Applications of Exponential and Logarithmic Functions

# Capacitance and the Time Constant

A capacitor is a passive component used in electrical circuits. It basically consists of two metal plates that sit a small distance apart. As current flows through the circuit the electrons are unable pass from one plate to the other and so pile up on one side, creating a potential difference between the plates. The amount of charge that a capacitor can hold is called the capacitance (C) and is measured in farads (F). The greater the capacitance the more charge a capacitor can hold. When the current flow drops the electrons are able to start flowing back into the circuit from the side where they had built up.

The symbol for the capacitor in a circuit diagram is:

The rate at which a capacitor charges and discharges is related to what is known as the time constant (τ), measured in seconds (s).

τ = RC, where R is resistance in ohms (Ω) and C is capacitance in farads (F).

The time constant gives the amount of time for the capacitor to charge to $1-\frac{1}{e} ≈63.2\%$. When discharging it is the time taken to discharge 63.2% of its charge.

Load the Yenka file “Time Constant of a Capacitor” and watch what happens to the graph of the charge in the capacitor as current is allowed to flow into it. Cut the current and see what happens. Change the values of the capacitor and resistor and note the changes to the rate of charging and discharging.

The charge curves can be modelled as logarithmic functions of the form: $A=B (1-e^{-kt})$, where *B* and *k* are constants and *t* is time. The discharge function is a decay function and can be modelled as an exponential function of the form: $A=A\_{o}e^{-kt}$, where *AO* and *k* are constants and *t* is time.

1. **For the given circuit calculate the time constant. Determine how many time constants before the capacitor can be said to be fully charged.**
2. **Produce a table showing the time constant calculated for a number of different values of R and C.**
3. **By allowing the current to flow and then cutting it off produce a series of graphs showing the full cycle of charging and discharging of the capacitor for the values of R and C previously used.**
4. **Determine the functions for the charging and discharging of the capacitor for the different values of R and C. How do the functions relate to the time constants calculated for the same R and C values?**