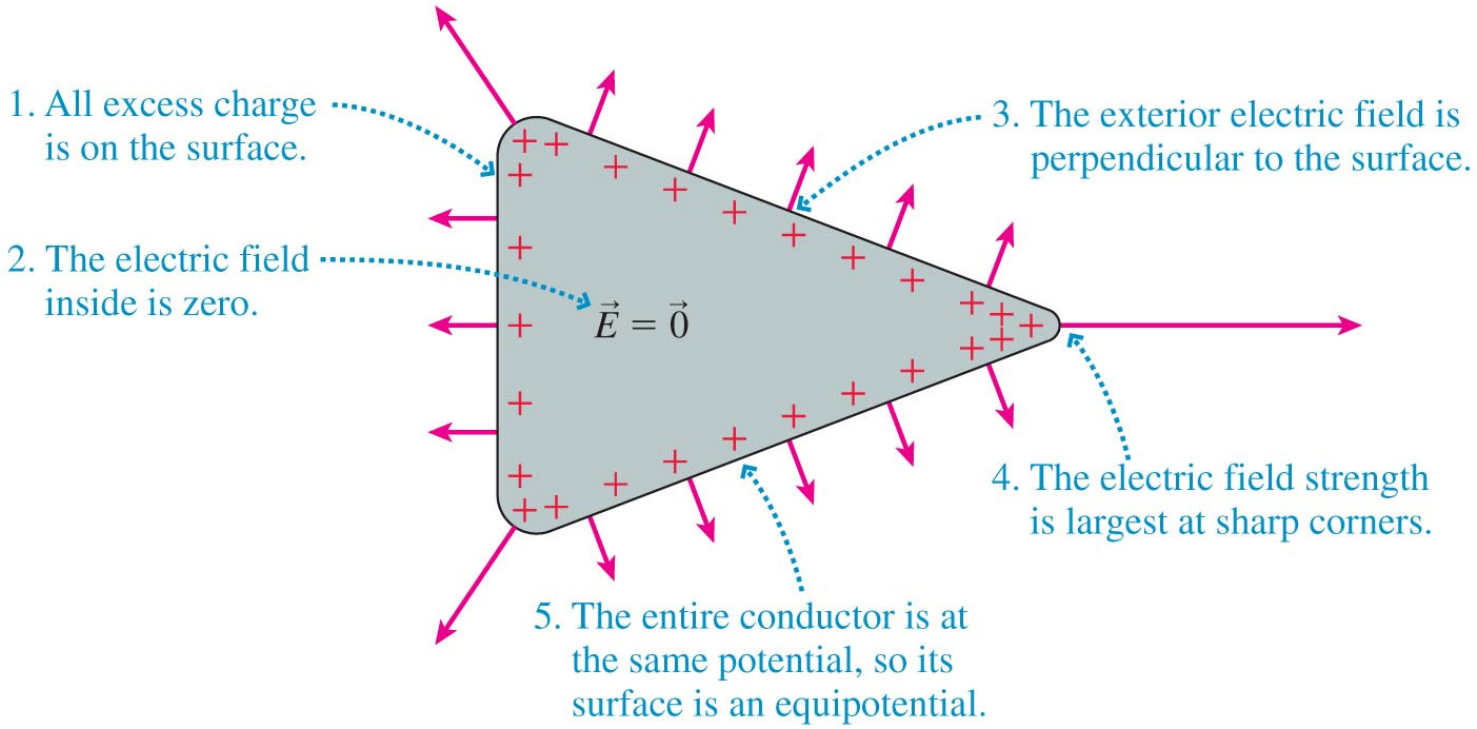
Capacitors and Dielectrics

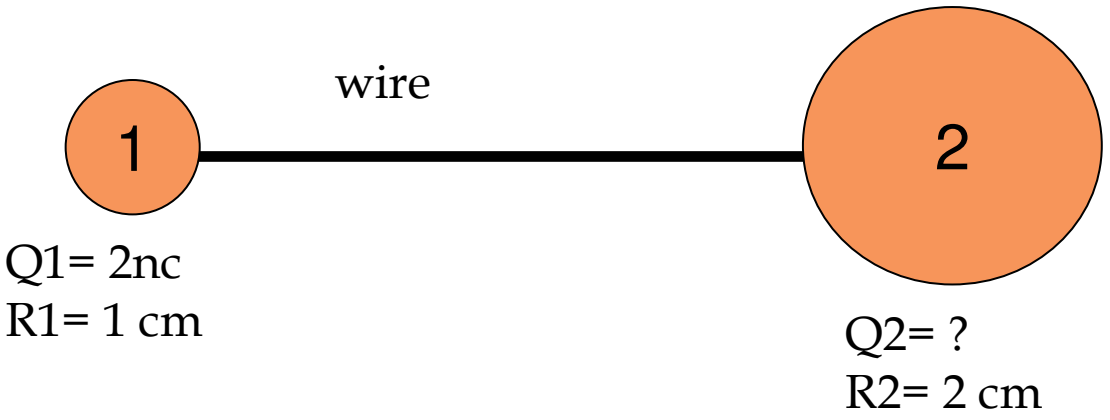
Acknowledgements: Several Images and excerpts are taken from
College Physics: A strategic approach, ***Pearson Education Inc***

Recap: A Conductor in Electrostatic Equilibrium

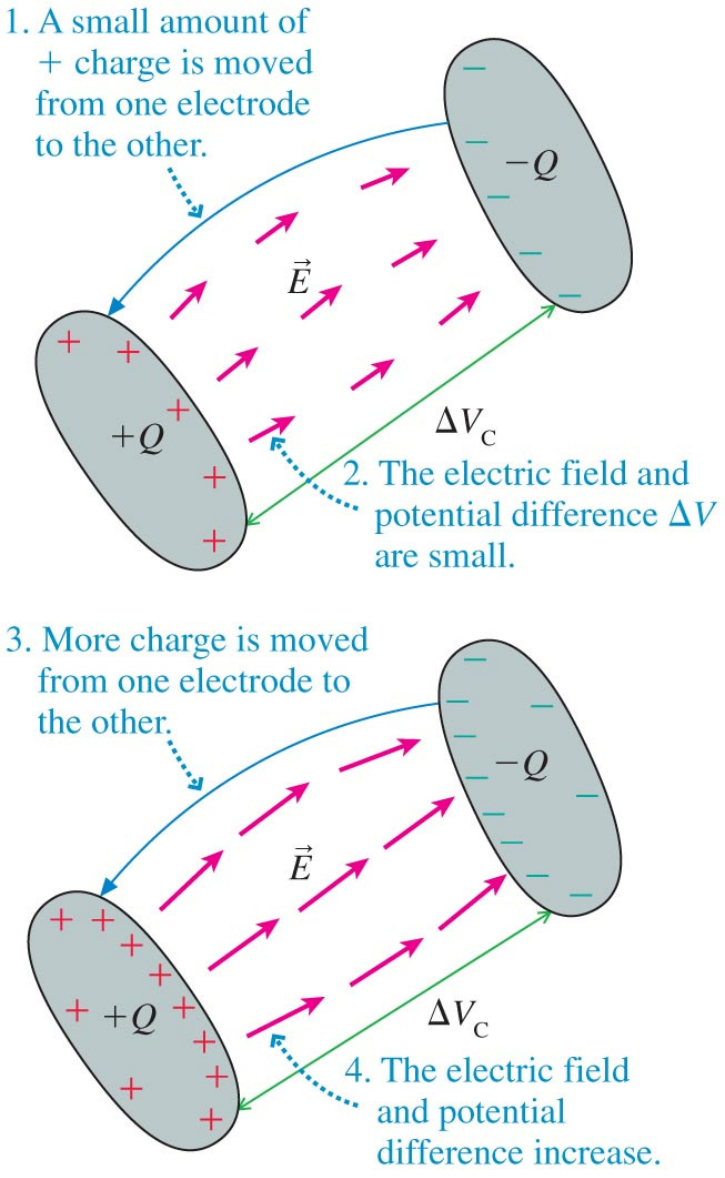


Problem

Two spheres are connected by a metal wire, as shown below. What is value of Q_2?



Capacitance and Capacitors

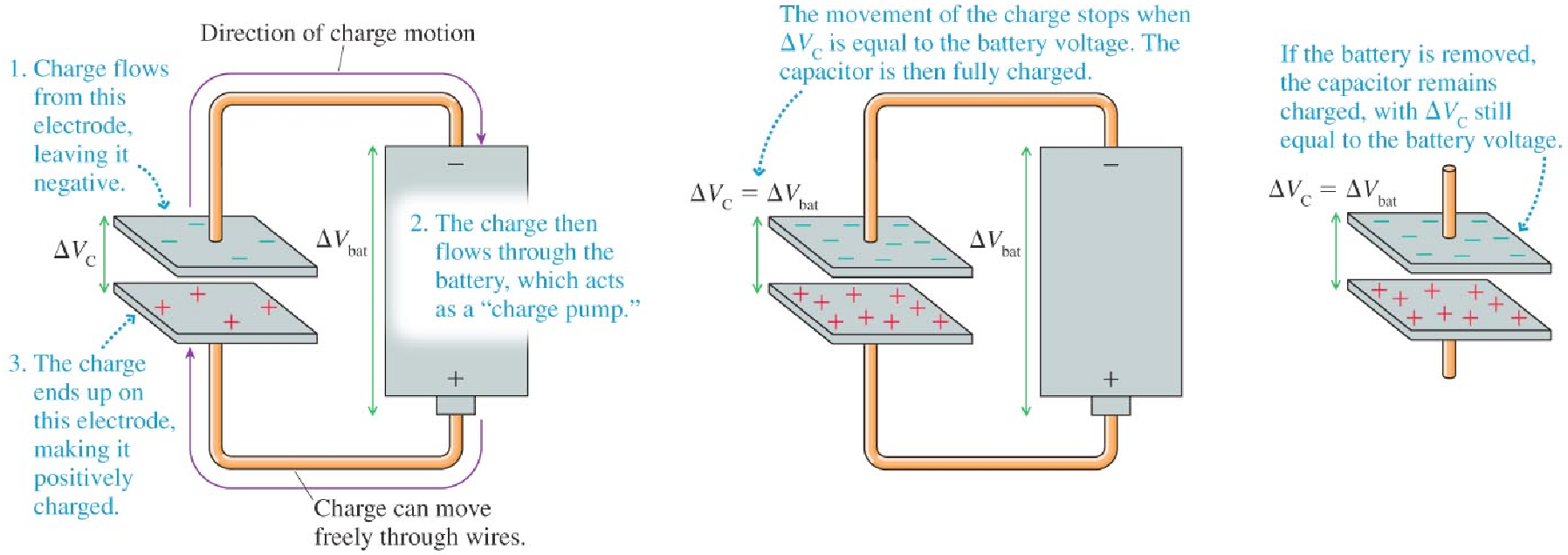


The charge $\pm Q$ on each electrode is proportional to the potential difference ΔV_C between the electrodes:

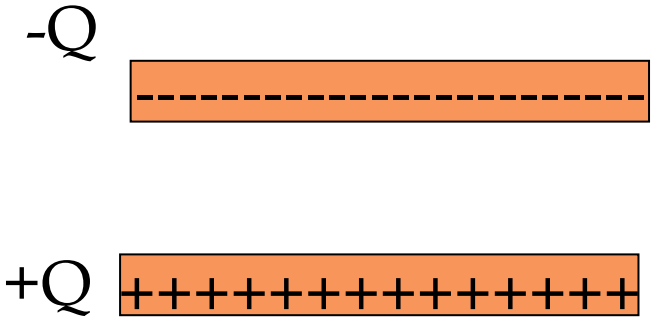
$Q = C\Delta V_c$

"C", the proportionality constant, is called capacitance of the capacitor, and its units is F (Farad)

How do we charge a capacitor and what will happen if we remove the battery?



The Capacitance of a Parallel-Plate Capacitor



Plates have area "A" & separation "d"

Electric field of a parallel plate capacitor is

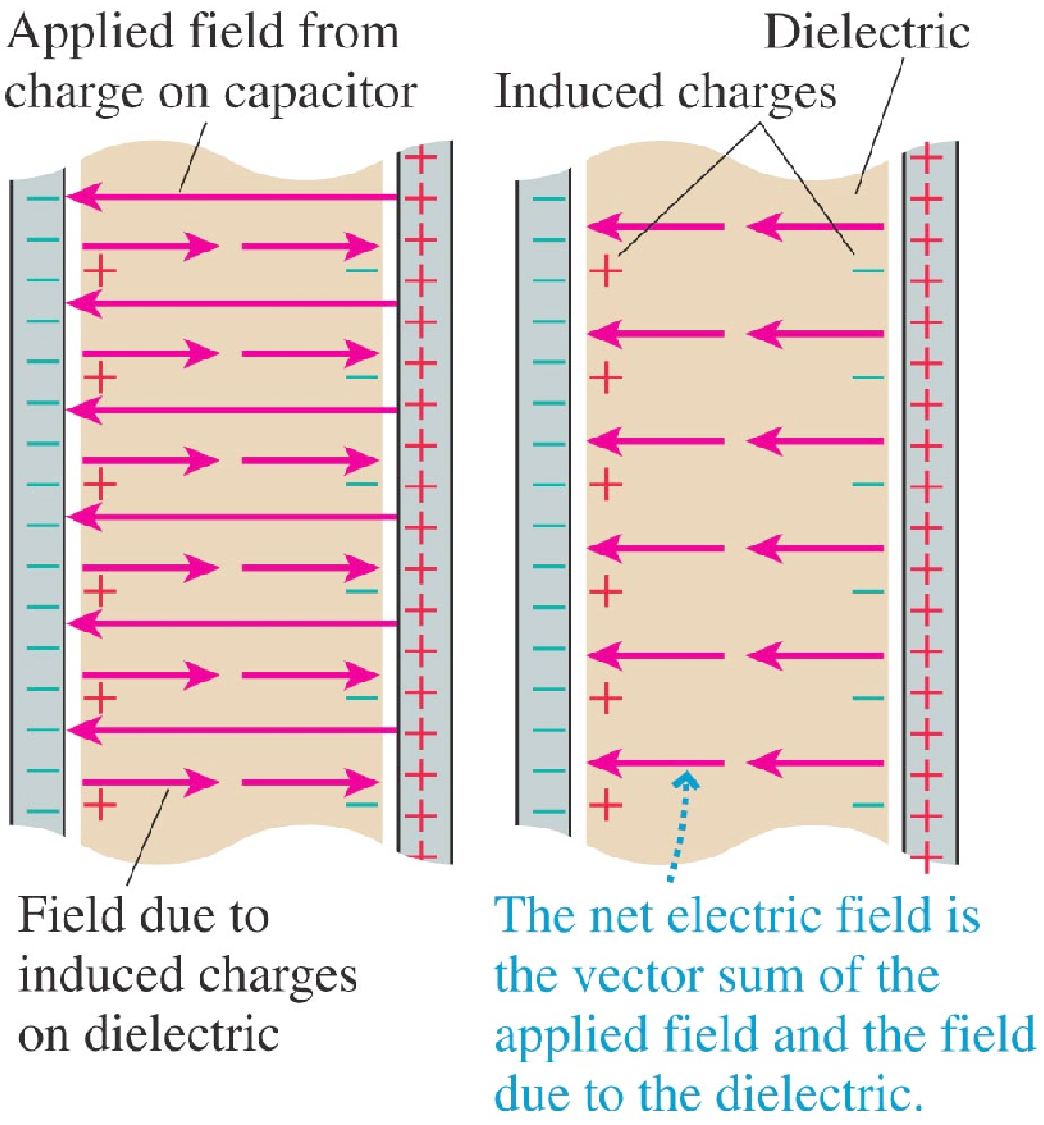
$$E = \frac{Q}{\varepsilon_o A}$$

$$E = \frac{\Delta V_c}{d}$$

$$Q = \frac{\varepsilon_o A}{d}\Delta V_c$$

$$\Rightarrow C = \frac{\varepsilon_o A}{d}$$

Dielectrics and Capacitors



Dielectric Constant

With a dielectric slab is placed between the capacitor plates, the capacitance of the capacitor is increased by a factor of the *dielectric constant* ε:

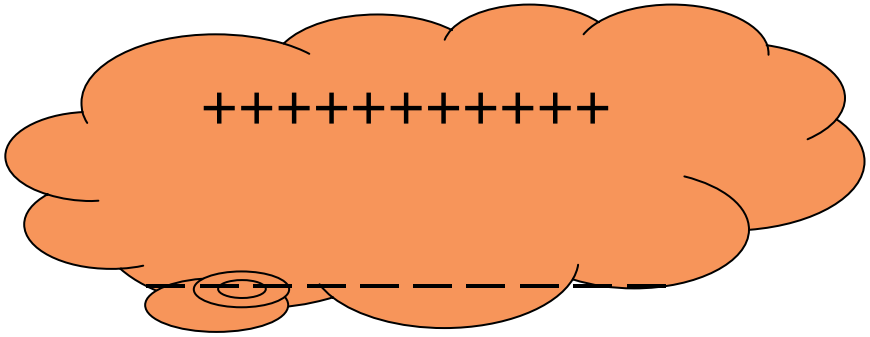
$$C = \frac{\varepsilon \varepsilon_o A}{d}$$

With a dielectric slab is placed between the capacitor plates, the electric field (E) capacitor is decreased by a factor of the *dielectric constant* ε:

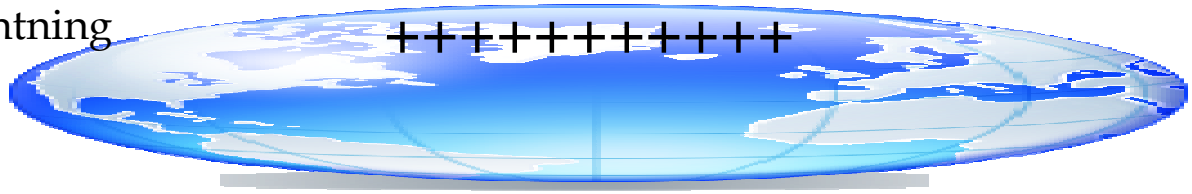
$$E' = \frac{E}{\varepsilon}$$

Lightening effect?

- In clouds, ice particles create charges through rubbing
- Heavier clouds fall at the bottom and gain a negative charges while the lighter clouds rise at top and gain a positive charge



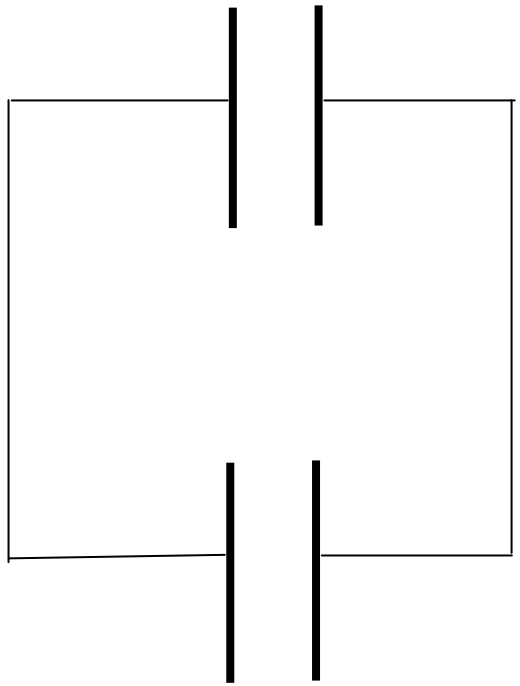
- This causes a positive charge to accumulate at the ground
- Net potential difference ~ 10^7 - 10^8 V
- This huge potential difference leads to charge to flow down in the air causing the lightning effect



Capacitor in parallel

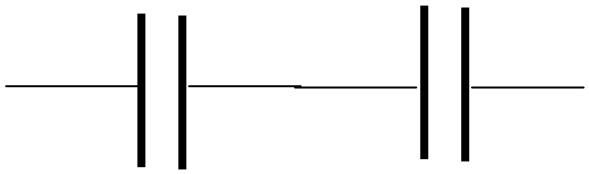
How can we join multiple capacitors

$$C_{eq} = C_1 + C_2 + C_3 + \ldots$$



Capacitor in series

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}\frac{1}{C_3} + \ldots$$



Problem: Equivalent capacitance?