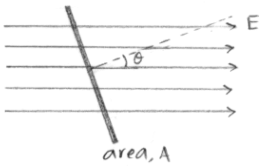
**Physical Sciences 3**
Lectures 3 and 4 – February 13, 2008 – Gauss' Law, Electric Potential, Columbic Forces in Chemistry
*Reading for Understanding: Chapter 22 s1-4, and Chapter 23 s1-5, 8*

## ELECTRIC FLUX ($\Phi_E$)

Electric field passing through a certain area. (perpendicular to each other)




Flux, $\Phi_E$ is proportional to the # of lines passing through this area because

$E \propto \frac{N}{A_\perp}$ (from Lect)

$\Phi_E = \vec{E}A\cos\theta$ ∴ $EA_\perp = \Phi_E \propto N$

This area is usually a closed surface, we denote as $\oint$
Basis of...

## GAUSS' LAW

Gives relationship between enclosed charge and $\vec{E}$, using $\Phi_E$

$\Phi_E = \oint E\,dA = \frac{Q_{enclosed}}{\epsilon_0}$ ← permittivity of free space

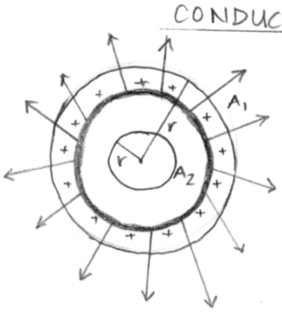
we know that $E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$ so plugging in,

$\oint E\,dA = \left(\frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\right)(4\pi r^2) = \frac{Q}{\epsilon_0}$


"Sphere" nonzero Flux

NOTICE:
* Flux (lines) entering is negative
* Flux (lines) leaving is positive
* Flux will ONLY be nonzero if 1 or more lines start or end within a surface - only possible if surface encloses a net charge..

## CONDUCTORS




$A_1$ = outside boundary contains $Q_{enclosed}$ = ⊕
Flux is non-zero
∴ $\vec{E} = \frac{Q}{4\pi\epsilon_0 r^2}$ ← point charge fall off

$A_2$ = inside boundary doesn't contain $Q_{enc}$ so $\vec{E} = 0$ b/c Flux = 0

## GAUSSIAN SURFACES : TIPS

* look for symmetry in surface
* look for where Flux is zero
* always consider <u>all</u> possibilities for E - inside, outside boundaries

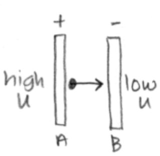
## POTENTIAL ENERGY, U

(leads to → Equipotential Surfaces)

defined for conservative forces = path independent

$\Delta U$ = change in potential = $-W$ (DONE BY FORCE to move q from A to B)

where $W = Fd = qEr$ ← where E is uniform




$U = qV$

$U = \frac{k_c Q q}{r}$ measured in Joules, (no Force involved doing work btwn charges)

related to

## ELECTRIC POTENTIAL, V

→ to measure in eV, $1\text{eV} = 1.6\times10^{-19}\text{J}$

$V = \frac{U}{q} = \frac{k_c Q}{r}$, and $\Delta V = \frac{\Delta U}{q} = \frac{-W}{q}$

measured in $\frac{J}{C}$ = volt

like potential, only differences are important - this requires a reference point, usually we take $V = 0$ at $r = \infty$

where $\frac{1}{\infty} = 0$

if $\vec{E}$ is uniform, then $\Delta V = -Ed$ so $V = Ed$

if not, integrate $\Delta V = -\int E\,dl$

⊕ moves from HIGH potential to LOW potential
⊖ moves from LOW potential to HIGH potential

(V, U are SCALAR quantities)

## EQUIPOTENTIAL SURFACES

* all points on surface are at the same potential
* must be ⊥ to the field at any point
∴ $W = 0$ along equipotential line