{{< include "1-Electric field.md" >}} {{< include "2-Gauss's law.md" >}}

Coulomb's law

$$F_{1,2} = \frac{1}{4\pi\epsilon_0} * \frac{q_1 * q_2}{r^2}$$

Electric field

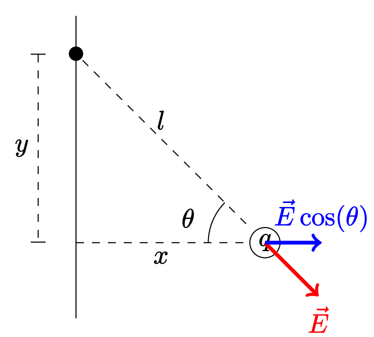
Electric field is the amount of force caused by a particle on another particle with arbitrary charge.

$$\vec{F} = \vec{E} * q_2$$
$$\frac{\vec{F}}{q_2} = \vec{E}$$

$$\frac{F_{q,\text{test charge}}}{q} = \vec{E} = \frac{1}{4\pi\varepsilon_0} * \frac{q}{r^2}$$

To measure electric field, one needs a test charge, which is some arbitrary small charge.

Electric field of a charged line



integrate the field force applied by every point on the line, integrate over $y = +\infty$ to $y = -\infty$

notice that since the integral is symmetric in the y-direction, only force in the x-direction remains.

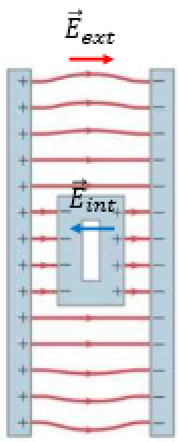
λ is the charge per length of the charged wire.

$$
\begin{aligned}
E &= \int_{y=+\infty}^{-\infty} E_x \\
&= \int_{y=+\infty}^{-\infty} E\cos(\theta) \\
&= \int_{y=+\infty}^{-\infty} \frac{\lambda}{4\pi\varepsilon_0 * l^2} dy * \cos(\theta)
\end{aligned}
$$

$$l = \sqrt{x^2 + y^2}$$

TODO finish this shit

Induced charges



Free charges in a conductor respond to external field such that total field inside the conductor is zero.

$$E_{\text{total}} = E_{\text{external}} + E_{\text{internals}}$$

Faraday cage operates on this principle.

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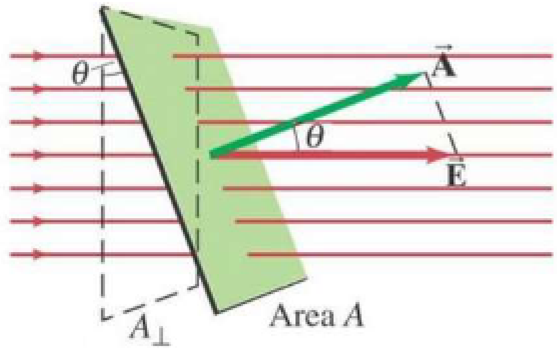
electric flux ϕ is the amount of electric field lines that pass through a surface.



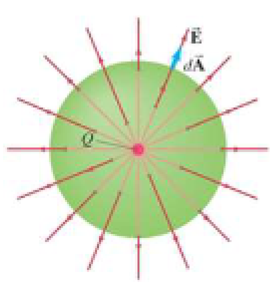
$$\phi = \overbrace{\iint}^{\text{surface integral}} \vec{E} \bullet d\vec{A}$$
$$= \iint \vec{E} * d\vec{A} * \cos(\theta)$$

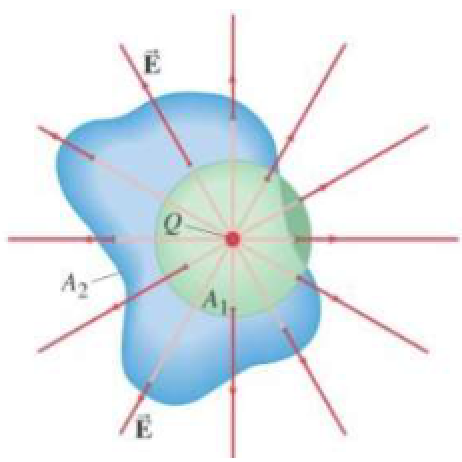
$\vec{A}$ is the normal vector of the surface, and whose magnitude is the area of the surface.

Gauss's law

Gauss's law: The electric flux through a closed surface is equal to the net charge enclosed in it divided by ε_0

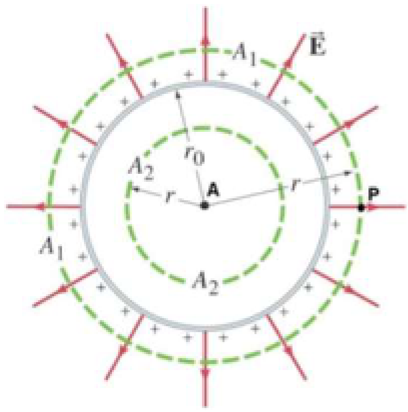
Notice that electric flux is the number of field lines that go through a surface, therefore the following two gauss surfaces have the same flux.





$$\phi_{\text{surface}} = \oiint_{\text{surface}} \vec{E} \bullet d\vec{A} = \frac{q_{\text{enclosed}}}{\varepsilon_0}$$

Field of a uniformly charged sphere



since all of the field lines are perpendicular to the gauss surface A_1, and that $\vec{E}$ has the same magnitude everywhere, this is analogous to a point charge.
Thusly, uniform homogenous charged spheres can be approximated to point charges.

Field of a non-conducting charge sphere

spoilers, exact same thing as above.

Field of a charged plate