ScienceCube

Capacitor

Draw and explain the time variation of voltage and current during charging and discharging when a DC voltage is applied to a capacitor.

Fundamental Concept

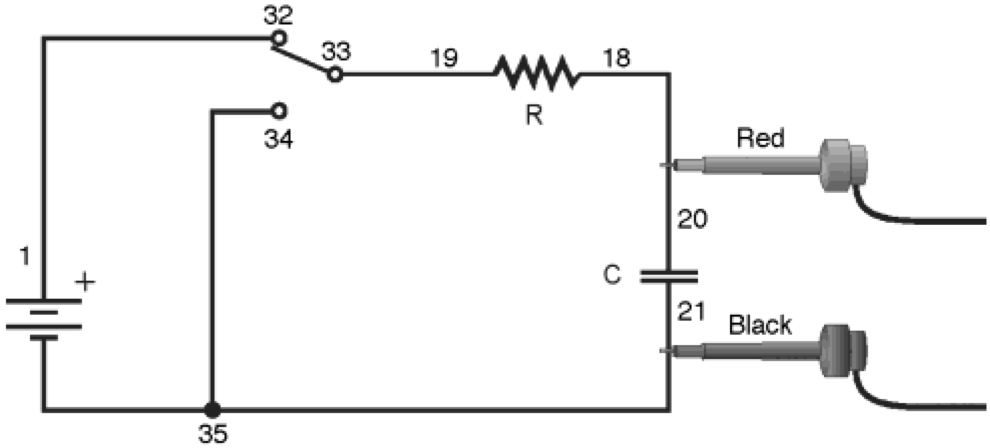
Capacitor

The charge q on a capacitor is proportional to the potential difference V across the capacitor.

$$V = \frac{q}{C}$$

Where VV is the potential difference, q is the charge, and C is the capacitance. The proportional constant C is called the capacitance of the capacitor, measured in farads (F).

If the capacitance C is charged by an initial potential difference $V0$ and connected to a resistor R, the current flows according to Ohm's law over time.



As current flows, the charge q decreases, and the potential difference across the capacitor decreases exponentially as it converts to current.

< Discharging of a Capacitor >

$$V(t) = V_0 e^{-\frac{t}{RC}}$$

Where V is the potential difference, $V0$ is the initial voltage, e is the base of the natural logarithm, t is time, and RC is the time constant.

The rate of decrease is determined by the time constant RC, and the larger the time constant, the slower the capacitor discharges.

When a capacitor is charged, the potential difference reaches the final value exponentially, expressed as follows:

< Charging of a Capacitor >

$$V(t) = V_0\left(1 - e^{-\frac{t}{RC}}\right)$$

(V: potential difference, V0: initial voltage, e: base of the natural logarithm, t: time, RC: time constant)

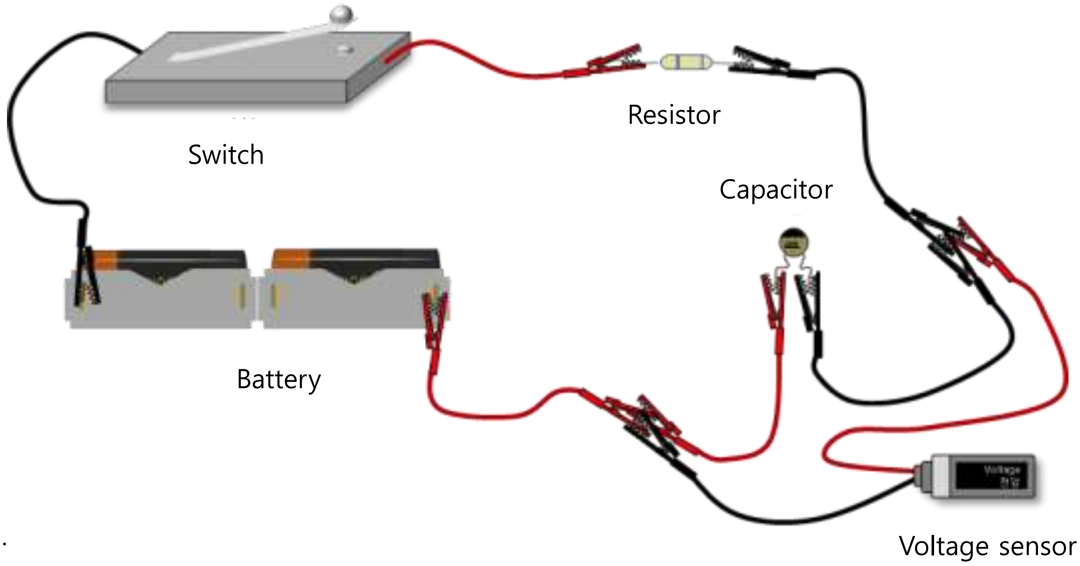
Experiment

Materials Needed

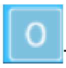
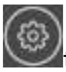
Interface, Science# Program, Voltage Sensor, Capacitors (10μF, 100μF), Resistors (1kΩ, 10kΩ), 1.5V Batteries (2), Switch, Clip Wires (4)

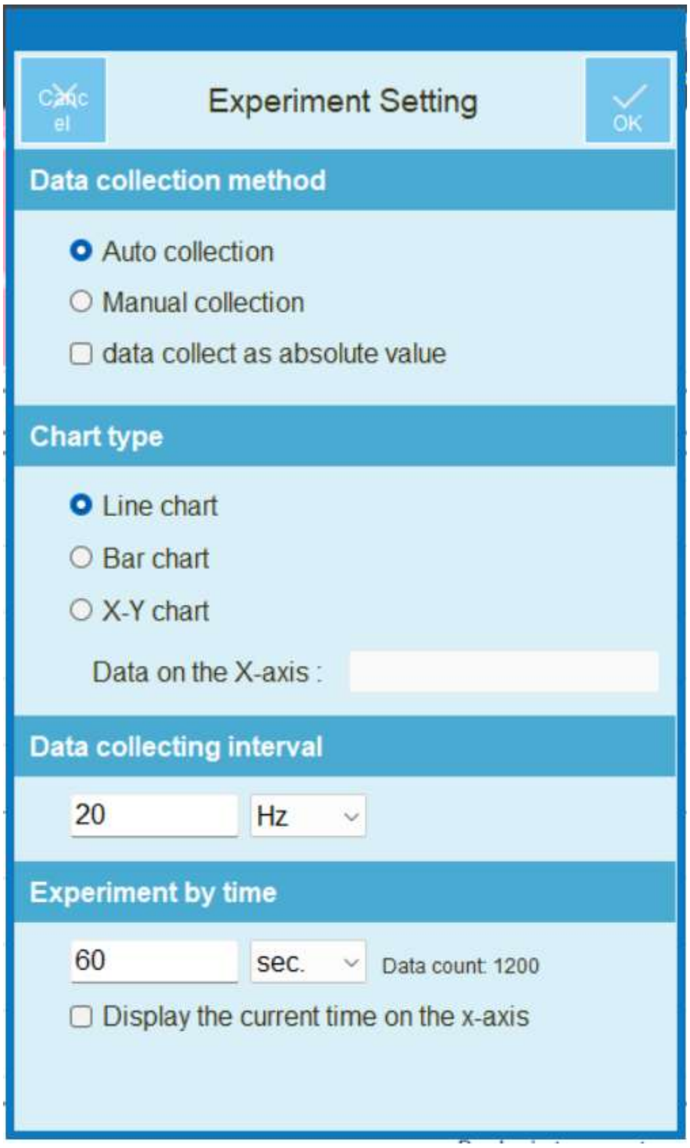
Preparation of Experimental Setup

1. Set up the circuit using a 10μF capacitor and a 10kΩ resistor as shown in the diagram.



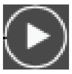
인터페이스 설정

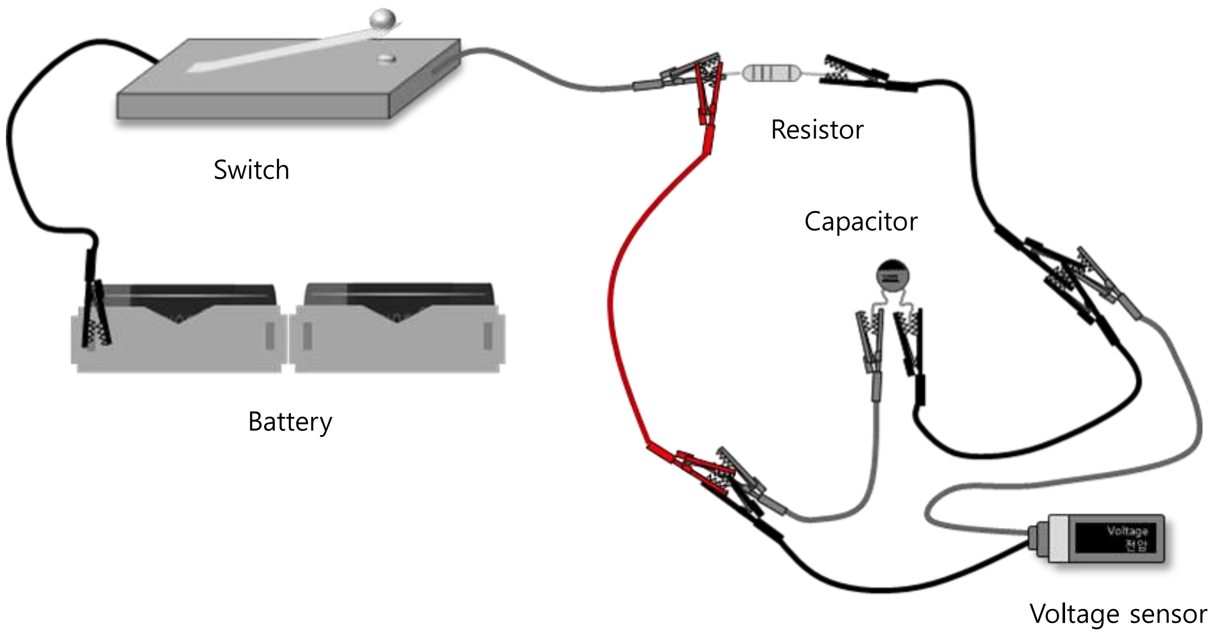
1. Launch the Science# program.
2. Connect the voltage sensor to the interface.
3. Press to calibrate the voltage sensor to 0.0V.
4. Set up the experimental environment as shown below, or use the automatic setting option. 



 Automatic setup

Data Collection

1.  Press to start collecting data.
2. Close the switch to charge the capacitor.
3. When charging is complete, move the clip wire from the battery to the resistor to discharge as shown below.



4. After discharging is complete, stop data collection and change the capacitor and resistor values as follows to draw the charging and discharging graphs:

   (10㎌, 1kΩ / 10㎌, 10kΩ / 100㎌, 1kΩ / 100㎌, 10kΩ)

Data Analysis

Recording Data

1. Note the capacitance and resistance used during the experiment and draw the charging and discharging graphs.

   [Experiment 1] Resistor: 1kΩ, Capacitor: 10μF

[Experiment 2] Resistor: 10kΩ, Capacitor: 10μF

[Experiment 3] Resistor: 1kΩ, Capacitor: 100μF

[Experiment 4] Resistor: 10kΩ, Capacitor: 100μF

2. Charge and discharge the capacitor with different resistor and capacitor values. Complete the table below.

Category	Resistor (kΩ)	Capacitor (μF)	RC (Resistor x Capacitor)	Charging Time (s)	Discharging Time (s)
Experiment 1	1	10			

Experiment 2	10	10			
Experiment 3	1	100			
Experiment 4	10	100			

Data Application

1. Explain the relationship between the size of the resistor and the charging/discharging time.

2. Explain the relationship between the capacitance of the capacitor and the charging/discharging time.

Extension Activities

1. Predict how the charging and discharging time will change if the number of batteries is reduced, lowering the voltage.

2. Research different types of capacitors and describe their characteristics..