CAPACITORS

PART ONE

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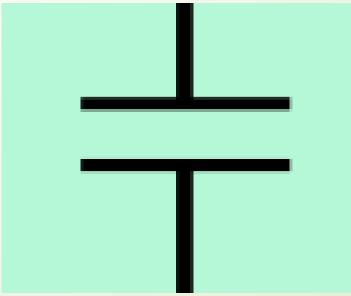
CAPACITORS

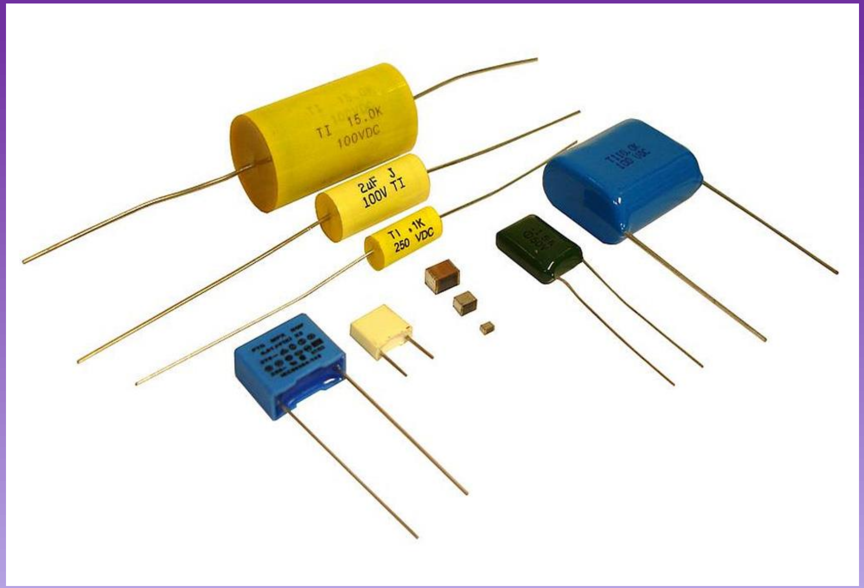
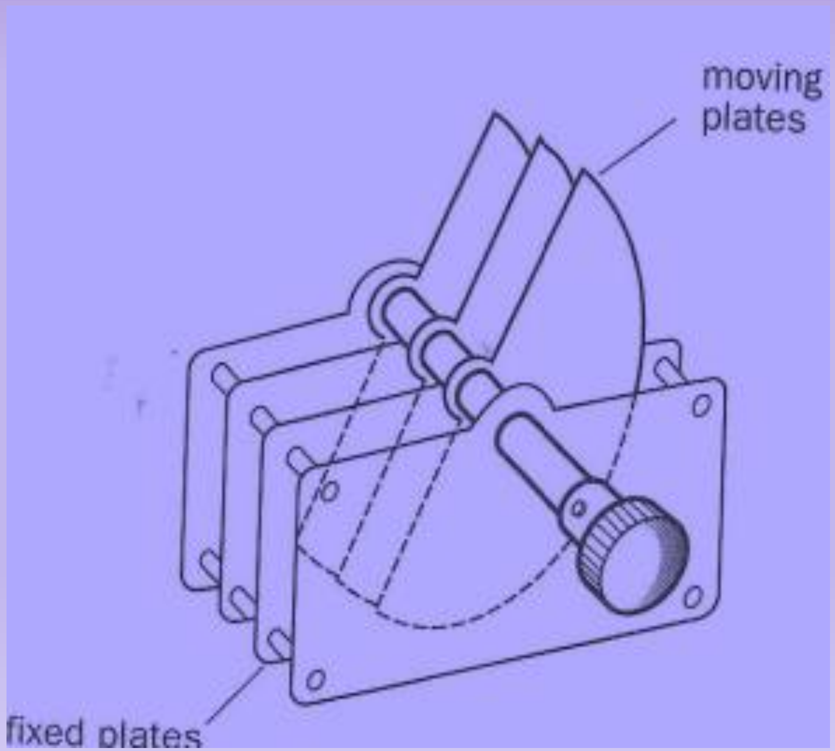
A **capacitor** is a device which stores **charge**

A capacitor consists of a pair of oppositely charged ***plates*** separated by an insulator called a **dielectric.**

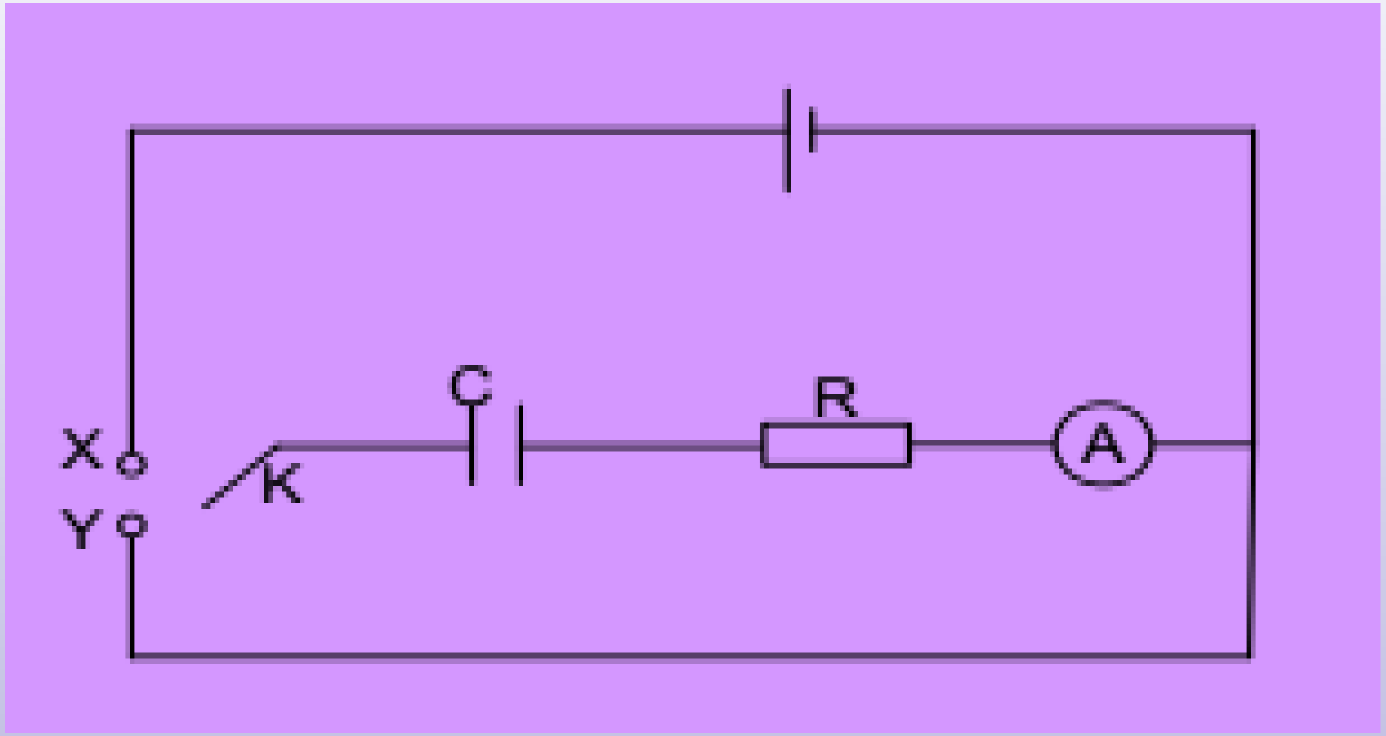
A **dielectric** is an insulator which breaks down when the potential difference is very high, the dielectric is can be air, oil, glass or a paper

The symbol of a capacitor is




nichicon
4700µF 35V
100µF 16V
SPRAGUE
VITAMIN Q
T.M.REG.U.S.PAT.OFF.
CAPACITOR
22-400 D.C.
196P22404T16
35V 470µF
189-505-5
193-10 8216
4.7µF 35V
103K
500V
224K
100V
561
10
151
15
7
22µF 35V

TI 15.0K
100VDC
2µF J
100V TI
TI .1K
250 VDC

moving plates
fixed plates

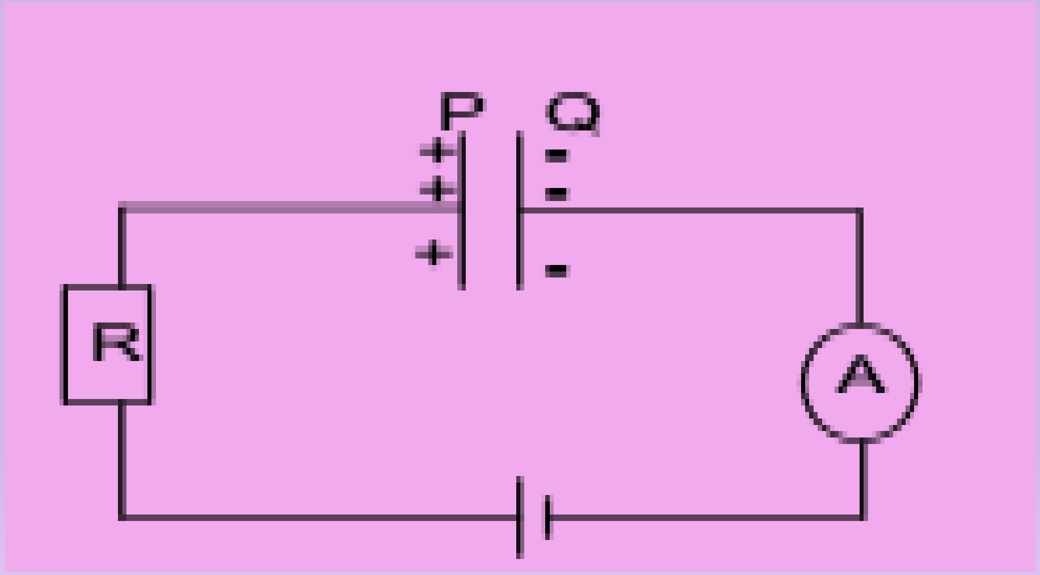
Charging and Discharging process



- When switch k is brought to contact x, capacitor, C charges. Current flowing through the ammeter is initially high but slowly comes to zero with time when the capacitor is fully charged.

- If switch k is brought in contact with y, capacitor C is discharged.
- The current is high but eventually comes to zero and in opposite direction to that when the capacitor is being charged.

Explanation of charging process.

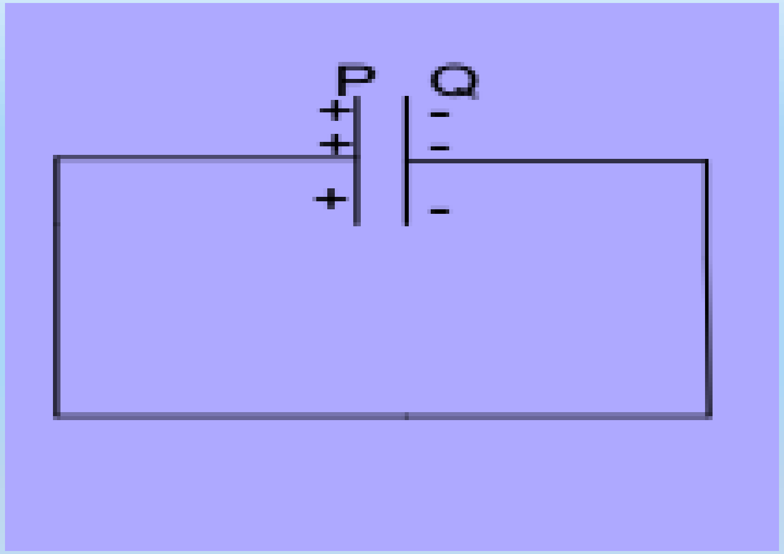


- ✓ When the capacitor is connected to a battery, electrons flow from the negative terminal of the battery to the adjacent plate of the capacitor and at the same rate electrons flow from plate P of the capacitor towards the positive terminal of the battery leaving positive charges at P.
- ✓ Positive and negative charges therefore appear on the plate and oppose the flow electrons that cause them .
- ✓ As charge accumulates the p.d between the plates increase and charge current falls to zero when the p.d between the plates of the capacitor is equal to battery voltage

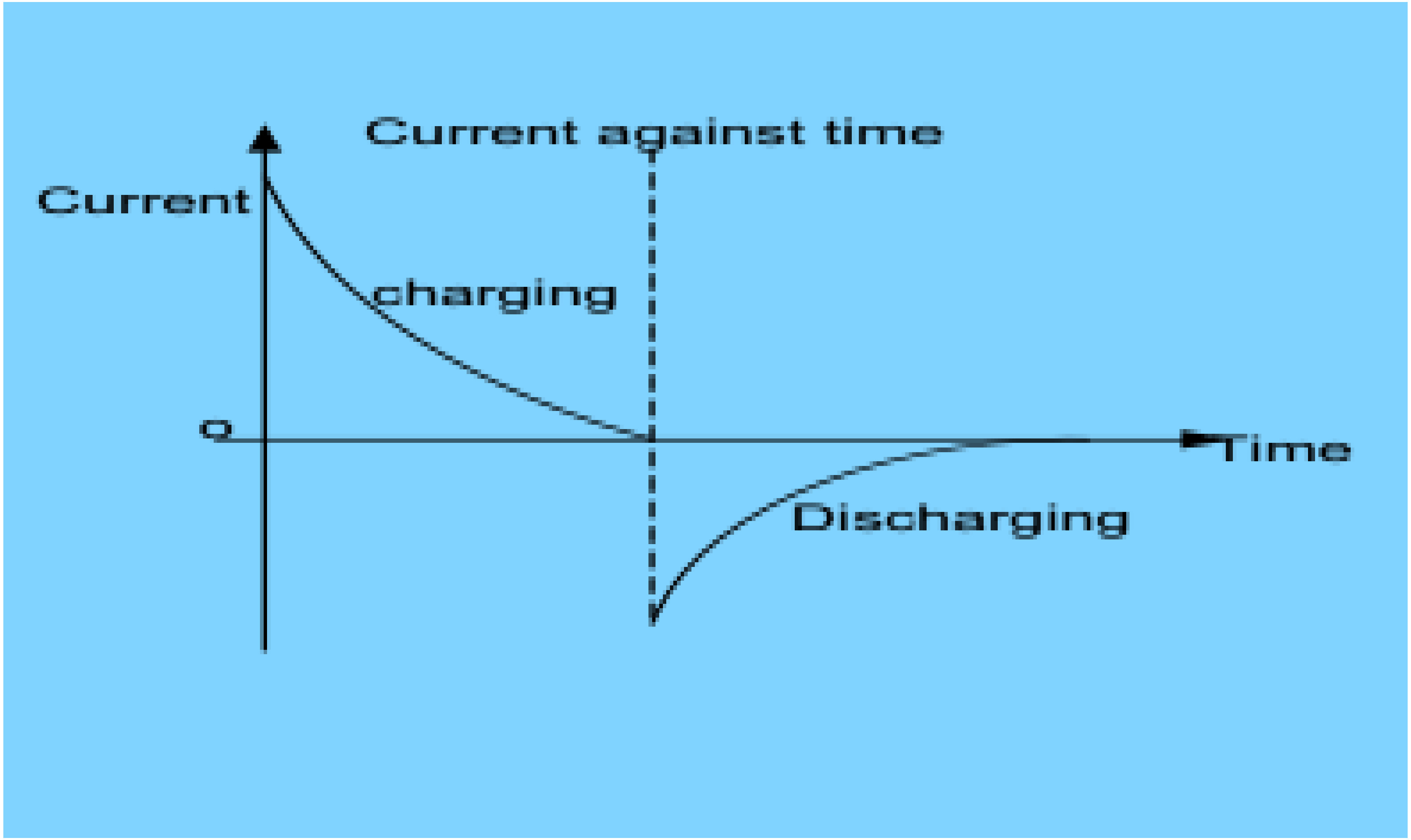
Explanation of discharging process.

A wire is connected from the positive plate to the negative plate Electrons flow form the negative plate to positive plate through wire until the p.d is zero.

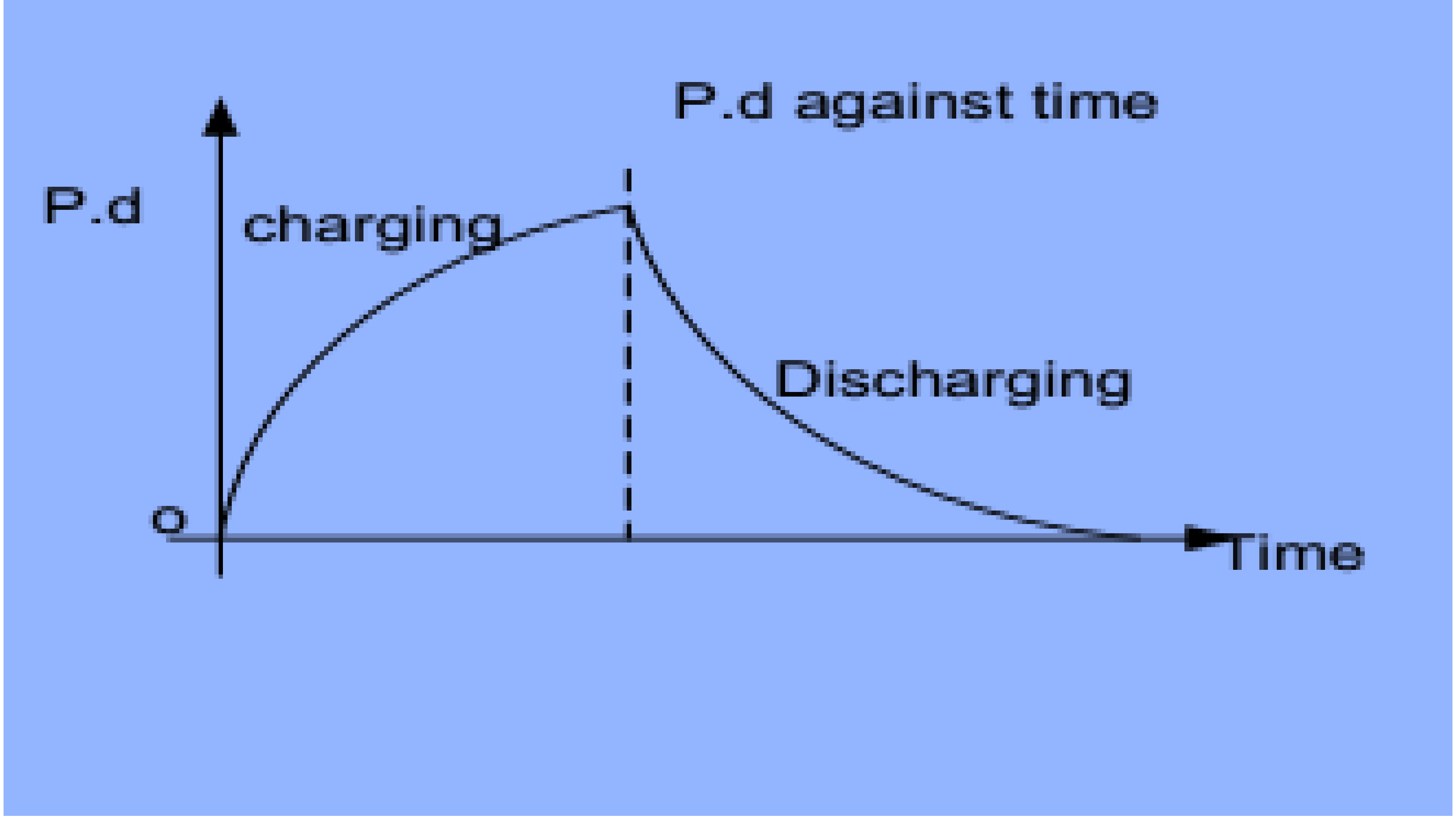
The capacitor is fully discharged



https://youtu.be/X5bzjs3ByBU



Current against time
Current
charging
0
Time
Discharging



https://youtu.be/6vX2ZIQzxmQ

Note

Energy changes in charging a capacitor include Chemical energy is changed to heat and electrical energy which is stored in the plates of the capacitor.

Capacitance of capacitor

This is the ratio of the magnitude of charge on either of the plates of a capacitor to the p.d between the plates of the capacitor.

$$\mathbf{C} = \frac{Q}{V}$$

The S.I unit of capacitance is **farad**, F

Definition

The farad is the capacitance of the capacitor when one coulomb of charge changes its potential difference by one volt.

Capacitance of a parallel plate capacitor.

Consider two parallel plate of capacitors each having charge Q and an area A separated by a distance d by a dielectric of permittivity .

Total electric flux ? through the surface is given by:

$$\emptyset = AE \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where E is electric field intensity .

From Gauss law $\emptyset = \frac{Q}{\varepsilon} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$

Equating (1) and (2) $\frac{Q}{\varepsilon} = AE.$

$\boldsymbol{But}\ \mathbf{E} = \frac{V}{d}$

$$\frac{Q}{\varepsilon} = A\frac{V}{d}$$

$$\frac{Q}{V} = \frac{\varepsilon A}{d}$$

$$C = \frac{\varepsilon A}{d}$$

For **parallel** plate capacitor placed in vacuum or air

$$C = \frac{\varepsilon_0 A}{d}$$

Example

1. Calculate the capacitance of a parallel capacitor whose plates are 10 cm by 10 cm separated b an air gap of 5 mm.

2. A parallel plate capacitor consists of two separate plates each of size 25cm and 3.0mm apart. If a p.d of 200V is applied to the capacitor. Calculate the charge in the plates.

To be tried in class with the teacher.

Capacitance of an isolated sphere.

Consider an isolated sphere of radius r. If the conductor is given charge Q, then its $V = \frac{Q}{4\pi\varepsilon_O r}$

Where ε_0– is permittivity of free space

$$4\pi\varepsilon_0 r = \frac{Q}{V}$$

$$C = 4\pi\varepsilon_0 r$$

Capacitance of concentric spheres

RELATIVE PERMITIVITY / DIELECRTIC CONSTANT

It is defined as the ratio of capacitance of a capacitor when the insulating material (dielectric) between its plates to the capacitance of the same capacitor with a vacuum between it plates,

$$\varepsilon_r = \frac{C}{C_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$c = \varepsilon_r c_o$$

But $C = \frac{\varepsilon A}{d}$ and $C = \frac{\varepsilon_0 A}{d}$ *put into* (2)

$$\varepsilon_r = \frac{\frac{\varepsilon A}{d}}{\frac{\varepsilon_0 A}{d}}$$

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\varepsilon = \varepsilon_o \varepsilon_r$$

Relative permittivity can also be **defined** as the ratio of the permittivity of a material to permittivity of free space

DIELECRTIC STRENGHT

It is the maximum electric field intensity an insulator can with stand without conducting

Or

Is the maximum potential gradient an insulator can with stand without conducting

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