17-2 Capacitance

**Vocabulary**

Capacitor: A device that stores charge on conductors that are separated by an insulator.

Capacitance is a measure of the amount of charge stored on the conductors, for a given potential difference.

\[
\text{capacitance} = \frac{\text{amount of charge}}{\text{potential difference}} \quad \text{or} \quad C = \frac{\Delta q}{V}
\]

The SI unit for capacitance is the farad (F), which equals one coulomb per volt (C/V).

A capacitor may be used in a circuit by storing charge on two parallel plates and then periodically releasing it into the circuit, creating an intermittent flow of charge.

**Solved Examples**

**Example 3:**
The first capacitor was invented by Pieter van Musschenbroek in 1745 when he and his assistant stored charge in a device called a Leyden jar. If \( \frac{5}{10} \times 10^{-4} \) C of charge were stored in the jar over a potential difference of 10,000 V, what was the capacitance of the Leyden jar? (When van Musschenbroek touched the jar, he received such a large jolt that he exclaimed he would not try the experiment again for all the kingdom of France!)

\[
\begin{align*}
\text{Given:} & \quad \Delta q = 5 \times 10^{-4} \text{ C} \\
& \quad V = 10,000 \text{ V} \\
\text{Unknown:} & \quad C = \text{?} \\
\text{Original equation:} & \quad C = \frac{\Delta q}{V}
\end{align*}
\]

\[
\begin{align*}
\text{Solve:} & \quad C = \frac{\Delta q}{V} = \frac{5 \times 10^{-4} \text{ C}}{10,000 \text{ V}} = 5 \times 10^{-8} \text{ F}
\end{align*}
\]

**Example 4:**
Lydia pushes the shutter button of her camera and the flash unit releases the \( 4.5 \times 10^{-3} \) C of charge that was stored in a 500-\( \mu \)F capacitor. What is the potential difference across the plates of the capacitor inside the flash?

**Solution:** The term \( \mu \) (micro) means \( 10^{-6} \), so a \( \mu \)F means \( 10^{-6} \) farad.

\[
\begin{align*}
\text{Given:} & \quad \Delta q = 4.5 \times 10^{-3} \text{ C} \\
& \quad C = 500. \times 10^{-6} \text{ F} \\
\text{Unknown:} & \quad V = \text{?} \\
\text{Original equation:} & \quad C = \frac{\Delta q}{V}
\end{align*}
\]

\[
\begin{align*}
\text{Solve:} & \quad V = \frac{\Delta q}{C} = \frac{4.5 \times 10^{-3} \text{ C}}{500. \times 10^{-6} \text{ F}} = 9.0 \text{ V}
\end{align*}
\]
Practice Exercises

Exercise 6: The nervous system of the human body contains axons whose membranes act as small capacitors. A membrane is capable of storing $1.2 \times 10^{-9}$ C of charge across a potential difference of 0.070 V before discharging nerve impulses through the body. What is the capacitance of one of these axon membranes?

Answer: 

Exercise 7: During a lightning storm, the separation between the clouds and Earth acts as a giant capacitor with a capacitance of 2500 μF. If the transmitting tower of radio station KBOZ is hit by a bolt of lightning carrying 50. C of charge, what is the potential difference between the cloud and the tower?

Answer: 

Exercise 8: Dr. Frankenstein brings his monster to life with electroshock treatment by discharging a 50-μF capacitor through the monster’s neck across a potential difference of 24 V. How much charge flows into the monster to make him come alive?

Answer: 

Exercise 9: On Saturday nights, Greg likes to go the Frisco Disco, where he can dance under the strobe light. The strobe contains a 200-μF capacitor that stores charge over a 1000-V potential difference. If the strobe flashes 4 times each second, what is the current flow created by the strobe’s capacitor?

Answer: 

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