Gauss's Law

Rather than love, than money, than fame, give me truth. I sat at a table where were rich food and wine in abundance, an obsequious attendance, but sincerity and truth were not; and I went away hungry from the inhospitable board. The hospitality was as cold as the ices.
Thoreau

More Quotes I Owe You

In my book a pioneer is a man who turned all the grass upside down, strung bob-wire over the dust that was left, poisoned the water and cut down the trees, killed the Indians who owned the land and called it progress. If I have my way, the land here would be like God made it and none of you sons of bitches would be here at all. *Russell*

Two More

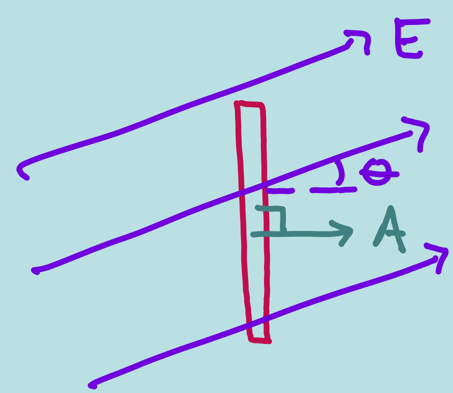
Curiosity about life in all of its aspects, I think is still the secret of great creative people. *Burnett*

The most exciting phrase to hear in science, the one that heralds new discoveries, is not "Eureka!" (I found it!) but "That's funny ..."

Electric Flux

- Electric Flux is proportional to the number of E-field lines penetrating a surface.
- Transparency 70
- The area vector has a magnitude equal to the total area and its direction is $\perp$ to the surface.
- $\Phi_E = E \cdot A$
- $\Phi_E = EA\cos\theta$
- Units are $\frac{N \cdot m^2}{C}$

Φ_E - electric flux



Varying E-Field

- In many situations the E-field may vary over the surface. Therefore our definition of flux is valid only over a small element of area.
- Define vector ΔA_i whose magnitude represents the area of the ith element and whose direction is $\perp$ to the surface element.
- The flux through this element is

  $\Delta\Phi_E = E_i \bullet \Delta A_i = E_i \Delta A_i \cos\theta$
- $\Phi_E = \lim_{\Delta A \to 0} \Sigma E_i \bullet \Delta A_i = \int E \bullet dA$

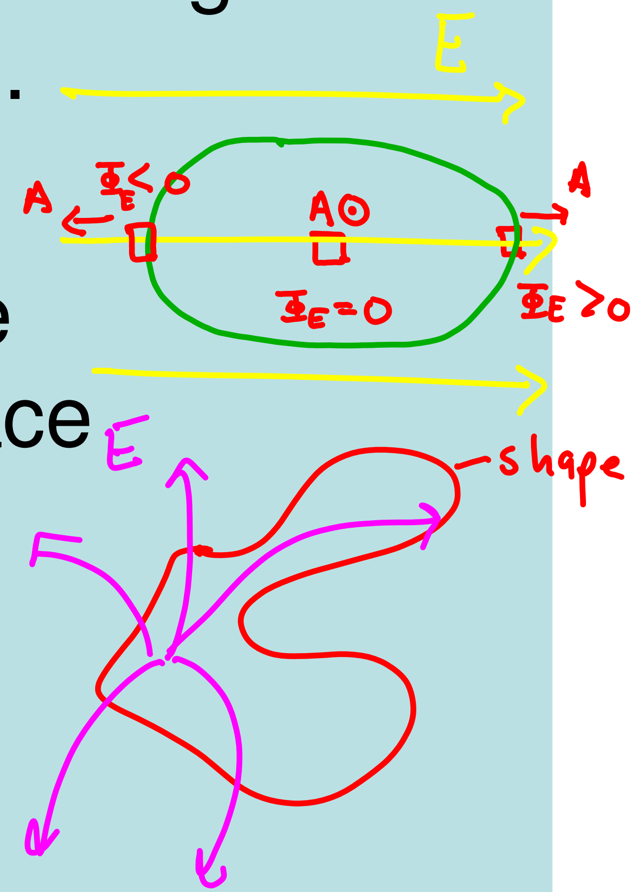
$\Phi_E = \int E \cdot dA$

Closed Surfaces

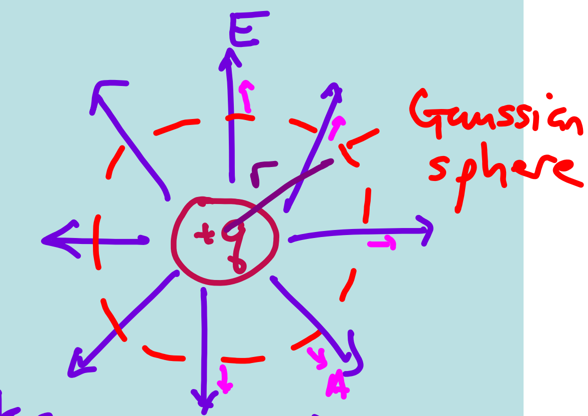
- We are usually interested in evaluating the flux through a closed surface.
- Negative, positive and zero.
- The net flux is proportional to the number of lines leaving the surface minus the number entering the surface.
- More lines leaving ⇒ + charge
- More lines entering ⇒ - charge
- $\Phi_E = \oint E \cdot dA$ (closed path)

$\oint$ - surface integral $\oint dA$ = surface area

$\oiint dA$



Gauss's Law



- Consider +q located at center of sphere, radius of *r*.
- $\Phi_E = \oint E \cdot dA = E \oint dA$
- $\Phi_E = kq(4\pi r^2)/r^2 = 4\pi kq = q/\epsilon_O$
- Net flux is independent of *r*.
- Transparency 71. Show S_2 & S_3
- The net flux through any closed surface surrounding a point charge q is given by q/ϵ_O.
- Now consider charge outside surface. The net flux is zero.

Gauss's Law

- The E-field due to many charges is the vector sum of the E-field produced by the individual charges.
- Transparency with S, S' & S". ✓
- $\Phi_E = \oint E \bullet dA = \oint (E_1 + E_2 + \ldots) \bullet dA$
- Therefore, Gauss's Law states

  $$\Phi_E = \oint E \bullet dA = q_{in}/\epsilon_O$$

- q_{in} is the net charge inside the gaussian surface, E is the total E-field due to all charges both inside and outside the surface.

Examples

- We have done a lot, let's summarize.

$\Phi_E = E \cdot A$

$\Phi_E = \oint E \cdot dA = \frac{q_{in}}{\epsilon_0}$ Gauss's Law

- 24.1-24.3

24.1 $\Phi_E = ?$ for $r = 1m$ & $q = 1\mu C$

$\Phi_E = \oint E \cdot dA$

$\Phi_E = \frac{kq}{r^2}(4\pi r^2) = k4\pi q$

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