**INVESTIGATION OF THE CHARGING AND DISCHARGING OF A CAPACITOR TO DETERMINE THE TIME CONSTANT**

**Specification reference:** **A level Component 2.4 – Capacitance**

## Theory:

The *discharge* of a capacitor is given by the equation: $Q = Q_o e^{-\frac{t}{RC}}$ which can be written in terms of the voltage across the capacitor as: $V = V_o e^{-\frac{t}{RC}}$.

By using logs, the above equation can be written as: $\ln V = -\frac{t}{RC} + \ln V_o$

which can be compared with $y = mx + c$.

The *charging of a capacitor* is given by: $V = V_o\left(1 - e^{-\frac{t}{RC}}\right)$.

## Apparatus:

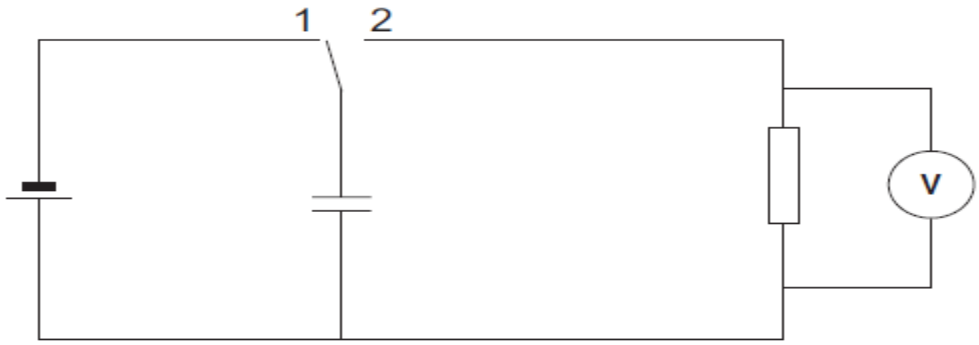
d.c. power supply
Voltmeter (multimeter set on d.c. voltage range or CRO) – resolution ± 0.01 V
Stopwatch – resolution - either ± 1 s or ± 0.01 s
4 mm leads
Suitable switches
Electrolytic capacitors e.g. 1 000 μF or 2 200 μF
Resistors e.g. 100 kΩ or other values

## Further Guidance for Technicians:

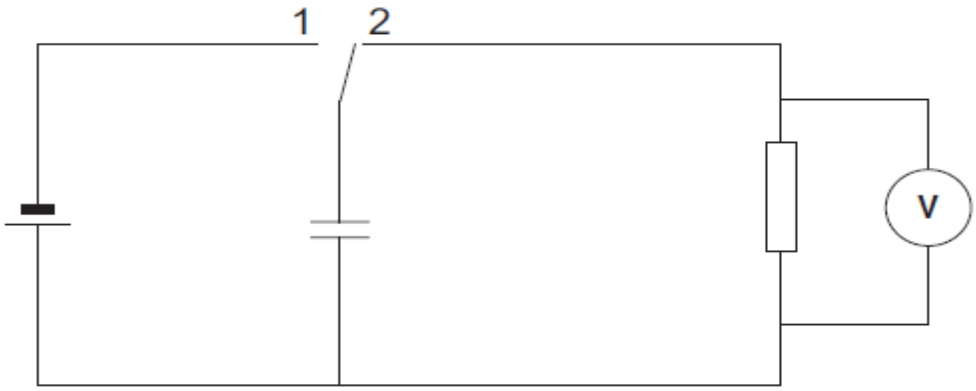
The polarity of the electrolytic capacitors should be indicated to learners so that the circuits can be set up correctly.

## Experimental method:

The following circuit can be used to investigate the *charging* of a capacitor:



The above circuit can then be re-arranged to investigate *the discharging* of a capacitor as follows:




*Charging the capacitor*:

Learners can set up the circuit from the above diagram and by using electrolytic capacitors the correct polarity connection needs to be checked by supervisors. The two way switch needs to be in position 1 so that the capacitor can be charged and then switched over to position 2 to discharge. Pre-trial readings can be taken to determine suitable time intervals.

*Discharging the capacitor:*

The method is similar to charging the capacitor. Initially the switch is to be left open and then connected so that the capacitor charges.

**Extension:**

The value of the capacitor could be hidden and the experimental set-up used to determine its value.

The equation ($t_{\frac{1}{2}} = 0.69RC$) i.e. the time taken for the voltage to fall to half its initial value could be investigated using the data obtained.

*Data Logging*: The voltage across the capacitor can be measured using a suitable voltage sensor.

**Practical Techniques:**

- Use signal generator and oscilloscope, including volts/division and time-base.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

**Relevant previous practical past papers:**

- PH6 2011 Experimental task