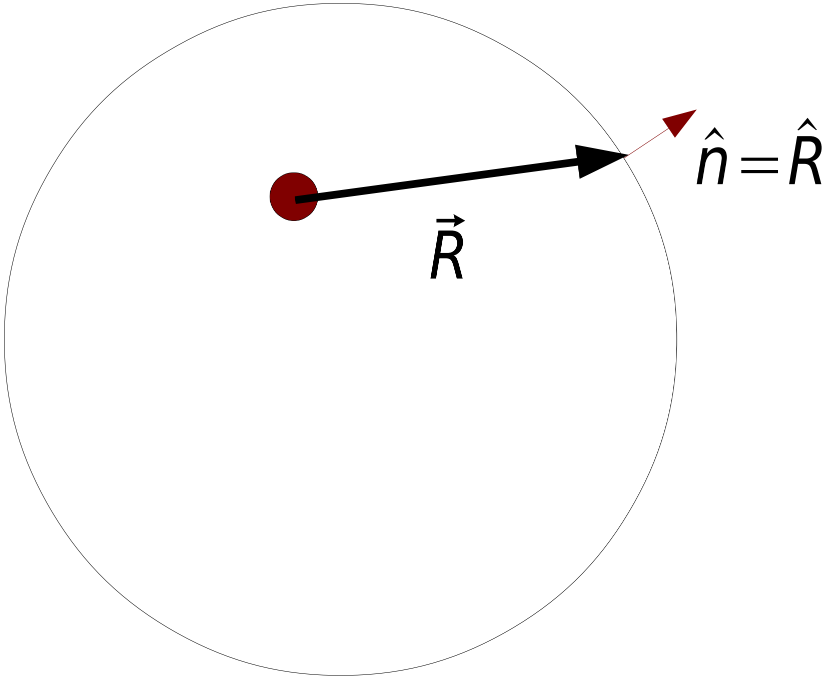
Electric Flux & Gauss' Law

The total flux out of the closed spherical surface is simply the total charge enclosed divided by a constant.



$$\Phi_E = \frac{q_{enclosed}}{\epsilon_0}$$

The total flux out of the closed spherical surface is STILL simply the total charge enclosed divided by a constant.

The Electric Field due to a continuous charge distribution

The General Case. Coulombs law for a distribution of charges:

$$\Delta \vec{E} = k_e \frac{\Delta q_i}{r_i^2} \hat{r}_i \qquad \textit{and} \qquad \vec{E} = \sum_i \Delta \vec{E} = k_e \sum_i \frac{\Delta q_i}{r_i^2} \hat{r}_i$$

Take the limit as the element of charge are infinitesimal

$$d\vec{E} = k_e \frac{dq}{r^2} \hat{r}$$

$$\vec{E} = k_e \int \frac{dq}{r^2} \hat{r}$$

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The Electric Field due to a continuous distribution of charge

Volume Charge Density. *If a charge Q is uniformly distributed throughout a volume V, then we may define a volume charge density ("rho"):*

$$\rho = \frac{Q}{V}$$

Surface Charge Density. *If a charge Q is uniformly distributed throughout a surface area A, then we may define a surface charge density ("sigma"):*

$$\sigma = \frac{Q}{A}$$

Linear Charge Density. *If a charge Q is uniformly distributed throughout a line of length l, then we may define a linear charge density ("lambda"):*

$$\lambda = \frac{Q}{l}$$

The Electric Field due to a continuous distribution of charge

Depending on whether the charge is distributed in the entire volume, or the surface or just a line....

Volume Charge Density. $\rho = \dfrac{Q}{V} \Rightarrow dq = \rho\, dV$

Surface Charge Density. $\sigma = \dfrac{Q}{A} \Rightarrow dq = \sigma\, dA$

Linear Charge Density. $\lambda = \dfrac{Q}{l} \Rightarrow dq = \lambda\, dl$

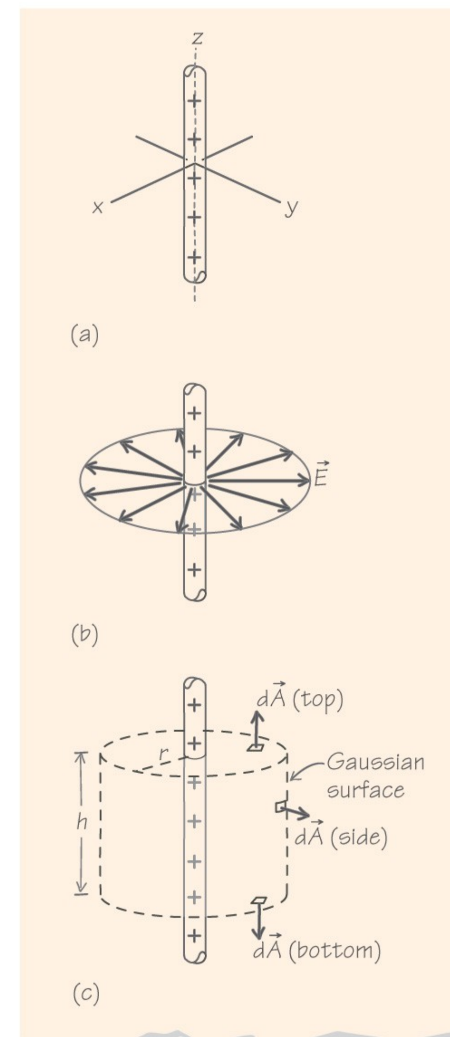
Then the integral: $\vec{E} = k_e \int \dfrac{dq}{r^2}\hat{r}$ ***is well-defined, because***

$\rho\,,\sigma\,,\lambda$ ***are constants***

Gauss' Law: Examples

A Line of Charge

Use Gauss' Law to find the electric field a distance l from a line of charge that extends to infinity and has a charge per unit length of λ

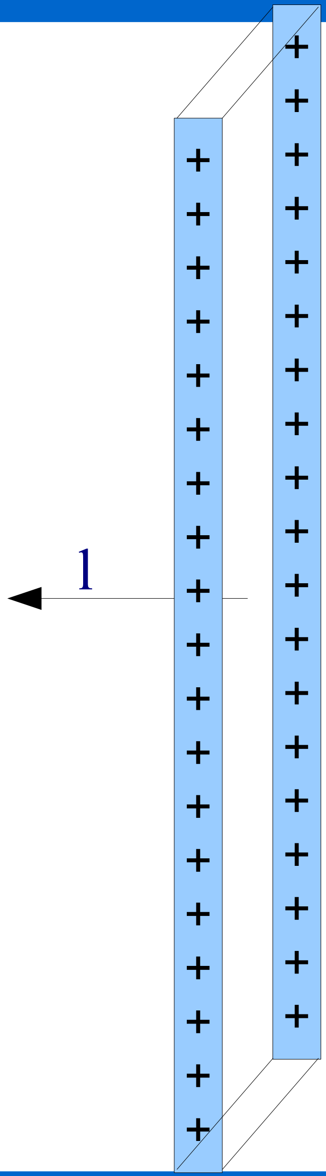


do in class

Gauss' Law: Examples

A Nonconducting Plane Sheet of Charge

Use Gauss' Law to find the electric field a distance l from a non-conducting infinite plane with charge per unit area σ



Note that innocuous word "non-conducting"
We will deal with conductors (e.g. metals) next week.

do in class