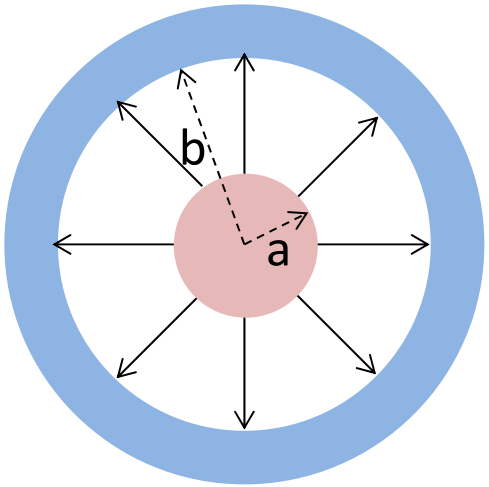
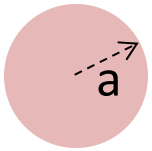
Capacitance

Spherical capacitor



$b \to \infty$



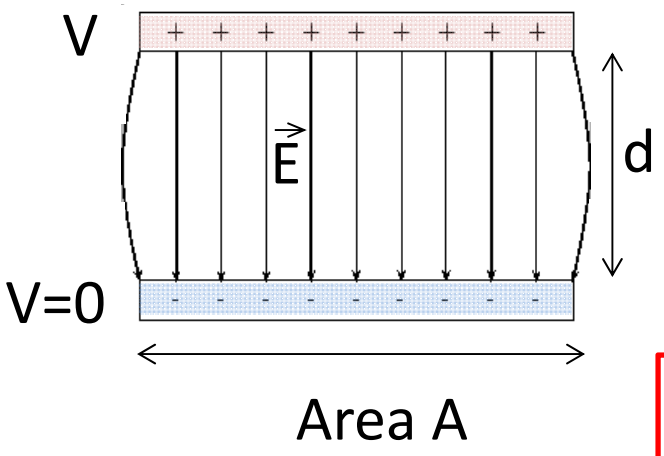
Capacitance of a single conductance sphere:

$$C = \frac{4\pi\varepsilon_0 ab}{b - a}$$

$$C = 4\pi\varepsilon_0 a \quad (C \propto a)$$

or $$\frac{1}{C} = \frac{1}{4\pi\varepsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right)$$

Parallel plate capacitor



Given C,

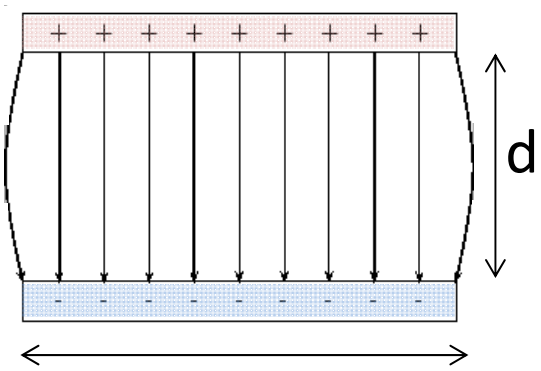
$Q \Leftrightarrow V \Leftrightarrow E$

$$C = \frac{\varepsilon_0 A}{d}$$

$$C = \frac{Q}{V} \qquad \text{(general)}$$

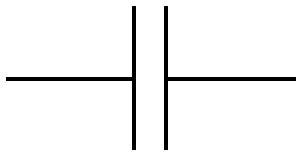
$$V = Ed \qquad \text{(parallel plate} \Rightarrow \text{constant field)}$$

Parallel plate capacitor

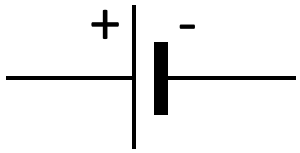


$$C = \frac{\varepsilon_0 A}{d}$$

Symbol of a capacitor:



Symbol of a Battery:

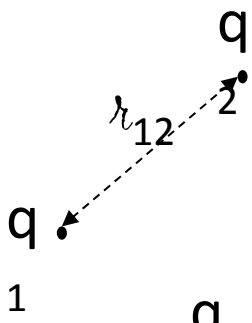


Symbol of a switch:

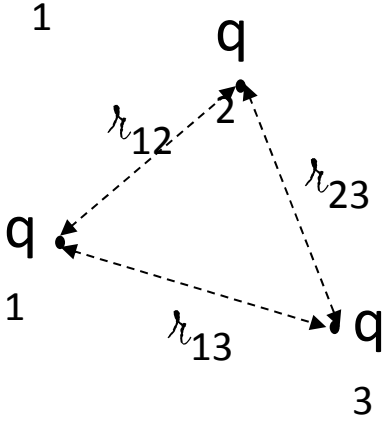
Open Closed

Class 16. Energy stored in a capacitor

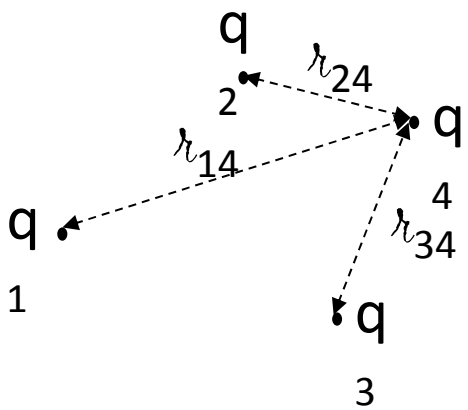
Energy to Assemble a Collection of Charges



$$W = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

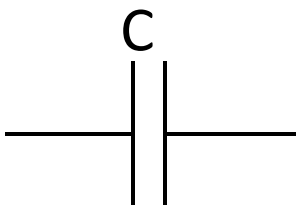


$$W = \left(\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}\right) + \left(\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_3}{r_{13}} + \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_3}{r_{23}}\right)$$



$$W = \left(\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}\right) + \left(\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_3}{r_{13}} + \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_3}{r_{23}}\right) + \left(\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_3}{r_{14}} + \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_4}{r_{24}} + \frac{1}{4\pi\varepsilon_0}\frac{q_3 q_4}{r_{34}}\right)$$

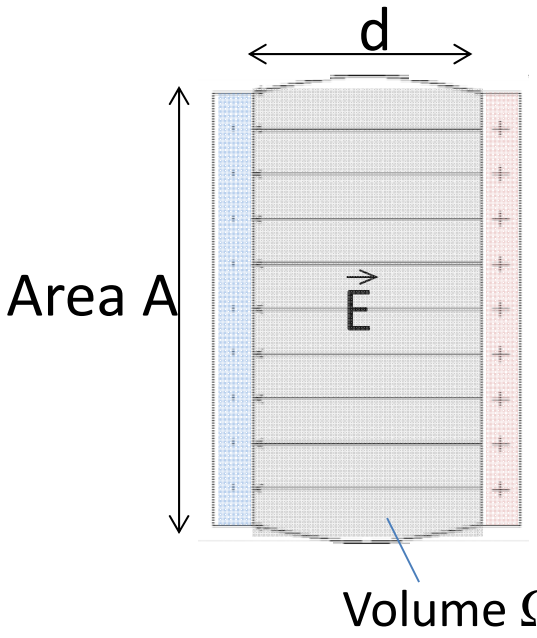
Energy Stored in a Capacitor



Energy stored in a charged capacitor:

$$U = \frac{1}{2} C V^2$$

(Do not forget $C = \frac{Q}{V}$.)



Energy density stored in an electric field:

$$u_E = \frac{U}{\Omega} = \frac{1}{2} \varepsilon_0 E^2$$