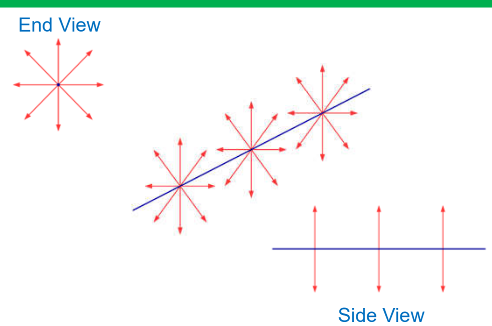
Gauss's Law

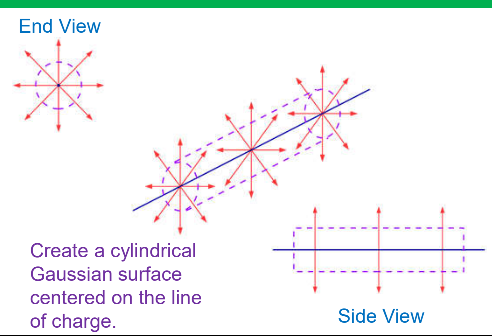
$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\epsilon_0}$$

Electric flux through a closed surface is proportional to the net charge enclosed.

Example: Electric field due to a long line of charge.

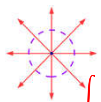


Example: Electric field due to a long line of charge.



Example: Electric field due to a long line of charge.

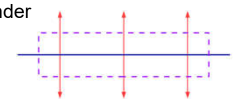
End View



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

$$\int_{\text{left end}} \vec{E} \cdot d\vec{A} + \int_{\text{side}} \vec{E} \cdot d\vec{A} + \int_{\text{right end}} \vec{E} \cdot d\vec{A}$$

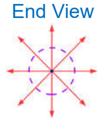
Note that the field lines go through the side of the cylinder and not through the ends.



Side View

Example: Electric field due to a long line of charge.

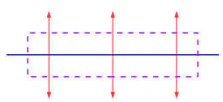
End View



$$\oint \vec{E} \cdot d\vec{A} = \int_{\text{side}} \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\epsilon_0}$$

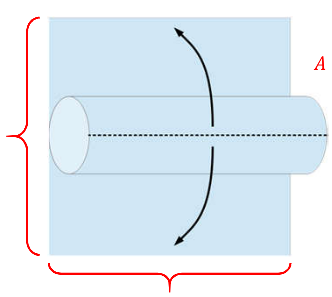
$$E \int dA = \frac{q_{\text{enc}}}{\epsilon_0}$$

$$EA = \frac{q_{\text{enc}}}{\epsilon_0}$$



Side View

Surface area of a cylinder



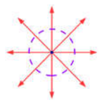
$A = 2\pi r L$

$2\pi r$

L

Example: Electric field due to a long line of charge.

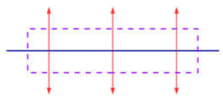
End View



$$EA = \frac{q_{\text{enc}}}{\epsilon_0}$$

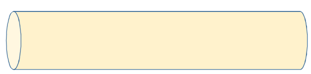
$$E(2\pi r L) = \frac{\lambda L}{\epsilon_0}$$

$$\vec{E} = \frac{\lambda}{2\pi\epsilon_0 r}\hat{r}$$

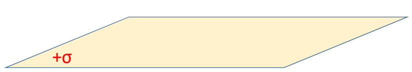


Side View

Example: Electric field due to a long cylindrical solid with a uniform volume charge density, ρ.



Example: Electric field due to a long cylindrical solid with a uniform volume charge density, ρ.



Symmetry	Gaussian Surface Area	Charge Type	Enclosed Charge
Spherical	$4\pi r^2$	Point	Q
		Surface	$0, r < R$ $\sigma(4\pi R^2), r > R$
		Volume	$\rho\left(\frac{4}{3}\pi r^3\right), r < R$ $\rho\left(\frac{4}{3}\pi R^3\right), r > R$
Cylindrical	$2\pi rL$	Line	λL
		Surface	$0, r < R$ $\sigma(2\pi RL), r > R$
		Volume	$\rho(\pi r^2 L), r < R$ $\rho(\pi R^2 L), r > R$
Planar	$2A$	Surface	σA
		Volume	$\rho(2\|z\|A), \|z\| < \frac{w}{2}$ $\rho(wA), \|z\| > \frac{w}{2}$

(w is the width of a slab of charge.)