

Charge storage, energy and RC time constants

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

A capacitor discharging through a resistor loses voltage by the same fraction in equal intervals of time. In this lab you record the voltage every ten seconds, take logarithms and use the straight line to measure the time constant and test it against the value of RC.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.7.4

Aim

To measure how the voltage across a capacitor falls as it discharges through a resistor and to find the time constant from a straight-line graph of $\ln V$ against time.

Equipment

- electrolytic capacitor, 1000 μF , 16 V rating
- resistor, 22 k Ω
- 9 V battery or low-voltage supply
- digital voltmeter (input resistance 10 M Ω or more)
- stopwatch, switch and connecting leads

Safety

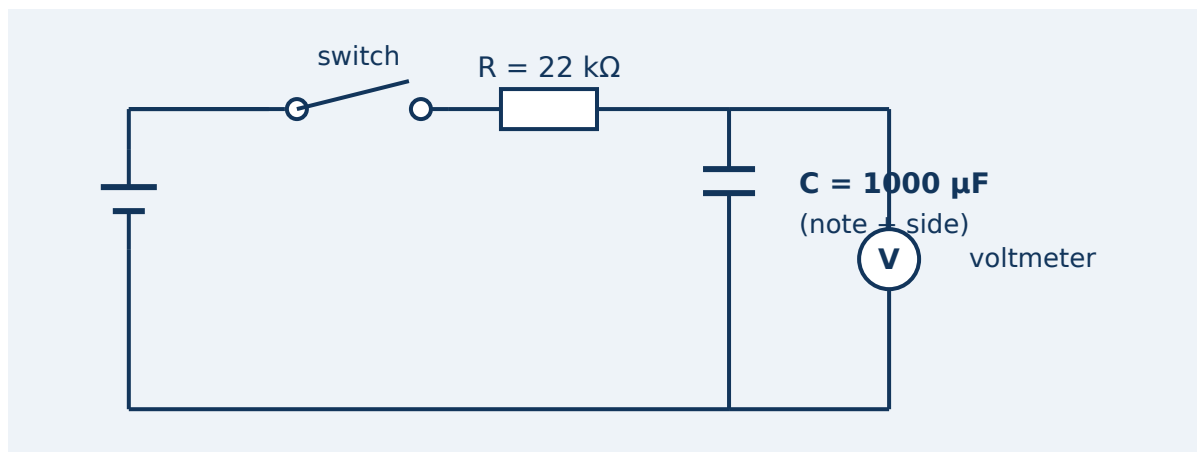
Safety

Electrolytic capacitors are polarised: connect the positive terminal to the positive side of the supply, and never exceed the voltage rating, because the capacitor can burst. Wear goggles and discharge the capacitor through the resistor before handling it.

Method

1. Connect the capacitor, resistor and battery in series with the switch, with the voltmeter across the capacitor.
2. Close the switch until the voltmeter shows about 9 V, then leave the capacitor fully charged.
3. Disconnect the battery so that the capacitor can discharge only through the resistor, and start the stopwatch.
4. Record the voltage every 10 s for 60 s.
5. Calculate $\ln V$ for each reading and plot $\ln V$ (vertical axis) against t .

6. Draw the line of best fit and find its gradient.



Charge the capacitor with the switch closed, then remove the battery from the loop and let the capacitor discharge through R .

Results

Sample measurements from one group:

Time t (s)	Voltage V (V)
0	9.0
10	5.9
20	3.9
30	2.6
40	1.7
50	1.1
60	0.7

Analysis questions

Question 1 Shape of the curve

Describe the shape of a graph of V against t for the sample data and state what it shows about the rate of discharge.

Question 2 Half the voltage

Use the data to estimate the time for the voltage to halve from 9.0 V, and relate it to the time constant using $t_{1/2} = \tau \ln 2$.

Question 3 Logarithm table

Calculate $\ln V$ for each reading and state why this graph is a straight line.

Question 4 Gradient and τ

Calculate the gradient of the $\ln V$ against t line using the first and last readings, and hence the time constant.

Question 5 Comparing with RC

Calculate the nominal RC value and the percentage difference from your measured time constant.

Question 6 Capacitor tolerance

Electrolytic capacitors have a typical tolerance of -20% to $+50\%$. Explain whether your result is consistent with the nominal value.

Question 7 Initial current

Calculate the current through the resistor at $t = 0$.

Question 8 Improving the method

Suggest two changes to make the measurements of τ more precise.