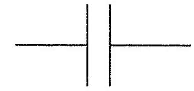
Capacitors



A capacitor is an electronic component that can store electrical charge and then release it.
It is made of two conducting plates separated by an insulator.
The charge that is stored by the capacitor is due to the potential difference across. We can write this as:

$$Q \propto V \quad \text{or} \quad Q = kV$$

k is a constant specific to the capacitor, this is called the capacitance and is represented by the symbol C

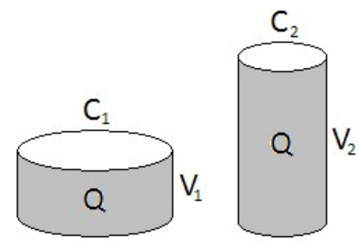
$$\boxed{Q = CV}$$

Capacitance is measured in Farads, F
Charge is measured in Coulombs, C

We can rearrange the equation into $C = Q / V$ and from this we can see that capacitance is a measure of the charge stored per volt of potential difference. 1 Farad means 1 Coulomb of charge is stored per Volt.

Water Analogy

We can think of the charge stored by a capacitor as the volume of water in a bucket.
The cross-sectional area of the bucket represents the capacitance of the capacitor. We can see that the capacitance of capacitor 1 is higher than the capacitance of capacitor 2.
The height of the water represents the potential difference across the capacitor.
We can see that the potential difference across capacitor 2 is higher than the p.d. across capacitor 1. The charge stored by both capacitors is the same.
A capacitor with a lower capacitance can store more charge if the p.d. across it is increased.



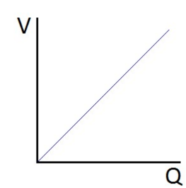
Charging and Discharging

When a capacitor is connected to a battery is sends out electrons to one of the plates, this becomes negatively charged. The same amount of electrons move from the second plate and enter the battery, leaving the plate positively charged. The capacitor is now storing a charge or is 'charged'.

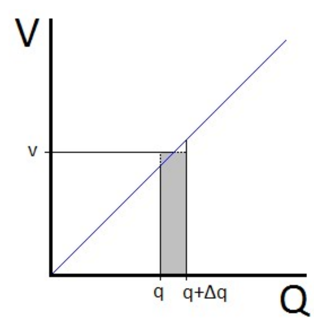
If the charged capacitor is disconnected from the battery and connected to a lamp it will give out the stored charge or will 'discharge'. The electrons on the negative plate move through the circuit and onto the positive plate. The plates now have no charge on them. The energy stored by the capacitor is transferred to the bulb whilst the electrons move (whilst a current flows).

Energy Stored by a Capacitor

The top equation shows us that the charge of a capacitor increases with the potential difference across it. If we plotted p.d. against charge we get a graph that looks like this →



We can derive an equation to find the energy that a capacitor stores by considering the energy transferred during the shaded section on the lower graph.
In this section the charge changes from q to $q+\Delta q$ when an average p.d. of v is applied across it.
Using $E = VQ$ (see AS Unit 1) the energy stored is $E = v\,\Delta q$.
The total energy is equal to the total of all the little rectangular sections and is given by $E = ½\,QV$. This is also equal to the area under the graph.
We can use the top equation to derive two more equations for the energy stored by a capacitor:



$$\boxed{E = \frac{1}{2}QV} \qquad \boxed{E = \frac{1}{2}CV^2} \qquad \boxed{E = \frac{1}{2}\frac{Q^2}{C}}$$

Energy is measured in Joules, J