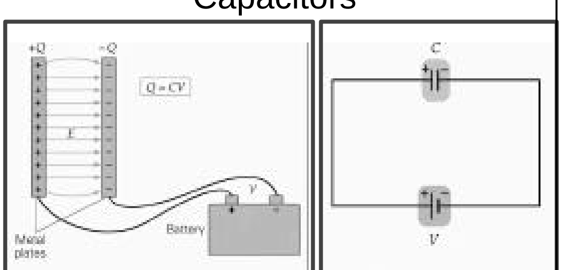
Capacitors

Capacitors

- Used to store a set amount of charge
- made of two conductors separated by an insulator
- measured in farads (F)
- most commercial capacitors are usually 10×10^{-12} F to 500×10^{-6} F

$$C = \frac{Q}{V}$$

Capacitors



(a) Parallel-plate capacitor
(b) Schematic circuit diagram

Factors affecting Capacitance

- Area of plates
- Distance between plates
- Material between plates
  - Example: paper, air, vacuum

Capacitors

- Capacitance of a parallel – plate capacitor (in air).

$$C = \frac{e_0 A}{d}$$

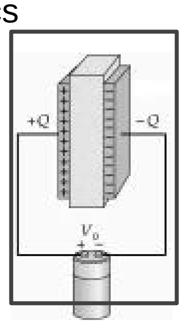
Permittivity of free space = e_o = 8.85 x 10 $^{-12}$ $C^2/(N \cdot m^2)$

- Energy in a charged capacitor

$$U_c = \frac{1}{2}QV = \frac{Q^2}{2C} = \frac{1}{2}CV^2$$

Dielectrics

- The material used in capacitors to increase the amount of charge stored on the plates.
  - Example: paper or plastic
- Keeps plates from coming into contact with each other.
- Each material has a specific value (K)



Dielectric Constant

- The capability of a capacitor to store charge depends on the material, and is characterized by the dielectric constant (K).
- P. 528 has a chart of some constants.
- K is dimensionless, and always greater than 1.
- Values are comparisons with vacuum values.

Dielectric Effect On Capacitance

- If we designate the vacuum values as E_o and V_o, then the dielectric constant is defined as

$$K = \frac{V_0}{V} = \frac{E_0}{E}$$

- The dielectric increases the capacitance by a factor of K: $C = \frac{Q}{V} = KC_0$

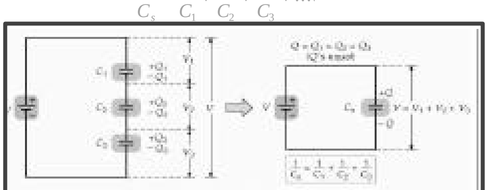
Capacitors in Series

- When capacitors are wired in series, the charge (magnitude Q) is the same on all the plates.
  - Q = Q1 = Q2 = Q3 = …
- The sum of the voltage drops add up to the voltage source.
  - V = V1 + V2 + V3 + …

Equivalent Series Capacitance

- The value of a single capacitor that could replace the series combination.

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



(a) Capacitors in series

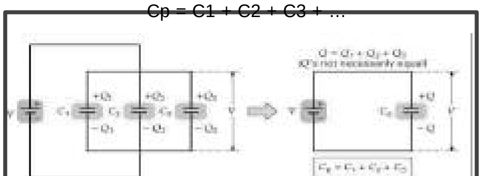
Capacitors In Parallel

- The voltage across parallel capacitors are the same.
  - $V = V1 = V2 = V3 = \ldots$
- Total stored charge is equal to the sum of the individual charges.
  - $Q_{total} = Q1 + Q2 + Q3 + \ldots$

Equivalent Parallel Capacitance

- The equivalent capacitance to parallel capacitors is the sum of the individual capacitances.

$$Cp = C1 + C2 + C3 + \ldots$$



(b) Capacitors in parallel