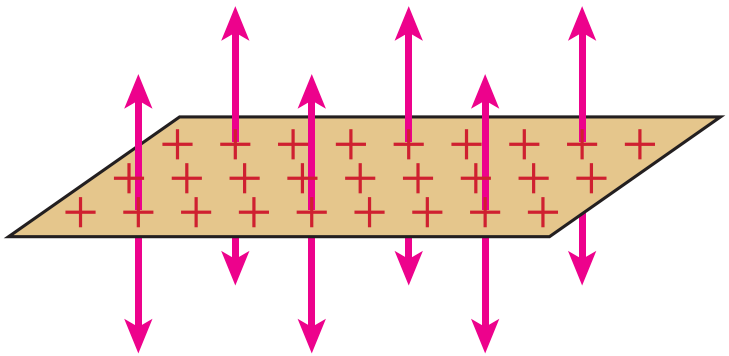


$\vec{E}$ Field for an Infinitely long Line Charge

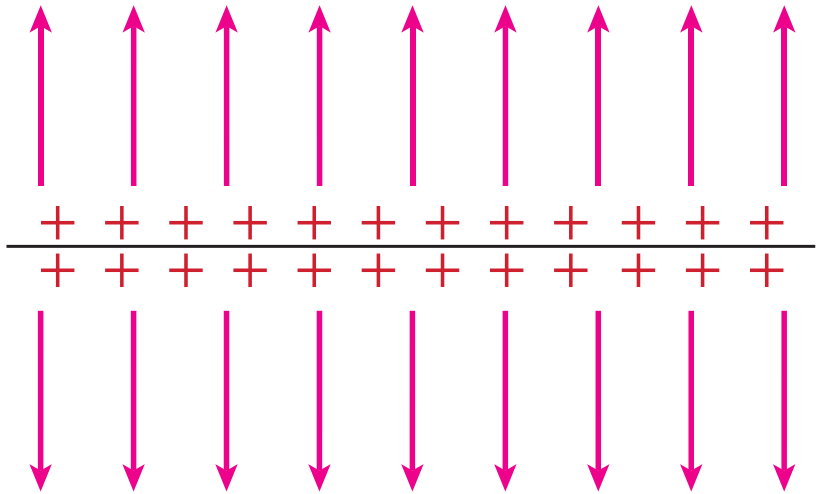
$$\vec{E}_{\text{Line}} = \left(\frac{\lambda}{2\pi\epsilon_0 r}\right)\hat{r}$$



$\vec{E}$ Field for a Sheet Charge

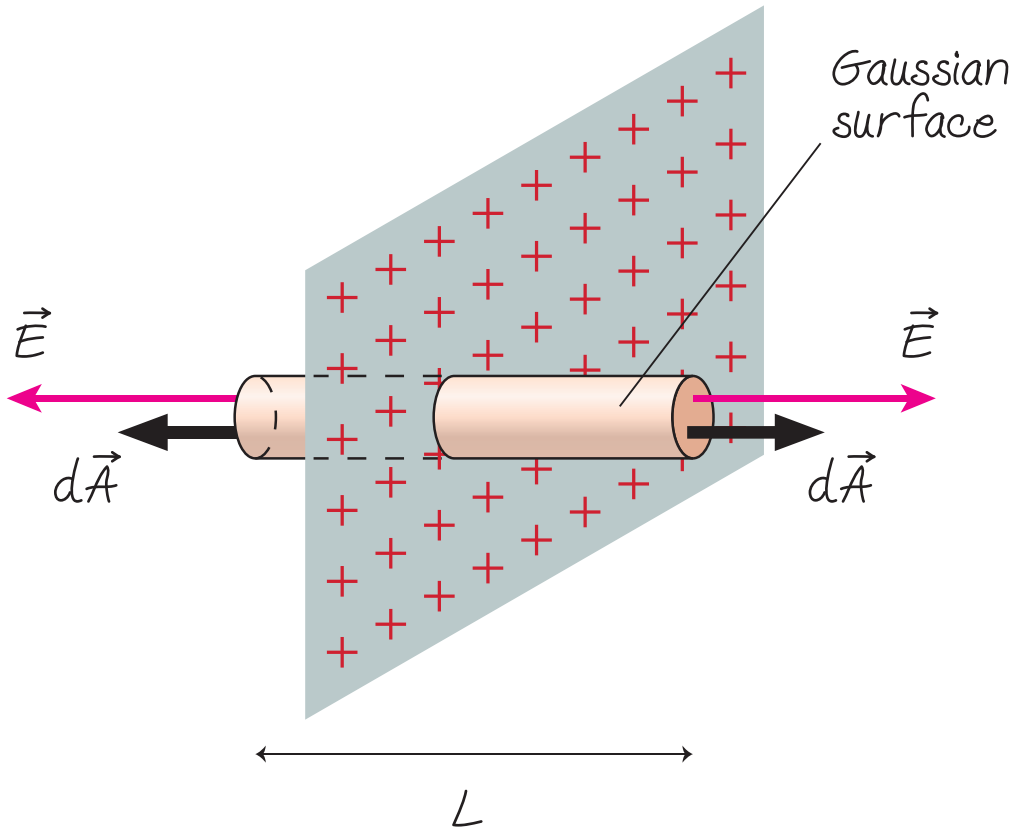


3D view

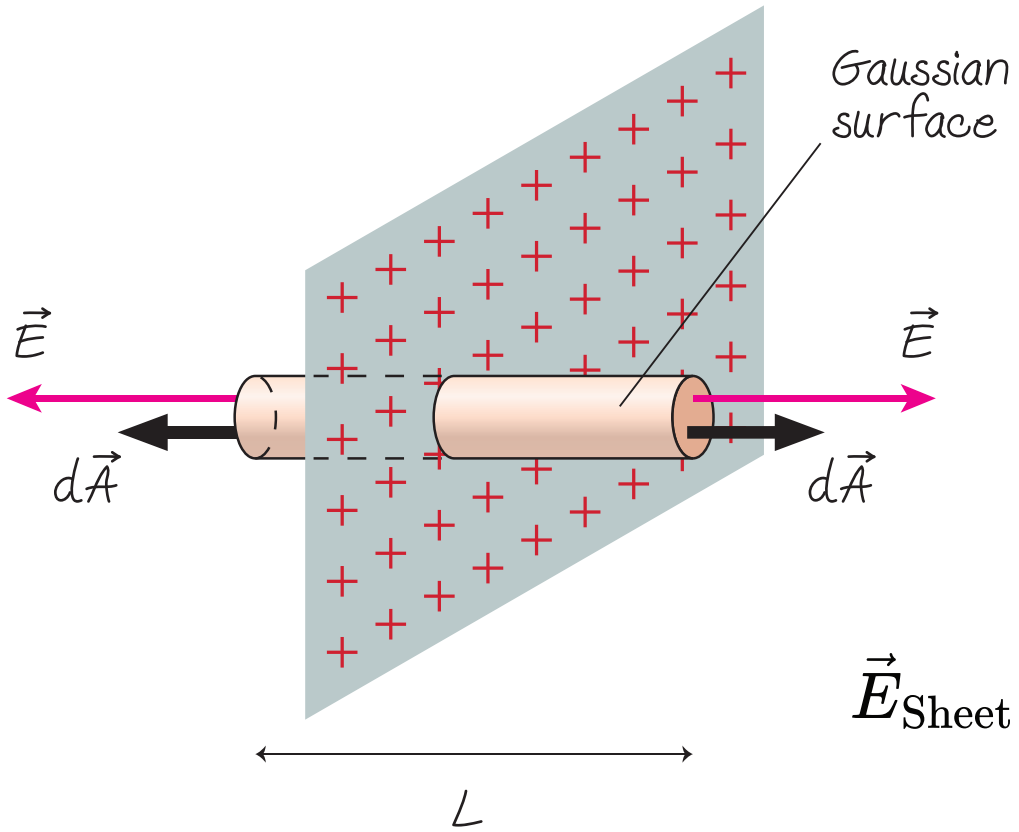


Side view

$\vec{E}$ Field for a Sheet Charge

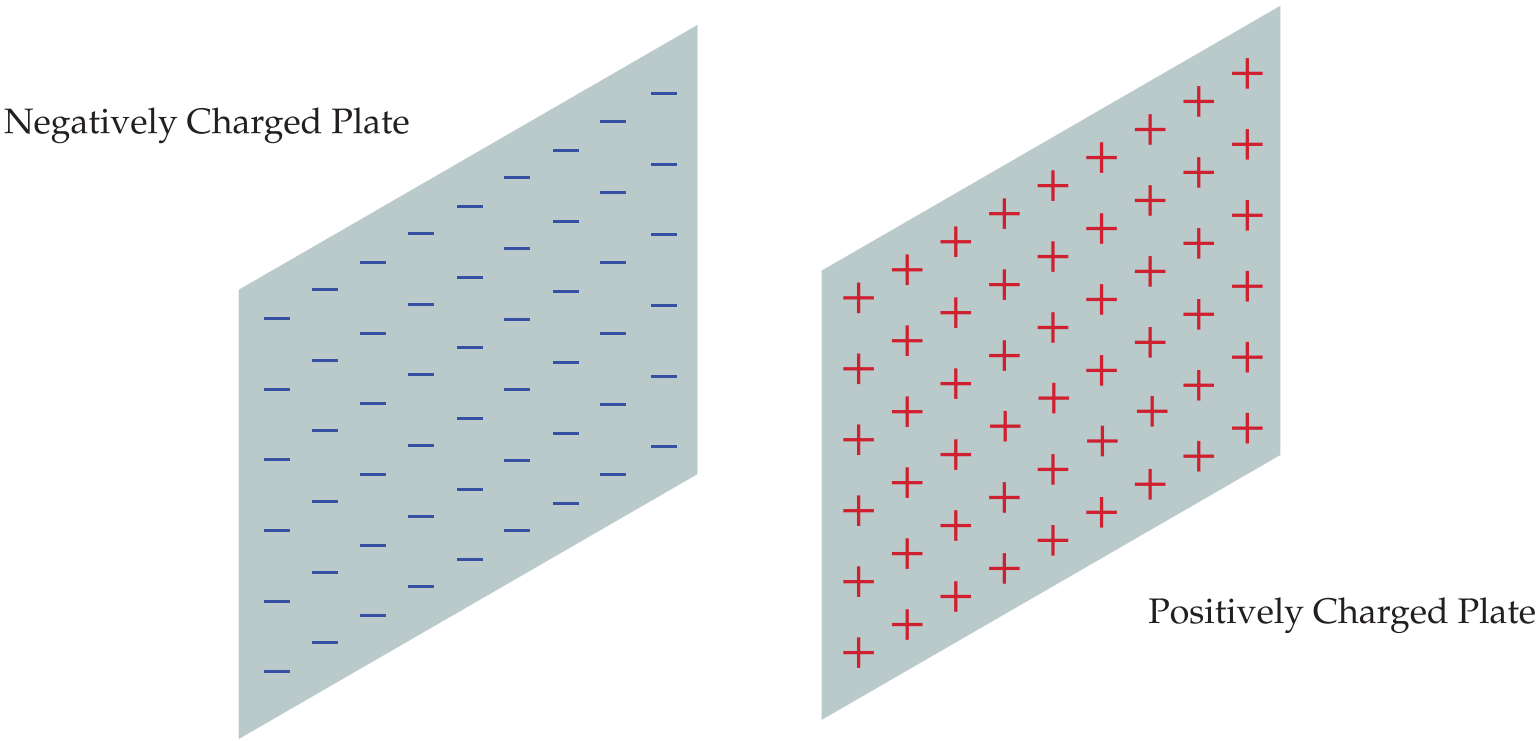


$\vec{E}$ Field for a Sheet Charge



$$\vec{E}_{\text{Sheet}} = \left(\frac{\sigma}{2\epsilon_0}\right)\hat{n}$$

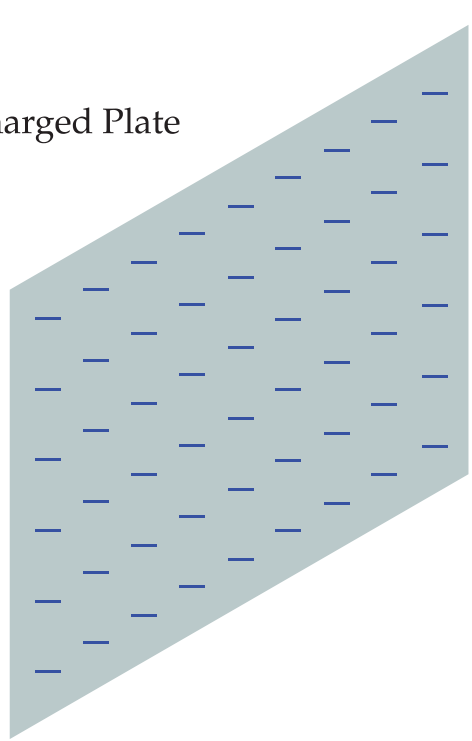
$\vec{E}$ Field for a Pair of Oppositely Charged Sheet

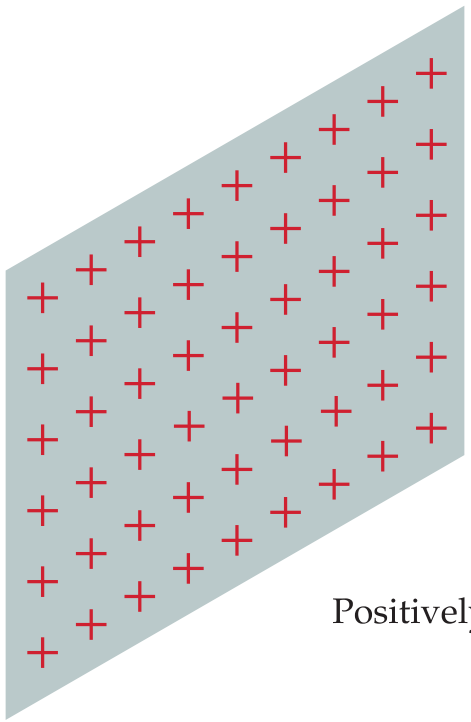


$\vec{E}$ Field for a Pair of Oppositely Charged Sheet

$$\vec{E}_{\text{Parallel Plate}} = \left(\frac{\sigma}{\epsilon_0}\right)\hat{n}$$

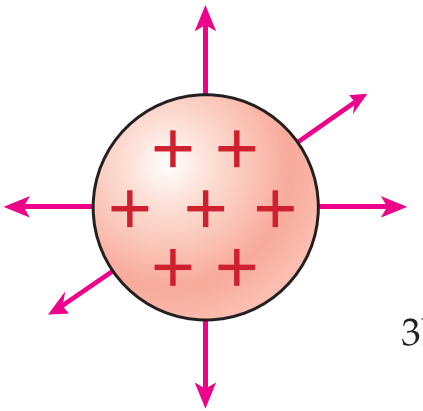
Negatively Charged Plate



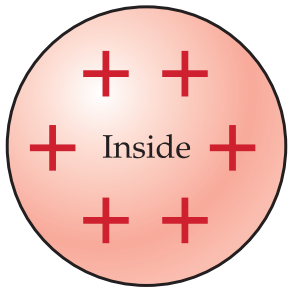


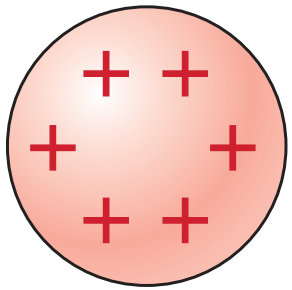
Positively Charged Plate

$\vec{E}$ Field for a Spherical Charge



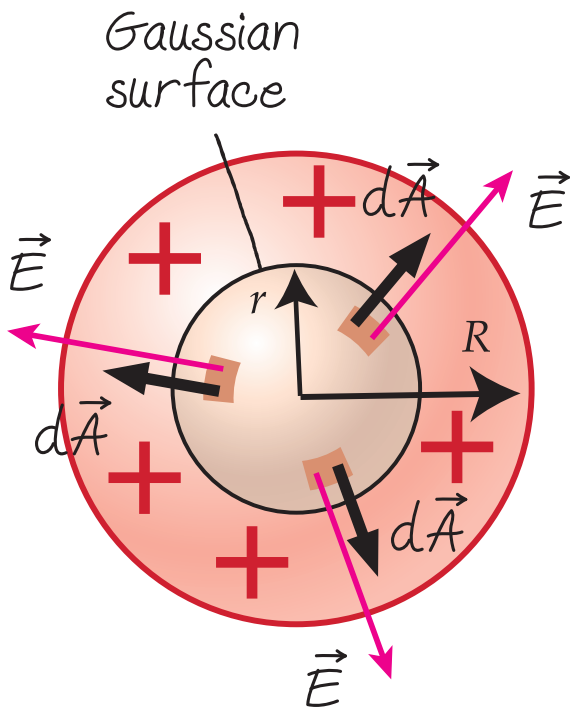
3D view



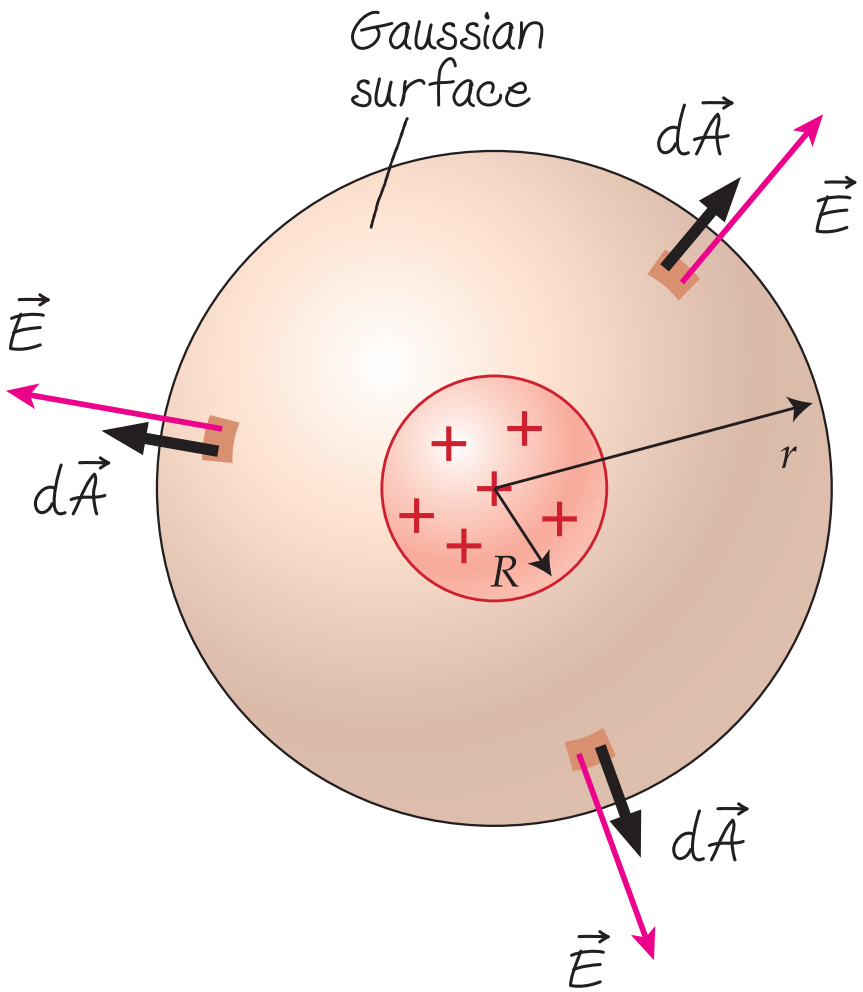


Outside

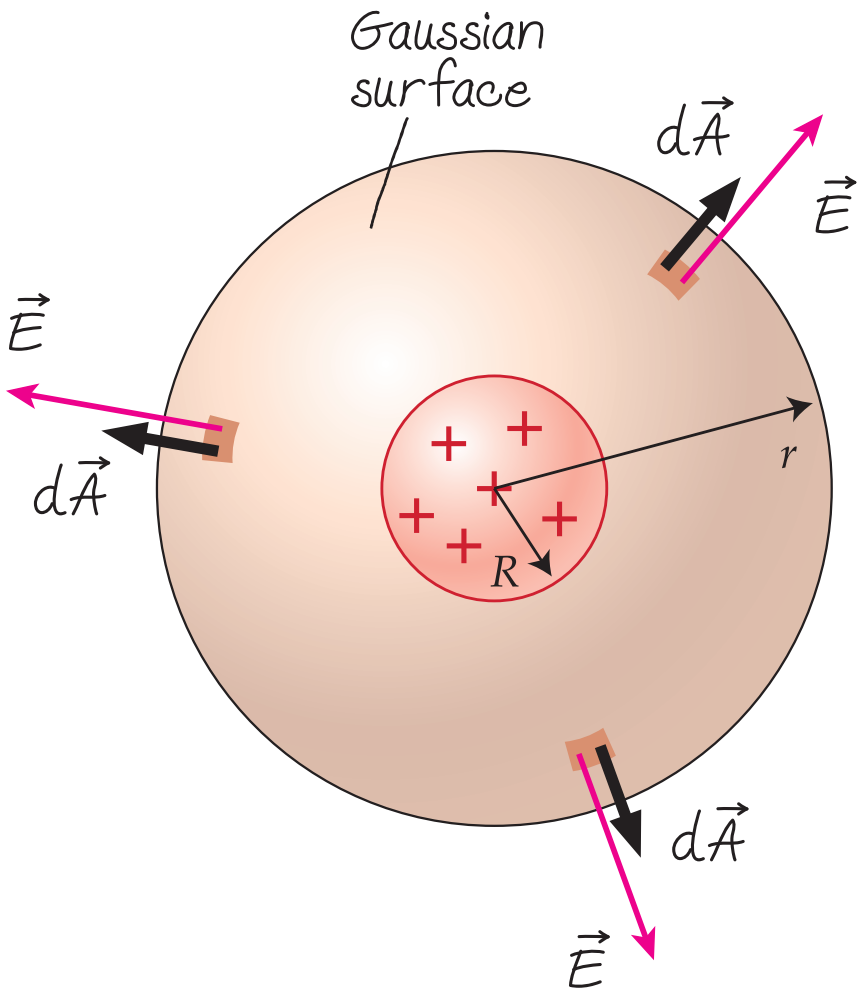
$\vec{E}$ Field for a Spherical Charge: Inside



$\vec{E}$ Field for a Spherical Charge: Outside



$\vec{E}$ Field for a Spherical Charge



$$\vec{E} = \left(\frac{r\rho}{3\epsilon_0}\right)\hat{r}$$

$\vec{E}$ Field for 3 Model Sources Using Gauss's Law

- Line Charge $\longrightarrow \vec{E} = \left(\frac{\lambda}{2\pi\epsilon_0 r}\right)\hat{r}$
- Surface Charge $\longrightarrow \vec{E} = \left(\frac{\sigma}{2\epsilon_0}\right)\hat{n}$
- Volume Charge $\longrightarrow \vec{E} = \left(\frac{r\rho}{3\epsilon_0}\right)\hat{r}$