Phys 2426 2016-09-01 Lec 3

Static Electric Model

- Source charges generate $\vec{E}$
- Test charges "feel" $\vec{E}$

Gauss's Law - Electric Flux

$$\Phi_E = \iint \vec{E} \cdot d\vec{A} \qquad -\frac{dq}{dt} = \iint \vec{J} \cdot d\vec{A}$$

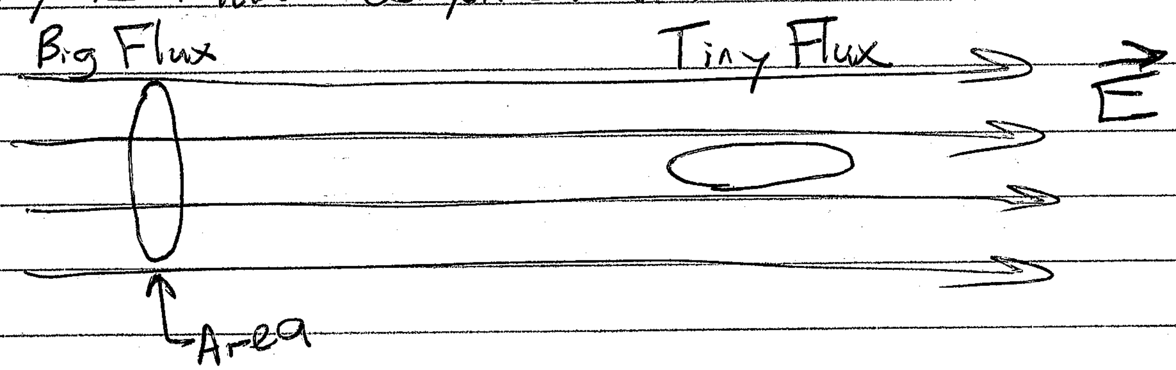
Electric flux

current density, like fluid flux

Φ_E is tough to calculate. Except:

- Spherical Symmetry $\Phi_E = E \cdot 4\pi r^2$
- Cylindrical Symmetry $\Phi_E = E \cdot 2\pi r L$
- Slab Symmetry $\Phi_E = E \cdot A$

Why is Flux complicated? Consider uniform $\vec{E}$



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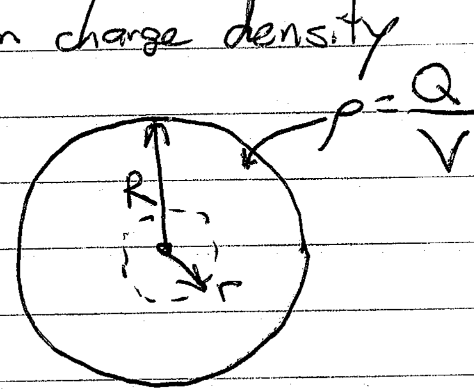
Spherical Symmetry — Uniform charge density

$$\Phi_E = 4\pi k Q_{enc}$$

charge "inside" radius used in Φ_E

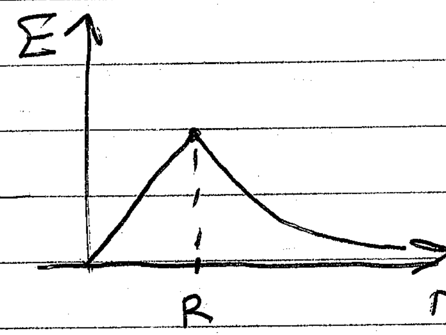


Dashed circle @ radius $r < R$.

$$\Phi_E = E \cdot 4\pi r^2 \qquad Q_{enc} = \rho \tfrac{4}{3}\pi r^3$$

$$(\cancel{4\pi r^2} E) = \cancel{4\pi} k \left(\frac{\rho \frac{4}{3}\pi r^3}{r^2}\right)$$

$$E = k\rho \tfrac{4}{3}\pi r$$



When $r > R$, Q_{enc} limited to total $Q = \rho \frac{4}{3}\pi R^3$

$$\cancel{4\pi r^2} E = \frac{\cancel{4\pi} k \rho \frac{4}{3}\pi R^3}{r^2}$$

$$E = \frac{k\left(\rho \frac{4}{3}\pi R^3\right)}{r^2} = \frac{kQ}{r^2}$$

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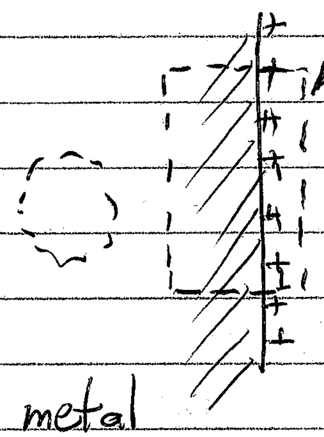
Metals and static Electricity

- Conductors let electrons move.
- If $\vec{E}$ exists, charges move.
- Static = nothing moving = zero E

E = 0 inside a conductor in static electricity.



only this part contributes to Φ_E

$\Phi = EA = 4\pi k(\sigma A)$

$E = 4\pi k \sigma$

surface charge dens. Q/A

- - - - = Gaussian "pancake" or "pillbox"

Round surface inside metal, $E = 0$, $\Phi_E = 0$

Q_{enc} by round surface is zero.

If the metal is charged, it's on the surface.

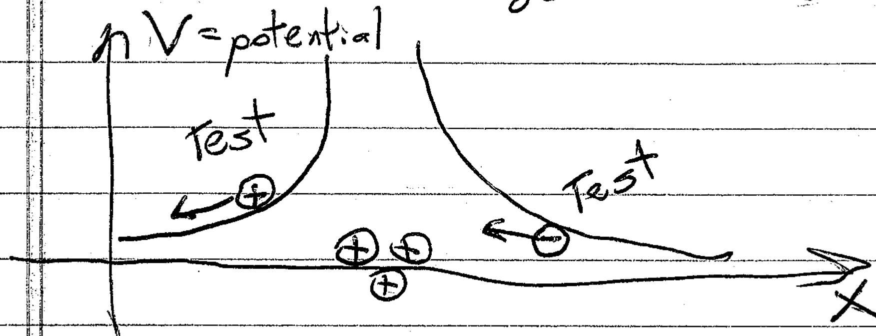
Use "E notation" in WebAssign

$1.6 \times 10^{-19} \rightarrow$ 1.6e-19

Electric Potential model

- Charges generate elec potential
  - ⊕ contributes ⊕ potential
  - ⊖ contributes ⊖ potential
  - potential is a scalar (not a vector)

- Potential influences charges.
  - ⊕ charges pushed "downhill"
  - ⊖ charges "bubble uphill"



Source Charges

Elec Field is the slope of Elec Pot.
E points downhill

$$E = -\frac{dV}{dx} \qquad E \text{ in } \frac{V}{m}$$

Potential (V) is measured in volts (V)

$$\vec{E} = \frac{\vec{F}}{q_0} \qquad E \text{ in } \frac{N}{C}$$