3EM

Discharging a Capacitor

A capacitor is a device used to store electric charge. The capacitance of a capacitor is a measure of the quantity of charge, Q, it can store for a given potential difference, V. Capacitance is defined by the following equation:

$$C = Q/V$$

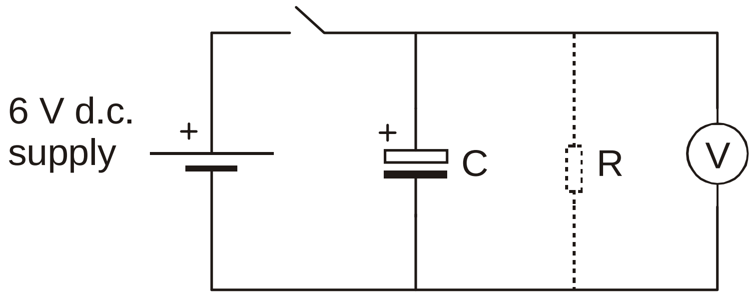
and so the units of capacitance are CV^{-1}. 1 CV^{-1} is called 1Farad (1F)

The capacitor is being studied here as it gives us another example of an *exponential* variation.

1. **Preparation:** a) Remind yourself how to measure the slope of a curved graph at a given point.

   b) See part 3 below.

2. The aim of the experiment is to plot a graph which shows how the voltage across a capacitor varies as it is discharging through a resistor.



R = 75 kΩ. The voltmeter is an "analogue" type using the 7·5v calibration (on this calibration, it has a resistance of 75 kΩ).

Do the experiment first *without* the resistor R in the circuit.

When the switch is closed, the capacitor charges (almost immediately) to the same voltage as the supply. As soon as the switch is opened, the capacitor starts to discharge through the voltmeter. (When using the 7·5v calibration of the voltmeter, its resistance is 75 kΩ.)

- charge the capacitor, read the voltmeter <u>with the switch closed</u>; this is the voltage at t = zero
- open the switch and start a watch simultaneously
- measure the time taken for the voltage to fall to, for example, 5 volts
- recharge C and measure the time taken for the voltage to fall to some lower value, for example, 4·5 volts
- repeat for other voltages.

Repeat one or two of the readings with the 75 kΩ resistor connected in parallel with the voltmeter, as shown.

Plot a graph of voltage against time.

3. If the graph is *exponential*, it will be found that the rate of fall of voltage is *directly proportional* to voltage.

   Or, fall in voltage per second = (a constant) × voltage

   but fall in voltage per second is the *slope* of the graph

   so, if we measure the slope at various voltages v we should find that

$$\text{gradient} / v = \text{a constant}$$

4. a) Prove that your graphs are exponential. To do this, measure the slope at three points on the curve, for example, at v = 5 V, v = 3·5 V and v = 1·5 V.

   b) Another way to prove that the results show an exponential fall in voltage is to find how long it takes for the voltage to fall to half of its starting value. This "halving time" should be constant no matter what time you consider as the start. (You could, of course, consider the time taken for the voltage to fall to some other fraction of its initial value.)

   c) In theory, how long would it take to completely discharge a capacitor ? In practice, how long (approximately) did it take ? Why is there this difference between theory and practice ?