PHYS 5C: Potential

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I. Gauss Law

- Solid sphere, radius R, uniform uniform p $\quad Q = \frac{4}{3}\pi R^3 p$
- E for $r < R$ $\int \mathrm{EdA} = \frac{Q_{\mathrm{encl}}}{\epsilon_0}$
- $E = \frac{Q}{4\pi\epsilon_0}\frac{r}{R^3}$
- for r>R
- $\int \mathrm{EdA} = E4\pi r^2$

  $Q_{\mathrm{encl}} = Q = \frac{4}{3}\pi R^3 p \qquad$ p=$\frac{4}{3}\pi R^3$

  $E = \frac{Q}{4\pi\epsilon_0 r^2}$ when $r > R$
- A conductor has a Field of 0 in the inside. Eletric field must be normal to field inside

II. Electric Potental (V)

- Electric force is conservative.

  Can define potential energy.$U_b - U_a = -\int_a^b F\,\mathrm{dL}$
- $E = \frac{F}{q}$ Define potential energy as: $V_b - V_a = -\int_a^b E\,\mathrm{dL}$
- V is a scalar field not vector
- Units: Volts $\frac{J}{C}$ for E: $\frac{V}{m}$
- Potential differences are what really matter

  Often try to set V=0, at reference ->∞
- $V_b - V_a$ is path independent
- V for a point charge +Q

  $V_n - V_a = \int_{r_a}^{r_b} E\,\mathrm{dL} \Rightarrow E = \frac{Q}{4\pi\epsilon_0 r^2} \Rightarrow \frac{-Q}{4\pi\varepsilon_0}\int_{r_a}^{r_b}\frac{1}{r^2}\mathrm{dr}$

  $= V_b - V_a = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{r_b} - \frac{1}{r_a}\right)$ If we put reference position at ∞: set $V_b \to 0$ at $r_b \to \infty$

  $V_a = \frac{Q}{4\pi\varepsilon_0 r_a}$ and drop subscript a

  V=$\frac{Q}{4\pi\varepsilon_0 r}$
- Parallel plates LxL seperated by d«L

  $E = \frac{\sigma}{\varepsilon_0} \quad V_b - V_a = -\int_a^b E\,\mathrm{dL} \quad \sigma = \frac{Q}{L^2}$

  $-\int \mathrm{EdL} = -E\int \mathrm{dL} = -\mathrm{Ed}$