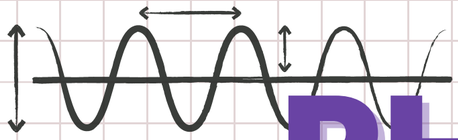


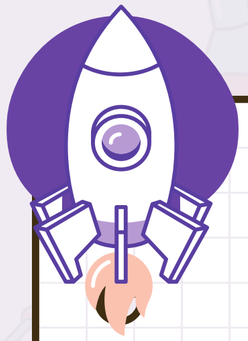
$$F=\frac{Gm_1m_2}{r^2}$$

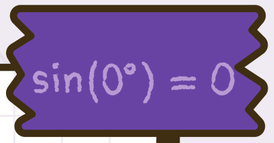
PHYSICS INVESTIGATORY PROJECT

$$E=m.c^2$$

2025-2026

$$K\mathcal{E}=\frac{1}{2}mv^2$$



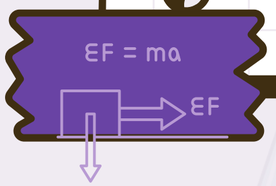


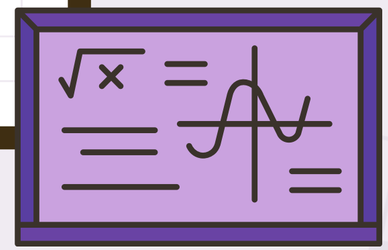
Certificate

This is to certify that the investigatory project titled "Comparative Study: Supercapacitor vs Battery (Charge and Discharge Analysis)" has been successfully completed by **Rajshree Routh** of Class XII-B under the guidance of the Physics department for the academic session 2025-26.

Teacher's Signature:_____

Date:





Acknowledgement

I sincerely thank my Physics teacher, Mr. **Mriganka Chatterjee** for guiding me throughout the course of this project. His valuable insights, constant encouragement, and support enabled me to conduct this experiment successfully. I also express gratitude to my parents and friends for their help, and to my school for providing resources.

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Teacher's Signature :_____

Objective

This project aims to **experimentally compare the voltage-time behavior of a supercapacitor** and **a battery** during both **charging** and **discharging cycles**, to evaluate their performance and applications.

Super capacitor

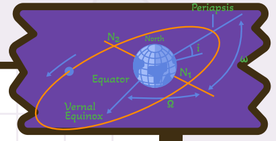
Battery

Introduction

Energy storage systems power everything from phones to electric vehicles. As technology advances, the need for efficient and fast-charging storage grows. Batteries, like lithium-ion, store large amounts of energy chemically but charge and discharge slowly. Supercapacitors store energy electrostatically, allowing rapid charge–discharge cycles and long life, though with lower total energy capacity.

The project is based on the following key scientific principles :

Principles

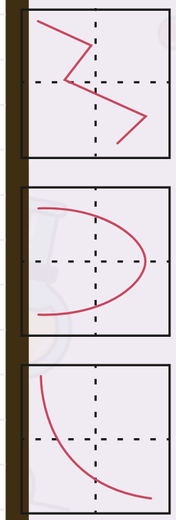


01 **Capacitor Charging Law:** The voltage across a capacitor charging through a resistor follows an exponential function, characterized by the time constant $\tau = RC$.

02 **Electrochemical Reactions:** Batteries store and release energy through reversible chemical reactions, influencing their charging behavior and discharge efficiency.

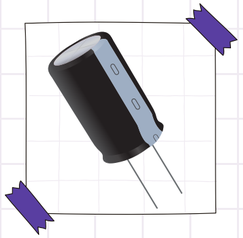
03 **Ohm's Law:** Voltage, current, and resistance in the circuit obey the fundamental relation $V = IR$, which is critical in interpreting experimental data.

04 **Energy Storage Mechanisms:** Capacitors store energy electrostatically, whereas batteries store it chemically, leading to different efficiencies and power handling characteristics.



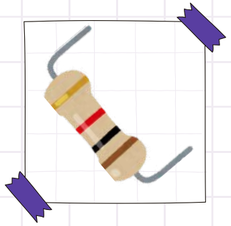
W=F×S

Apparatus required

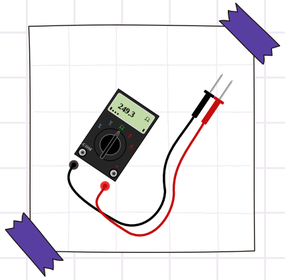


Supercapacitor (1F, 5.5V)

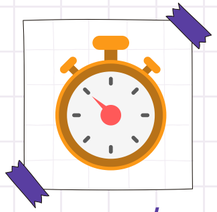
Rechargeable Li-ion Battery (3.7V)



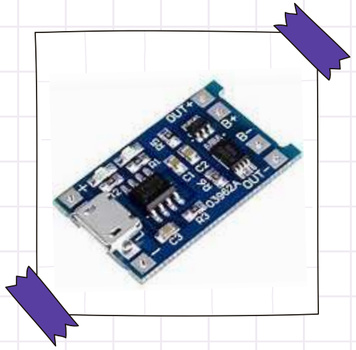
Resistors (10Ω, 75Ω, 82Ω, 100Ω)



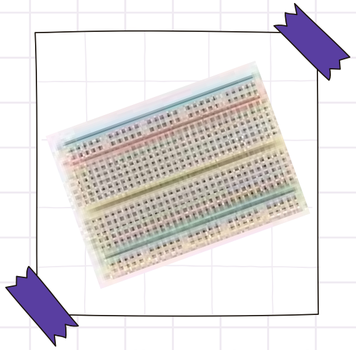
Multimeter



Stopwatch/timer



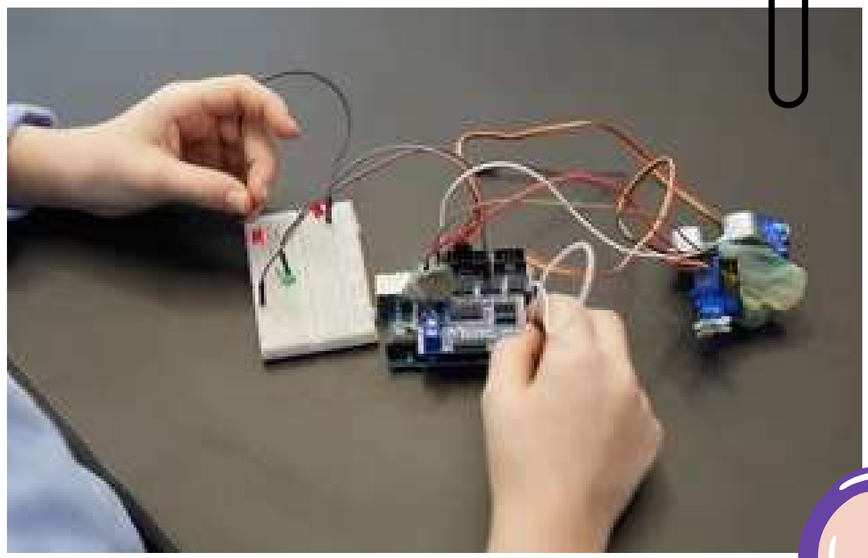
TP4056 Battery charging module



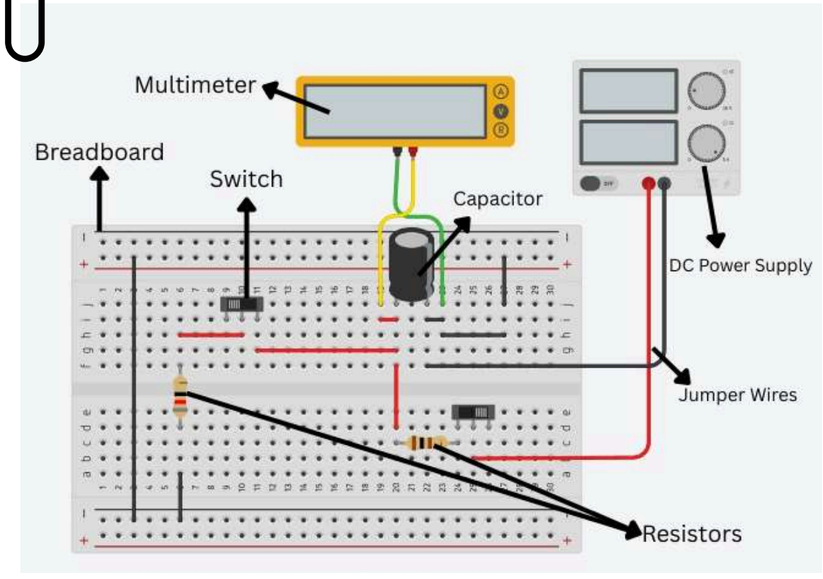
Breadboard and connecting wires.
5V power supply or battery bank

Experimental Setup

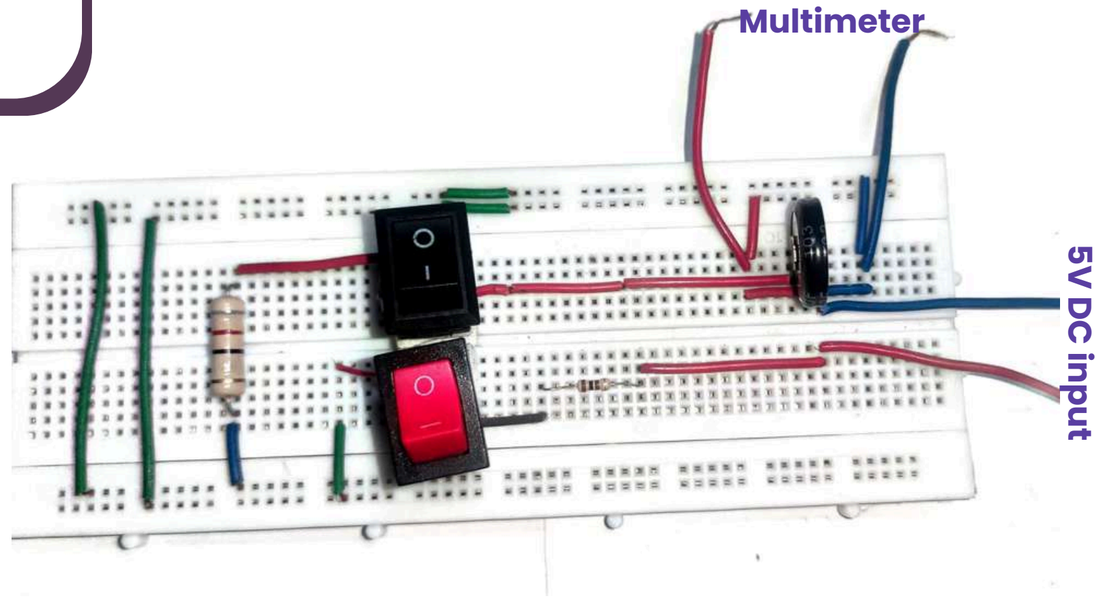
- Connect the supercapacitor to a 5V supply through a resistor.
- Measure voltage across the capacitor in intervals using a multimeter.
- Stop when voltage nears 5V (fully charged).
- Disconnect the supply and connect a load resistor.
- Measure voltage during discharge in intervals as well.
- Repeat the process for the rechargeable battery.



Circuit diagram of capacitor



Real circuit of capacitor

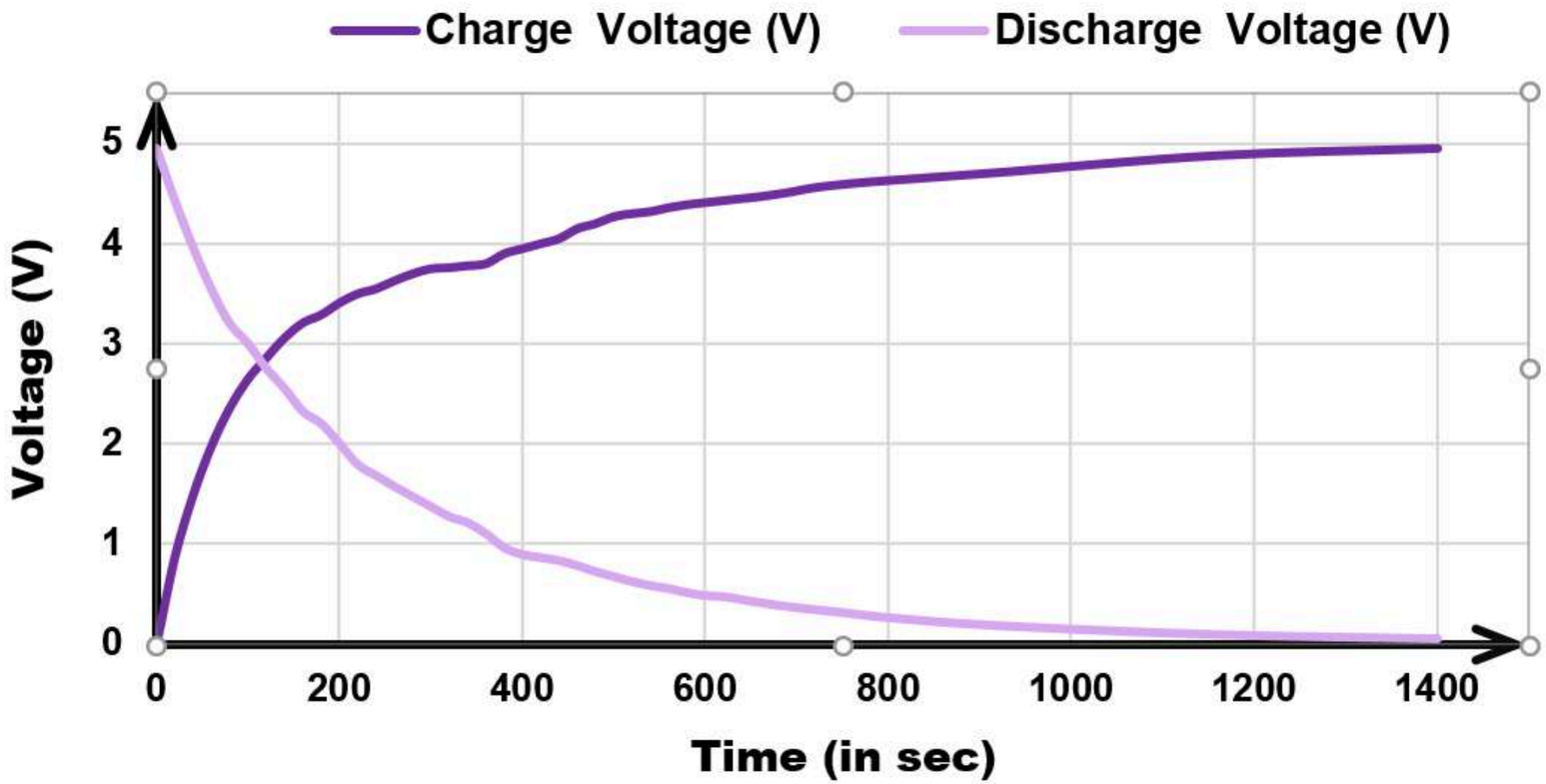


Observation Table

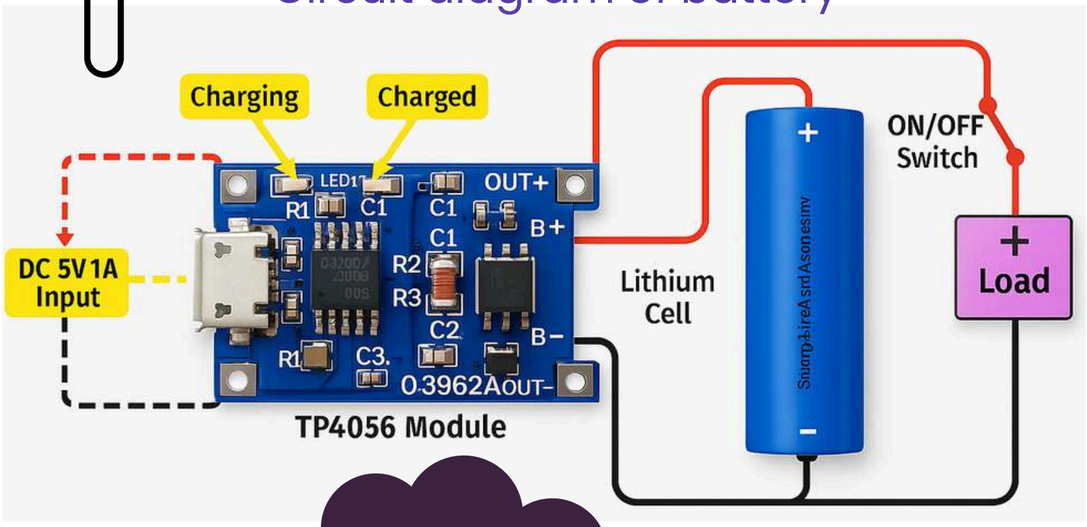
Time (sec)	Charge Voltage (V)	Discharge Voltage (V)
0	0	4.95
40	1.49	3.96
80	2.36	3.2
120	2.86	2.75
160	3.21	2.32
200	3.41	2
240	3.55	1.68
280	3.7	1.47
320	3.76	1.27
360	3.8	1.1

Time (sec)	Charge Voltage (V)	Discharge Voltage (V)
400	3.95	0.89
440	4.05	0.83
480	4.2	0.72
520	4.3	0.62
560	4.36	0.55
600	4.41	0.48
640	4.45	0.44
760	4.6	0.34
920	4.71	0.18
1400	4.95	0.05

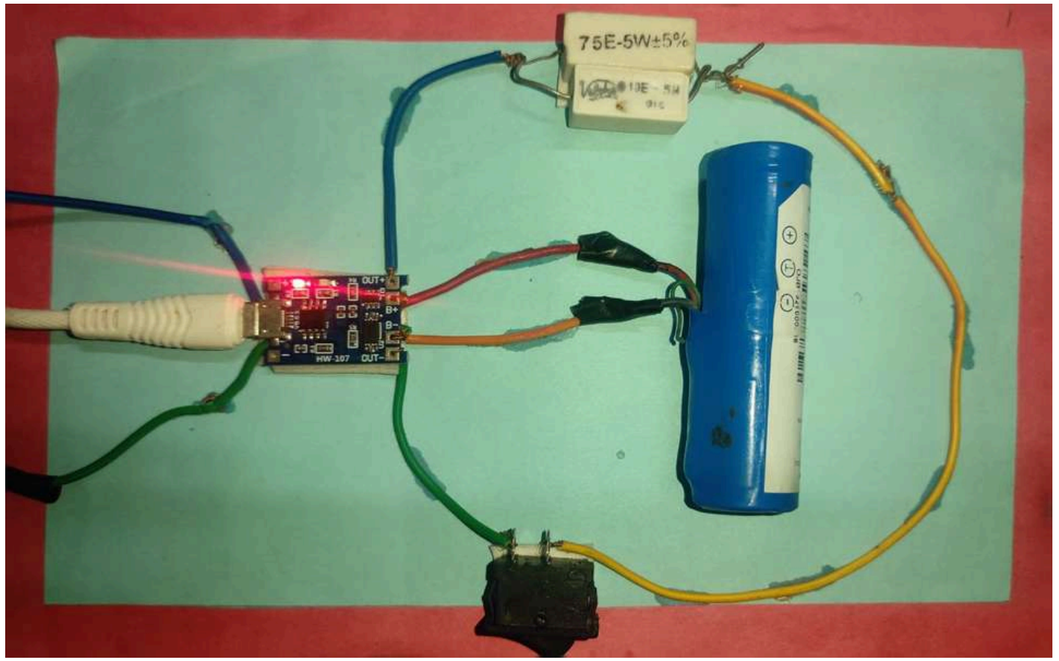
Characteristics graph of capacitor



Circuit diagram of battery



Real circuit of battery

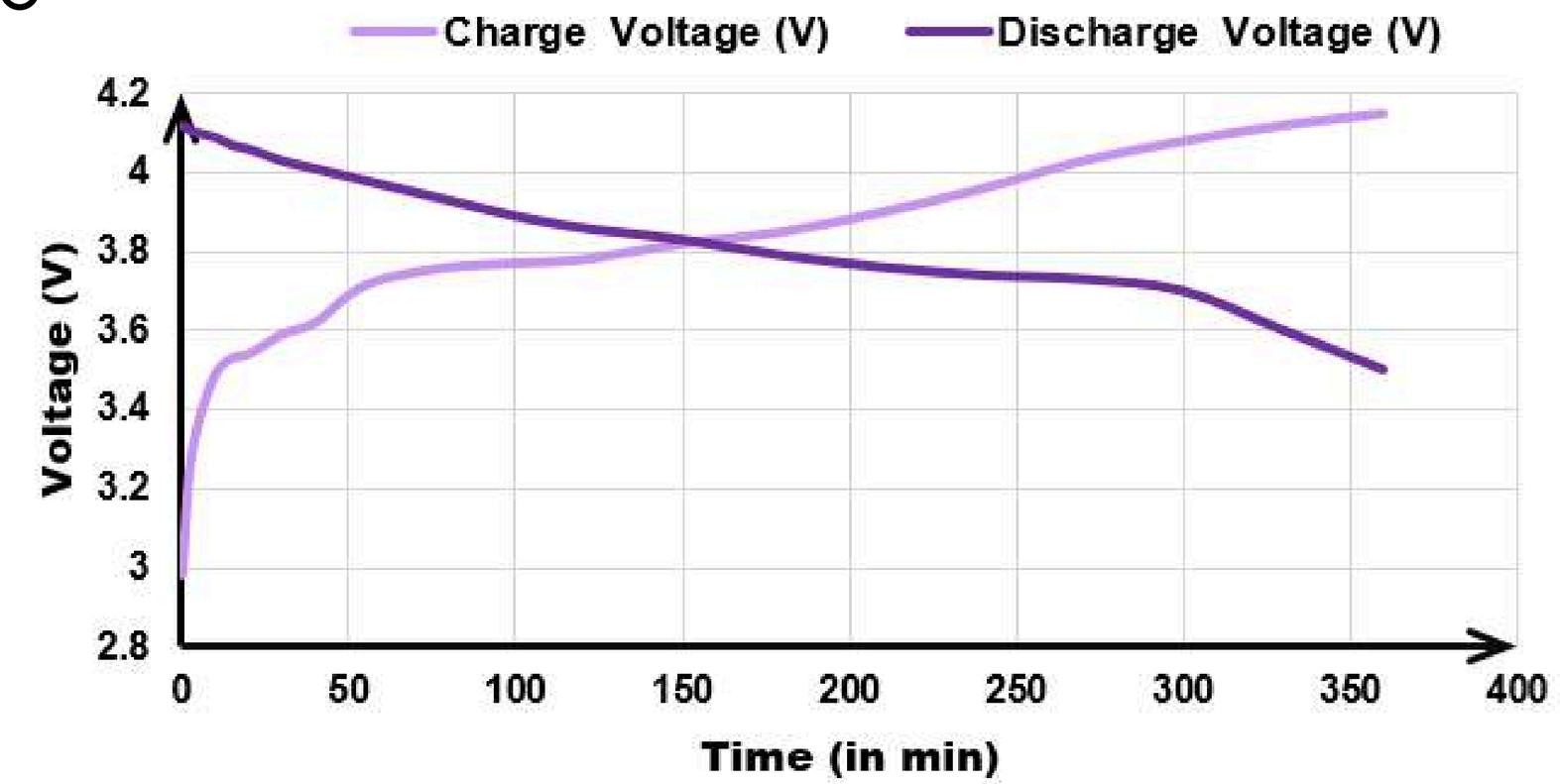


Observation Table

Time (min)	Charge Voltage (V)	Discharge Voltage (V)
0	2.98	4.12
2	3.23	4.11
5	3.37	4.1
10	3.49	4.09
15	3.53	4.07
20	3.54	4.06
30	3.59	4.03
40	3.62	4.01
50	3.69	3.99
60	3.73	3.97

Time (min)	Charge Voltage (V)	Discharge Voltage (V)
80	3.76	3.93
100	3.77	3.89
120	3.78	3.86
150	3.82	3.83
180	3.85	3.79
210	3.9	3.76
240	3.96	3.74
270	4.03	3.73
300	4.08	3.7
330	4.12	3.6
360	4.15	3.5

Characteristics graph of battery



Results

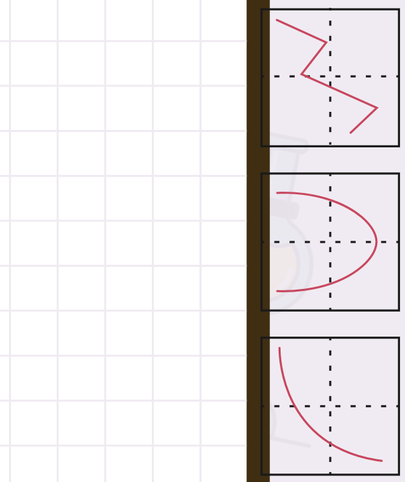
Through experimental data, it was observed that

01 The supercapacitor charged up to near its maximum voltage within a very short time (depending on resistance).

02 The battery took significantly more time to reach its full voltage.

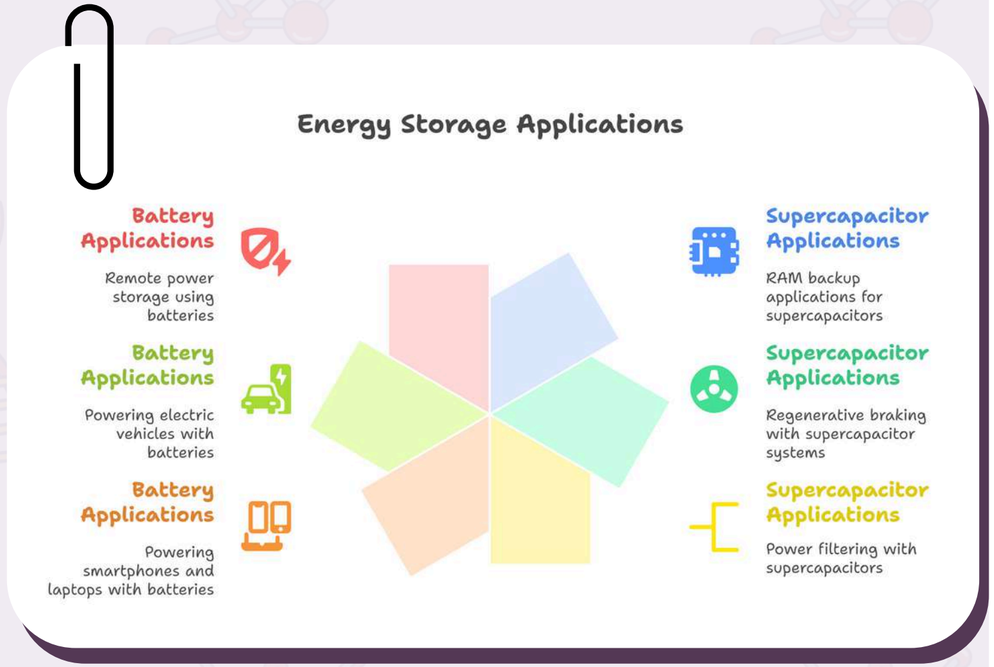
03 During discharge, the supercapacitor's voltage dropped rapidly.

04 The battery maintained a more constant voltage during discharge.



This demonstrates the faster power handling capability of supercapacitors compared to batteries.

W=F×S



Applications

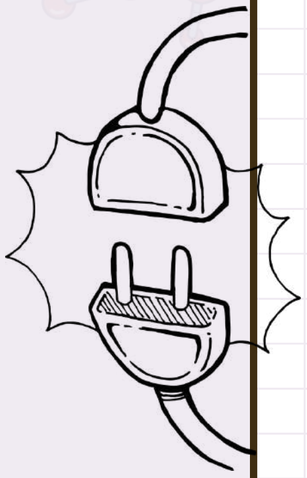
Supercapacitors:

- RAM backup
- Regenerative braking systems
- Power filtering

Batteries:

- Smartphones and laptop
- Electric vehicles
- Remote power storage

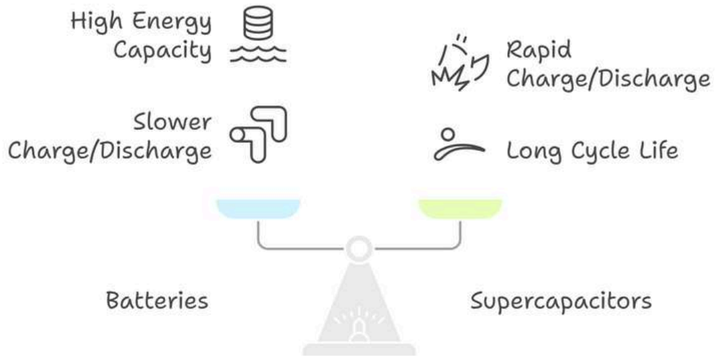
Conclusion



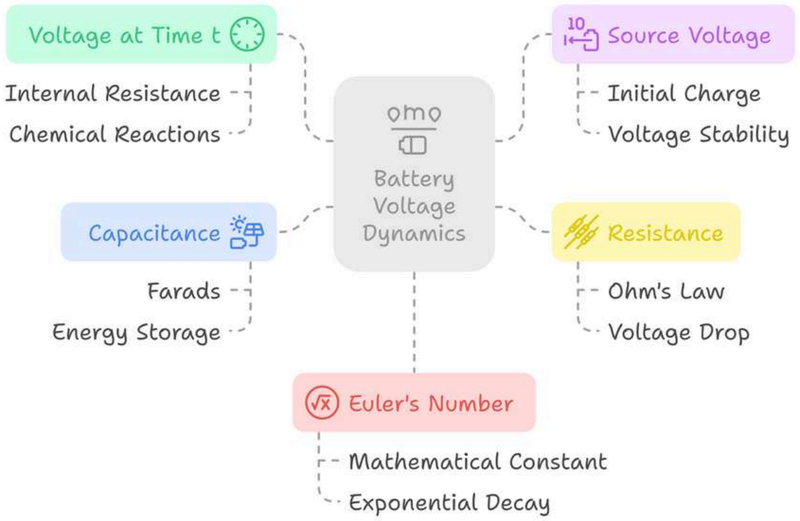
- From the detailed experimental analysis and observations, it is evident that supercapacitors and batteries operate on fundamentally different principles and exhibit distinct behaviors during charging and discharging cycles.
- Supercapacitors demonstrated rapid energy intake and release, which makes them extremely efficient for high-power, short-duration applications such as regenerative braking or quick energy bursts. However, their limited energy storage capacity restricts them from being used as the sole energy source for long-term usage.
- Batteries, in contrast, showcased a slow and steady charge and discharge pattern, indicating their suitability for applications that require consistent energy supply over longer periods, such as mobile phones, laptops, and other portable electronics.
- Hence, the experiment not only affirmed the theoretical expectations but also emphasized the importance of selecting the appropriate energy storage solution depending on the application. In real-world designs, a hybrid system using both components can offer the best of both worlds—quick response and sustained energy.

Illustrations

Comparing Energy Storage Technologies



Battery Voltage Dynamics and Discharging Characteristics



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