Lesson 13f: Capacitors

Capacitors are simple devices found in electric circuits.
- At their simplest, they are made up of two metal parallel plates separated by a non-conductor called the **dielectric medium**. *Note, sometimes the dielectric medium is simply a vacuum.*
- These capacitors are called **parallel-plate capacitors**.
  - When a voltage is applied across the capacitor, it builds up charge on the two plates (one positive, the other negative), in effect storing electricity.

Capacitors can be used to store up charge so that it can be released in a quick burst on demand.
- This is what a camera flash does when it charges up before you take a picture.
- Capacitors can also be used to block DC current, while allowing AC current to go through.
- They are also used to "smooth" out electricity, like on some high end power bars used for sensitive electronics.

Illustration 1: A Leyden jar is a primitive version of a capacitor.

The amount of charge that can be stored in a capacitor depends on several factors, but is often stated as a single variable, the **capacitance**.

$$Q = CV$$

Q = amount of charge stored (C)
C = capacitance (Farads = F)
V = voltage (V)

- The unit of capacitance, the farad, is the number of coulombs that can be stored per volt.
- Most capacitors have a dielectric medium that is measured in micro- or nanofarads, since 1 F is actually a very high capacitance.

Example 1: In a camera, the flash has a 185 µF capacitor connected to two AA batteries, causing 3.0 V of potential difference across the capacitor. **Determine** how much charge can be stored in this capacitor.

$Q = CV$
$Q = 185e{-}6 \,(3.0)$
$Q = 5.6e{-}4 \text{ C}$

Illustration 2: Modern capacitors often look like tubes.

As long as we assume that the dielectric constant is just a vacuum, there is a formula that can be used to calculate the capacitance based on a couple of factors.

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

C = Capacitance (F)
ε_o = "epsilon naught" = permittivity of free space = 8.84e-12 C/V·m
A = area of plates (m^2)
d = distance between plates (m)

Example 2: We are building simple capacitors in class by laying down a sheet of aluminum foil with a surface area of 0.12 m², then a sheet of 0.5 mm thick card stock paper (same area), and finally another sheet of similar aluminum foil on top. Ignoring that the dielectric medium (the paper) in between is not a vacuum, **determine** the capacitance of this simple resistor.

Don't forget to change the distance into metres.

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

$$C = \frac{8.84\text{e-}12\,(0.12)}{0.5\text{e-}3}$$

$$C = 2.1\text{e-}9\,F = 2.1\,nF$$

In circuit diagrams, the symbol for a capacitor looks a LOT like a battery, so be careful to not get them mixed up.

- The difference is that a capacitor has two parallel lines that are the same size.

Battery

Capacitor