PHYS 5C: Capacitors Cont.

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- $C = \frac{Q}{V}$
- $V_{\text{battery}} = V_{\text{cap}} = \frac{Q}{V}$
- $V = \frac{Q_1}{C_1} = \frac{Q_2}{C_2} = \frac{Q}{C_{\text{eq}}}$ where $Q = Q_1 + Q_2 = C_1 V + C_2 V = (C_1 + C_2) V$

  $\Rightarrow \frac{(C_1 + C_2) V}{C_{\text{eq}}} \Rightarrow C_{\text{eq}} = C_1 + C_2$
- If Capaacitors are parrallel then, $C_{\text{eq}} = C_1 + C_2$

  If not let $\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2}$

I. Energy

- Charging a capacitor requrie swork
- Potential energy $U = \text{qV}$
- If there is asome V across capacitor moving an amount of charge dq requires an amount of work

  $\text{du} = \text{dqV}$
- If you charge a capacitor from 0 to Q, then $\text{U} = \int_0^Q \text{dqV} \Rightarrow \frac{1}{C} \int_0^Q \text{dq}\, q = \frac{Q^2}{2C} = \frac{1}{2} \text{CV}^2$
- Energy is stored in the Electric field itself
- $C = \frac{\varepsilon_0 A}{d}$ $\quad$ V=Ed

  $\frac{1}{2} \text{CV} = \frac{1}{2} \left(\frac{\varepsilon_0 A}{d} \right) V^2 = \frac{1}{2} \left(\frac{\varepsilon_0 A}{d} \right) (E^2 d^2) = \frac{\varepsilon_0}{2} E^2 [\text{Ad}]$
- Suggests that $\frac{\varepsilon_0}{2} E^2 \text{is an energy per volume or energy density}$
- Generally, $U = \frac{e_0}{2} \int E^2 d(\text{volume})$

II. Dielelectrics

- Some insulators are polarizable
- $E_D = \frac{E_0}{k} \text{where } k \geqslant 1$
- $C_d = \text{kC}_0 \quad V_D = \frac{V_0}{k} \quad C_d = \frac{Q}{V_0} = k \frac{Q}{V_o} = \text{kC}_0$
- Define $\varepsilon = k \varepsilon_0 \text{permitivity of dieletric}$