CAIE Physics A-level

19 - Capacitance

Flashcards

What is a capacitor?

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- A capacitor is an electrical component that stores charge on 2 separate metallic plates.
- An insulator, called a dielectric, is placed between the plates to prevent the charge from travelling across the gap.

What is capacitance?

What is capacitance?

The capacitance, C, is the charge stored, Q, per unit potential difference, V, across the two plates.

Therefore we have $C = Q / V$. It is measured in Farads, F ($1F = 1CV^{-1}$).

Using the equation for capacitance and your knowledge of the behaviour of current, voltage and resistance, provide an expression for capacitance in terms of resistance.

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$C = Q / V$ and $Q = It$, therefore $C \propto I / V$.

Ohm's law dictates that $R = V / I$, therefore:

$C \propto 1 / R$.

Using the relationship between capacitance and resistance derived, what is the equation for the total capacitance in series?

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$$R_{total} = R_1 + R_2 + \ldots + R_n$$

And C α 1 / R, so

$$1/C_{total} = 1/C_1 + 1/C_2 + \ldots + 1/C_n$$

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And C α 1 / R, so

$$C_{total} = C_1 + C_2 + \ldots + C_n$$

What does the area under the graph of charge against pd represent?

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The energy stored by the capacitor.

Draw a Q against t graph for the discharging of a capacitor through a resistor.

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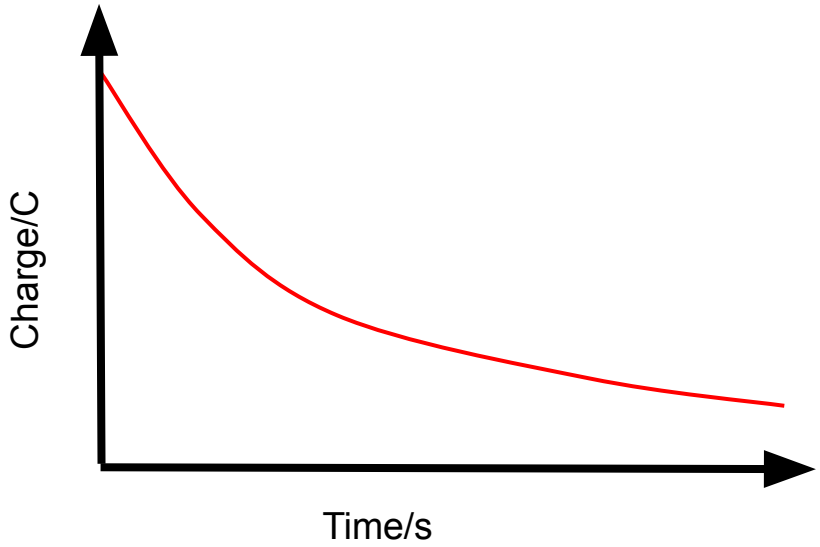

Draw a V against t graph for the discharging of a capacitor through a resistor.

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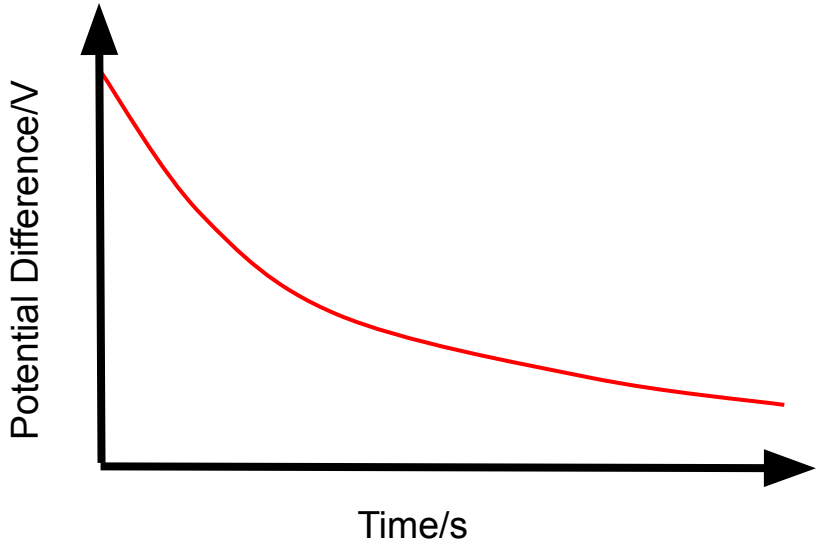
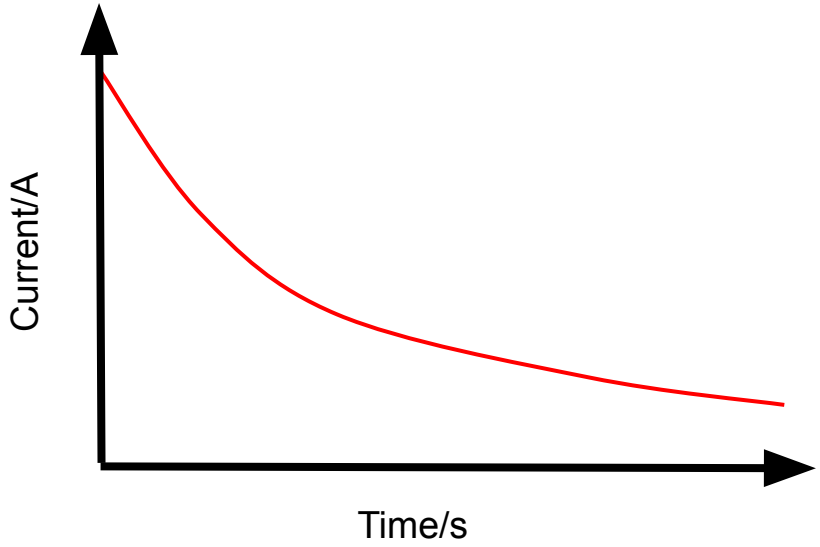


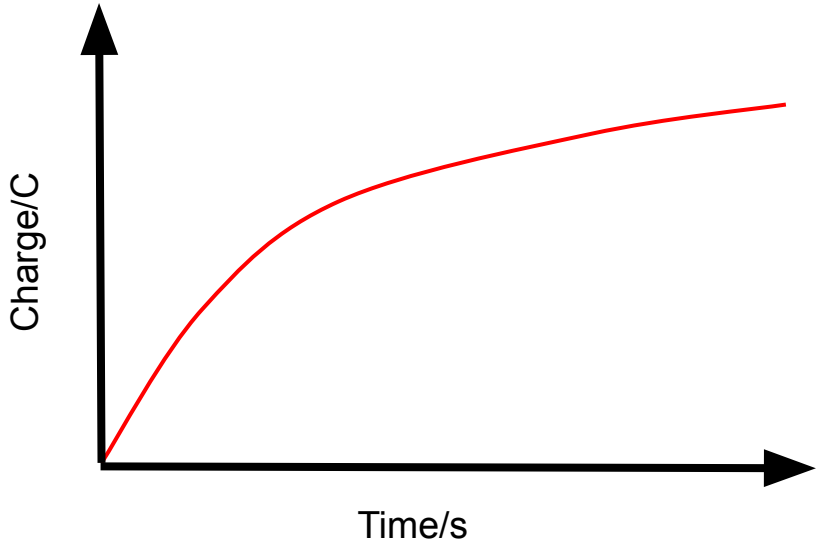
Draw an I against t graph for the discharging of a capacitor through a resistor.

Draw an I against t graph for the discharging of a capacitor through a resistor.



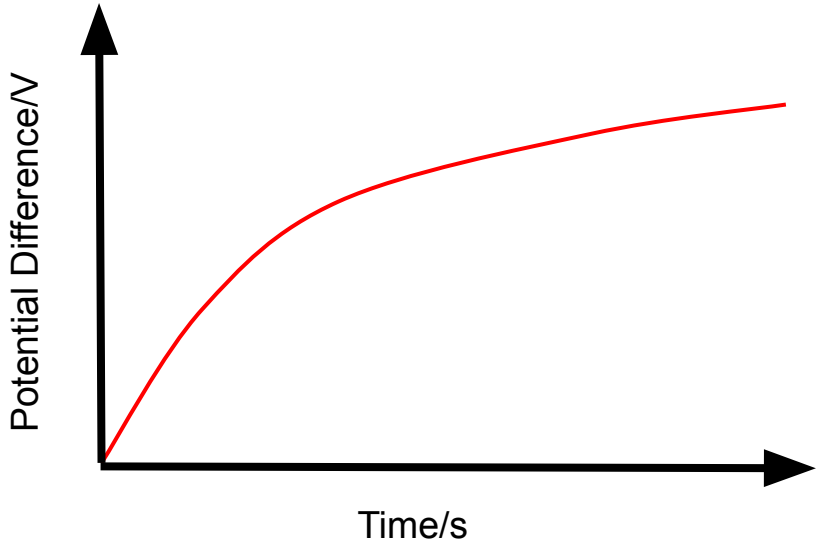
Draw a Q against t graph for the charging of a capacitor through a fixed resistor.

Draw a Q against t graph for the charging of a capacitor through a resistor.



Draw a V against t graph for the charging of a capacitor through a fixed resistor.

Draw a V against t graph for the charging of a capacitor through a resistor.



What is the time constant (τ)?

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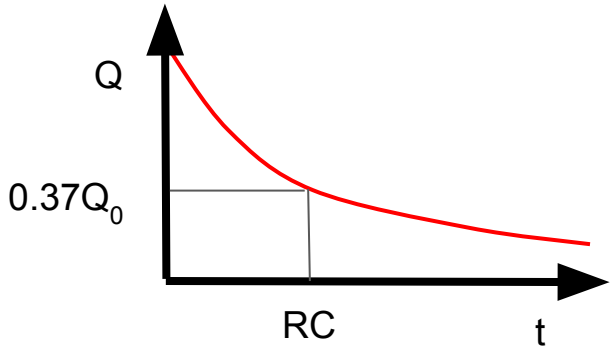
The time it takes for the charge in a capacitor to fall to 37% of its initial value (explained in the following slide) given by RC (resistance x capacitance) i.e. τ = RC . This is the same time it takes for a capacitor to charge to 63% of its maximum capacity.

A capacitor is considered fully discharged after 5 time constants.



How was 37% derived when using the time constant?

How was 37% derived when using the time constant?

- Start with the formula $Q = Q_0 e^{-t/RC}$
- When $t = \tau = 1 \times RC$ (after 1 time constant), the formula becomes $Q = Q_0 e^{-1}$
- $e^{-1} \approx 0.37$, which is where the 37% comes from.

What equations do we require to calculate the time constant for charging a capacitor?

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Charging up a capacitor produces $Q = Q_0(1 - e^{-t/RC})$ &

$V = V_0(1 - e^{-t/RC})$ where V_0 is the battery PD and $Q_0 = CV_0$.

How does a capacitor charge up?

How does a capacitor charge up?

1. Electrons move from negative to positive around the circuit.
2. The electrons are deposited on plate A, making it negatively charged.
3. Electrons travel from plate B to the positive terminal of the battery, giving the plate a positive charge.
4. Electrons build up on plate A and an equal amount of electrons are removed from plate B, creating a potential difference across the plates.
5. When the p.d across plates = source p.d., the capacitor is fully charged and current stops flowing.

Describe and explain in terms of the movement of electrons how the p.d across a capacitor changes, when it discharges across a resistor.

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1. Electrons move in opposite direction than when the capacitor was charging up.
2. Charge on one plate A decreases as it loses electrons, and plate B gains electrons, neutralising them.
3. P.d. decreases exponentially across the plates.

State some uses of capacitors.

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- Flash photography.
- Nuclear fusion.
- Backup power supplies.
- DC blocking.
- Smoothing AC to DC.
- Tuning (Resonating magnetic field).

State the 3 expressions for the energy stored/work done by a capacitor.

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$$E = \frac{1}{2}\left(\frac{Q^2}{C}\right) = \frac{1}{2}(QV) = \frac{1}{2}(CV^2)$$

What 2 factors affect the time taken for a capacitor to charge or discharge?

What 2 factors affect the time taken for a capacitor to charge or discharge?

- The capacitance of the capacitor, C. This affects the amount of charge that can be stored by the capacitor at any given potential difference across it.
- The resistance of the circuit, R. This affects the current in the circuit and how quickly it flows, hence how quickly the capacitor charges/discharges.