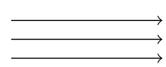
AP Physics C: Chapter 24

Zach Baylin

February 21, 2019

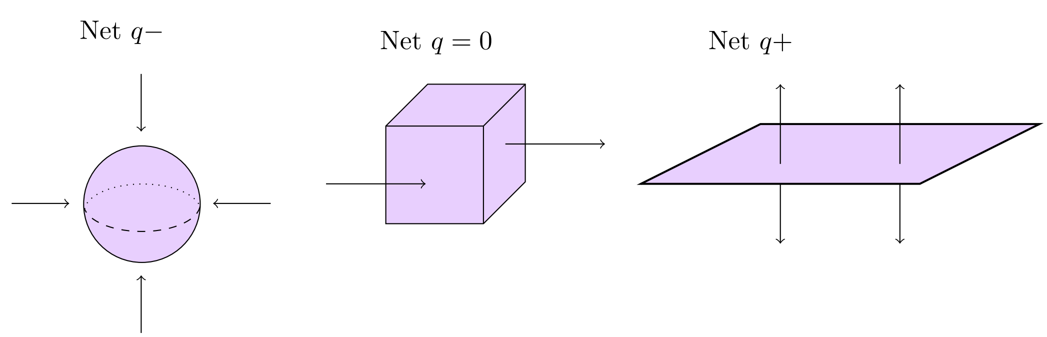
1 Gauss' Law

- Symmetry remains important
- Symmetry of E_1 *must* be similar symmetry of charge distribution
  - cylindrical - infinitely long
  - planar - infinitely wide
  - spherical
- Flux (Φ_E): amount of electric field lines that pass through a surface

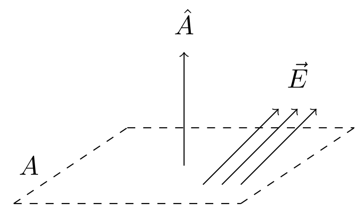


E implies charge

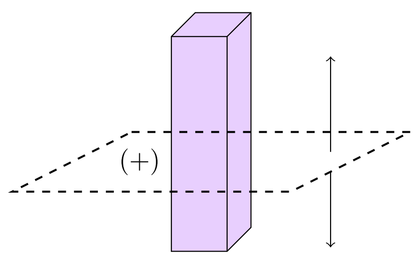
- if Φ_E is only in, $q_{\text{net}} = (-)$
- if Φ_E is only out, $q_{\text{net}} = (+)$
- if in matches out $q_{\text{net}} = \phi$
- imaginary surface = Gaussian surface encloses a region of space around a charge



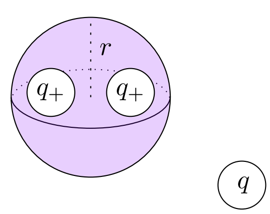
- choose the Gaussian surface closest to the symmetry of the distribution
  - point charge → sphere
  - cylinder → cylinder
  - cylinder → plane
- ex.



- $\phi_E = \vec{E} \cdot \vec{A} = |E||A|\cos(\theta)$
- $\phi_E = \int_{\text{Surface}} \vec{E} \cdot \mathrm{d}A = \int |E| \cos\theta \, \mathrm{d}A = EA\cos\theta$
- <u>Closed Surface</u>: a surface that is contained
  - $\Phi_E = \oint \vec{E} \cdot \mathrm{d}\vec{A}$
  - ex.

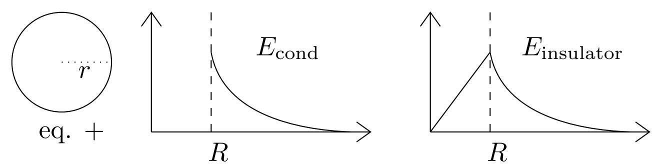


- **Summary**:
  - $\hat{A}$ = normal to the surface of area A
  - $E_\perp$ to the surface and has the same magnitude, then $\vec{E} \cdot \mathrm{d}\vec{A} = EA$
  - Φ_E is MAX when $\theta = 0$ when $E_\perp$ to the surface
  - $\Phi_E = 0$ when $\theta = 90° = \dfrac{\pi}{4}$
- ex. for two point charges:

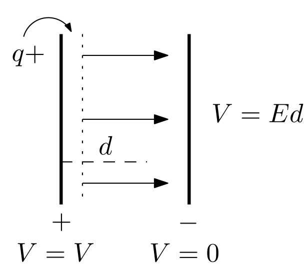


surround both in a single sphere

- Charge densities:
  - **Linear Charge Density** (λ): $\dfrac{Q}{L}$
  - **Area Charge Density** (σ): $\dfrac{Q}{A}$
  - **Volume Charge Density** (ρ): $\dfrac{V}{A}$
- Electric field as distance increases:



2 Capacitors



- Work done on a charge q in a constant electric field E

$$\begin{aligned} F_E &= qE \\ &= q\frac{V}{d} \\ W_{\text{done}} &= F_E \cdot d = q\Delta V = \Delta k \end{aligned}$$

$$\begin{aligned} W &= \Delta k \\ W_{\text{done by external force}} &= \Delta U_E \\ W_{\text{done by field}} &= -\Delta U_E \end{aligned}$$

- Objects with non-constant E
  - point charge
  - sphere
  - rod

- To solve with non-constant E
  - Find E, either using superposition or Gauss' law
  - Find $\Delta V = \oint E \cdot \mathrm{d}r$
- Electic field is the negative slope of potential: $E = \dfrac{-\mathrm{d}v}{\mathrm{d}r}$
- Calculating U_E

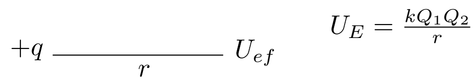


Figure 1: A diagram of U_e

3 Capacitors

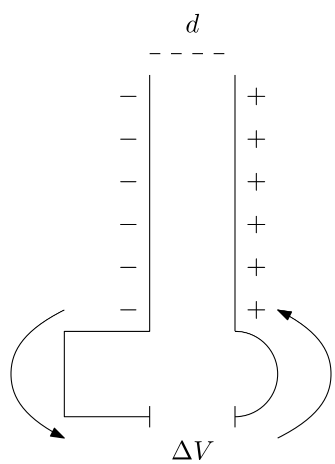


Figure 2: A diagram of metal plates

- **Capacitor -** stores charge/electric energy
- **Parallel plates**

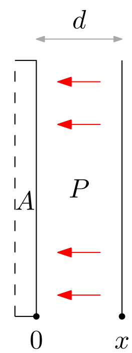


Figure 3: A diagram of parallel plates

- To find the electric potential between the plates:

$$\begin{aligned}\Delta V = V_\mathrm{f} - V_\mathrm{i} &= -\int_0^x E \cdot \mathrm{d}s \\ &= -\int_0^x \frac{-Q}{\varepsilon_0 A} \cdot x \\ &= \frac{Q}{\varepsilon_0 A} \cdot x \\ &= \frac{Q}{\varepsilon_0 A} \cdot d\end{aligned}$$

- **Capacitance**: ratio of charge to change in electric potential

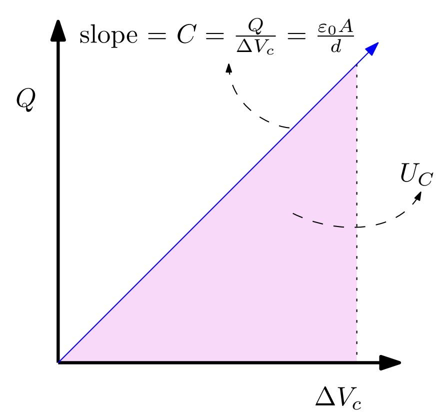


Figure 4: A plot demonstrating capacitance

- **Dialectric**: insulator between plates polarizes to create an $\vec{E}$ opposite E_C

- **Dielectric constant**: $K = \dfrac{E_0}{E}$
  - air: ≈ 1
  - water: ≈ 80
- Amt. of charge is a function of the capacitance and the battery: $Q = C\Delta V$
-