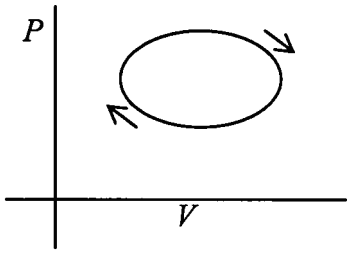
KIRCHHOFF'S RULES: PHYSICAL BASIS

Loop Rule: Change of potential between two points is independent of the path because potential is derived from potential energy and the latter is defined for a CONSERVATIVE force so net change of potential on a closed loop must be zero.

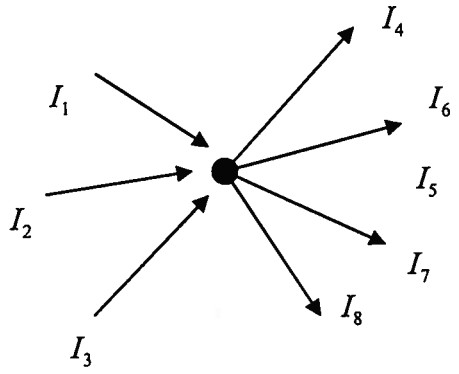
$$\sum_{LOOP} \Delta V_i \equiv 0$$

Potential at any point is unique!



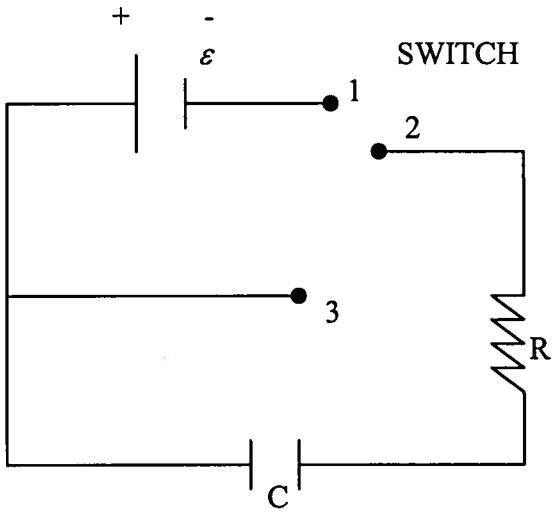
[Recall that in a Thermodynamic cyclic process $dU = 0$, Thermodynamic potential (Internal energy)]

Junction Rule: Flow of charge is continuous, i.e., apart from what is involved in setting up the original field to drive a current, there can be no continuous accumulation (depletion) of charge at junction consequently,
Current is flux of charge, charge is conserved hence charge flow per sec. out of function must be equal charge flow into function per sec.

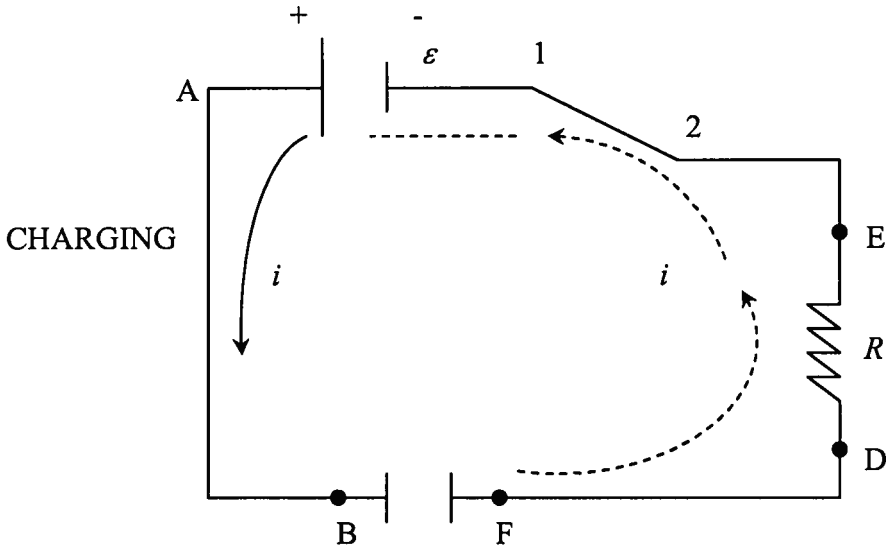


$$\Sigma\, I_{out} = \Sigma\, I_{in}$$

Next, put all 3-devices together in a Circuit:

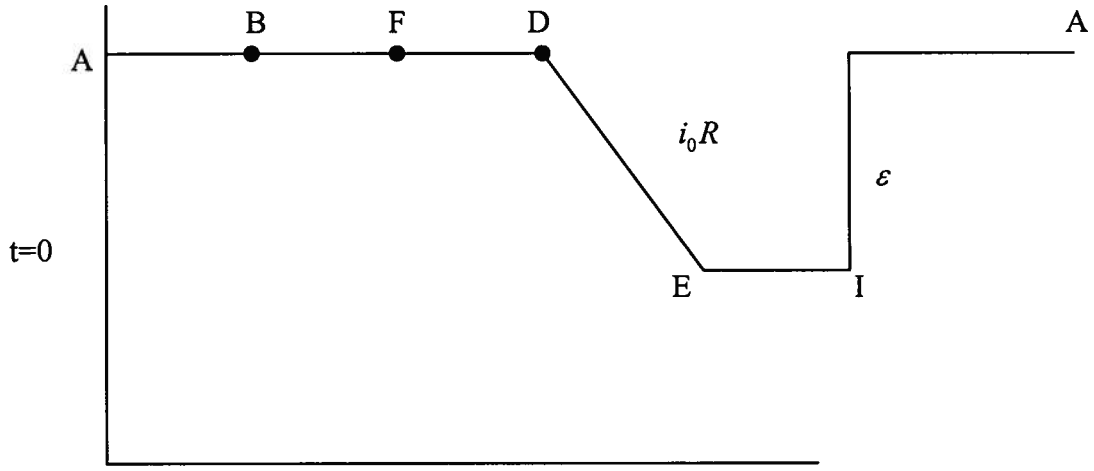


At t=0, connect 1 to 2: charge will flow from battery to capacitor plates.



NOTICE NO CURRENT IN CAPACITOR.

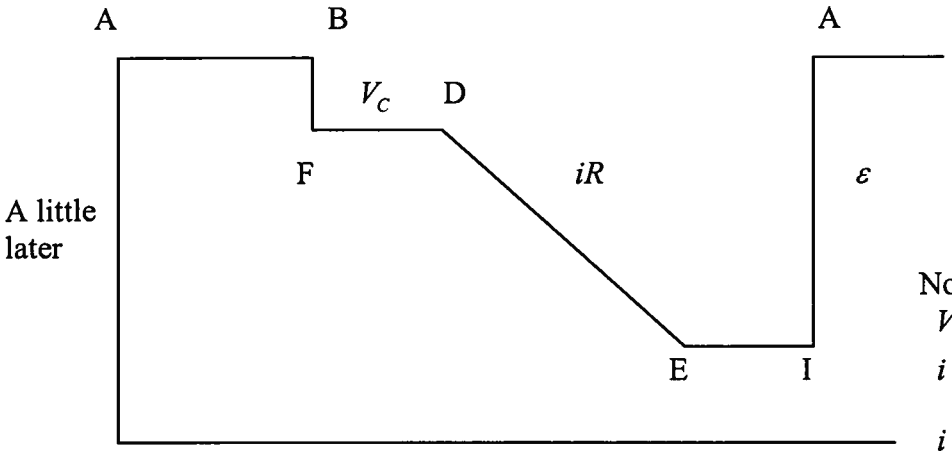
At t=0, no charge on C, $V_C = 0$, Potential at various points looks like



So $i_0 = \dfrac{\varepsilon}{R}$

That is, R limits the maximum current that can flow so it will take time to build up charge on C.

a little later C has $\overset{+}{q}\,|\;|\,\overset{-}{q}$, $V_C = \dfrac{q}{C}$, and the Potential becomes



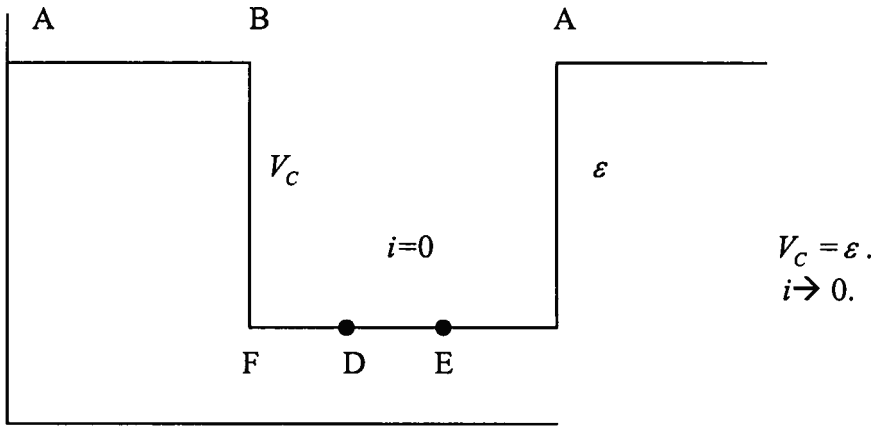
Now

$V_C + iR = \varepsilon$

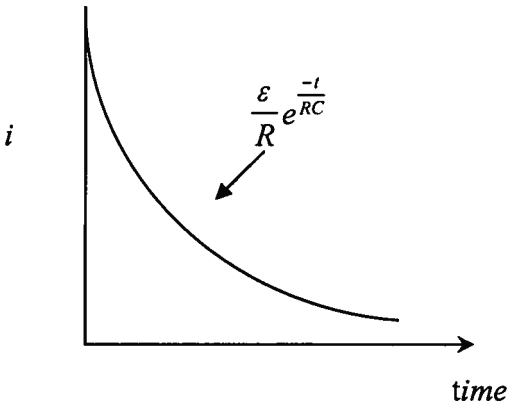
$i < i_o$

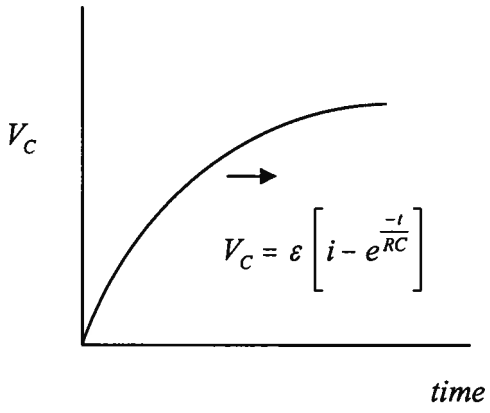
$i = \dfrac{\varepsilon - V_C}{R}$

Eventually $q \rightarrow C\varepsilon$



Mathematically it can be proved that:



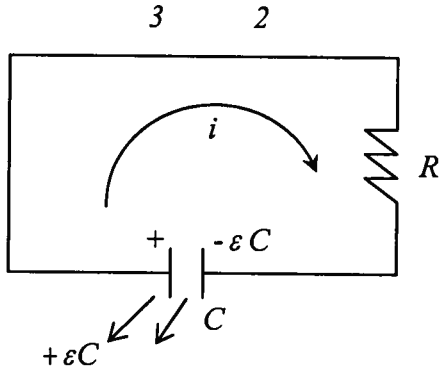


So now $V_C = \varepsilon$, i=0

Switch from 2 → 1 to 2 → 3. circuit is

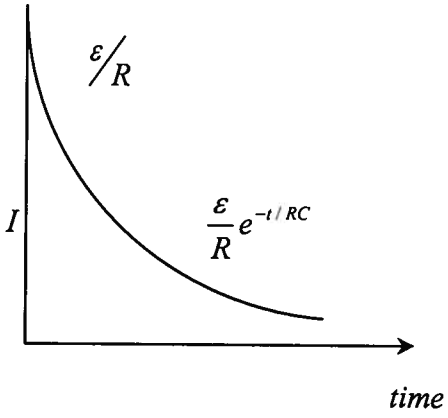
Start clock again

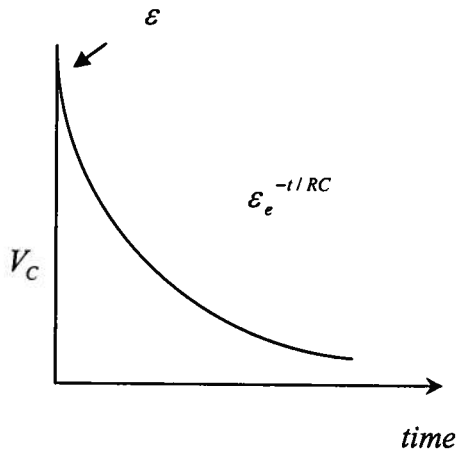
DISCHARGING: No battery in circuit current is due to capacitor's store charge ($\underset{\rightarrow}{E}$-field)



current flows in opposite direction

NO CURRENT IN CAPACITOR





CHARACTERISTIC TIME $\tau = RC$!!!

$$R = \frac{V}{I} \Rightarrow \frac{VT}{Q}$$

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

$$So,\ RC \Rightarrow \frac{Q}{V} \bullet \frac{VT}{Q} \Rightarrow T$$

RC has dimension of time!

Process involves transference of charge [from batter to C during charing from one terminal OFC to the other during discharging]. R controls rate of flow. C controls amount of Q to be transferred for a given ε.