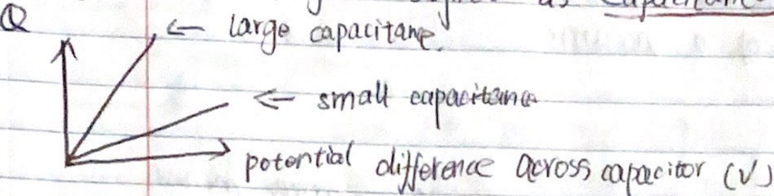
$F = \frac{kQ_1Q_2}{r^2}$ $k = \frac{1}{4\pi\varepsilon_0} = 9.0\times10^9$

Capacitors

- Capacitors are fundamental component used in a variety of electronics applications are used to store energy and charge in form of electric field.

Ability to store charge is defined as Capacitance, C



$Q = CV$ where C is the capacitance of capacitor. (unit: f / farad)

※ $C = \frac{Q}{V}$ (C/V) = F (farad)

Ex. If a 22 μF capacitor is connected to a 10 V source, the charge is?

$Q = CV \therefore Q = 22\times10^{-6} \times 10\ V = 220\ \mu C$

Capacitance: Analogy: rubber bands in a bottle:

To ensure more charges/bands in bottle, either increase bottle size / capacitance, or increase the force / Voltage [$Q = C \times V$]

- Construction:
  - Composed of 2 conductive plates separator by an insulator.

  Capacitance increases with.
  - Increasing surface area of the plates
  - Decreasing the spacing between plates
  - Increasing the relative dielectric constant of the insulator between the 2 plates,

$C = k\varepsilon_0 \frac{A\ (m^2)}{d\ (m)}$ unit of $k\varepsilon_0$ (naught) (F/m) $k\varepsilon_0$ is called permittivity.

C directly proportional to relative dielectric constant and the plate area.

C is inversely proportional to the distance between the plates,

$\varepsilon_0 = 8.85\times10^{-12}\ C^2/N\cdot m^2$ / k varies with a minimum value of 1.

Relative Permittivity:

Permittivity: The ratio of the flux density to the electric field intensity in the dielectric: A measure of how easily the dielectric will "permit" the establishment of flux lines within the dielectric.

Relative Permittivity: Often called the dielectric constant, it's the ratio of the permittivity of any dielectric to that of a vacuum.

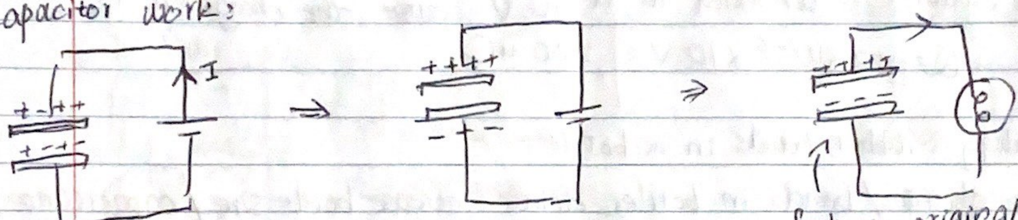
Circuit Symbols for Capacitors

← arrow means adjustable.

Fixed Capacitor

Variable capacitor.

Capacitor work:



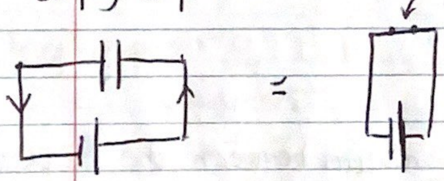
back to original state

Capacitors in circuits:

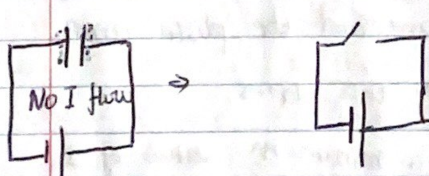
Steady states: full / empty

- Empty Capacitor.

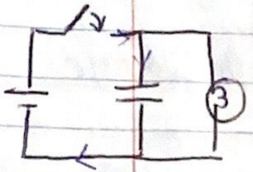
closed switch.



- Full Capacitor:

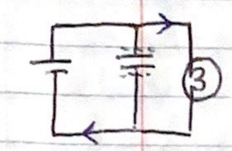


Ex. An empty capacitor is in the circuit below



when switch is closed, all current will go through the capacitor, lamp will not light up as no I will pass through

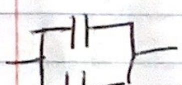
steady states.



When the capacitor is full after some time and cannot accept more charge, current will then flow through lamp instead.

In reality, the lamp will transition from dim to bright gradually.

In parallel Capacitors:

eg 

$C_T = C_1 + C_2$

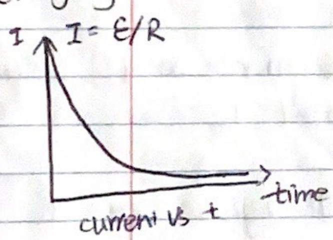
Think of it as making a bigger capacitor.

In series Capacitors:

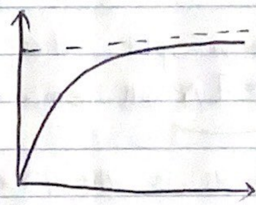
$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$$

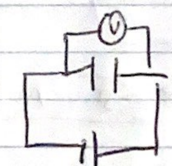
Transient Phase: A period of time transition from one steady to the other steady phase.

Charging Capacitor Graphs:

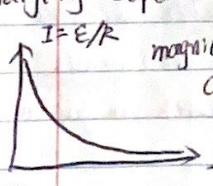


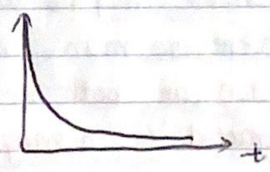
$Q = C\mathcal{E}$





Discharging Capacitor Graphs: $Q = C\mathcal{E}$





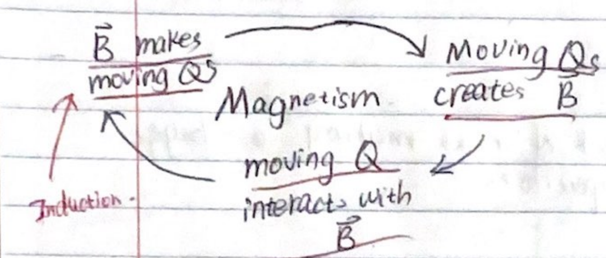
Capacitors in Circuits : RC circuit

$\tau = \Omega \cdot F$ $(R \times C)$ (unit in seconds / s)

- In series circuit, the charge on each capacitor stays the same, the voltage is different depending on its capacitance.
- In parallel circuits, the voltage across each capacitor is the same, the charge depends on its capacitance.

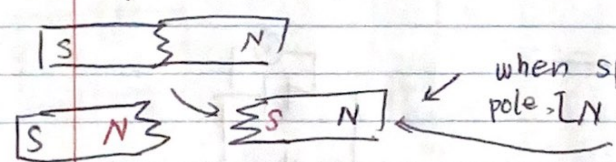
Magnetism

Q is charge $\vec{B}$ is magntism.



Most permanent magnets have iron in them are called ferromagnetic.

- Each magnet has two poles, North and South.
- Magnets always have North pole to Magnetic North : South to magnetic south.
- There're no magnetic monopoles - one cannot divide a magnet North and a South in isolation.
- Magnetic poles exhibit for interactions: Opposite poles attract and like poles repel.



when split, they still have north and south pole. [N will remain, S is created]

- A property shared by magnetic materials is the presence of small regions called Domains.
- Few elements exhibit magnetic properties in pure state: iron, nickle, cobalt, gadolinium and dysprosium. there are man-made magnetic materials.
- The domain model explains how iron can both be a magnet (with an active magnetic field), and magnetic (attracted to a magnet)