IA Circuits

No. 1

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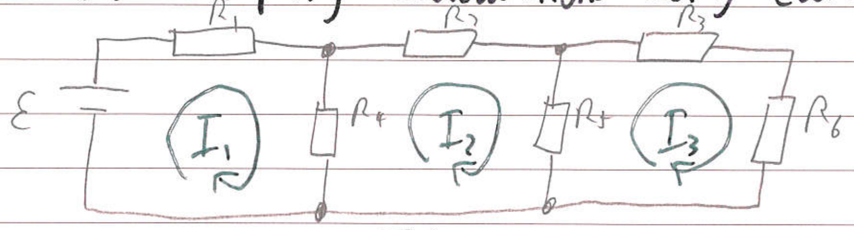
- charge in an electric field experiences $\vec{F} = q\vec{E}$
- In a wire: $I = \frac{dQ}{dt} = nqA\langle v\rangle$ ← A: cross sectional area.
- p.d is work done per unit charge, in moving q in $\vec{E}$.
- emf ε is the energy gained per unit charge in a cell.

- ~~Kirchh~~ Kirchhoff's current law: current conserved at junction
- Kirchhoff's voltage law: around any loop, $\sum V_i = 0$ (for cons energy).
- We can simplify calculations using current loops:



$\therefore\ \varepsilon - I_1R_1 - (I_1 - I_2)R_4 = 0, \quad -I_2R_2 - (I_2 - I_3)R_5 - (I_2 - I_1)R_4 = 0$

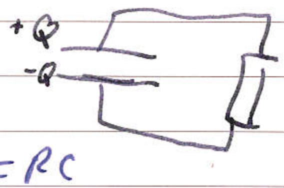
... (3 eq with 3 unknowns).

- For voltage, we can arbitrarily label voltage w.r.t any reference point of our choosing (negative terminal usually).

Capacitors

Defined by $C = \frac{Q}{V}$. $\therefore\ W = \int V\,dq = \frac{1}{2}CV^2$

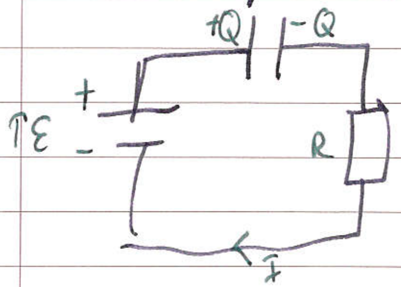
- In an RC circuit with a charged capacitor:



$V = IR = \frac{Q}{C}$ $\therefore\ \frac{dQ}{dt} = \frac{Q}{RC} \Rightarrow Q(t) = Q_0 e^{-\frac{t}{RC}}$

↳ exponential decay with characteristic time $\tau = RC$

- To charge a cap



$\varepsilon = IR + \frac{Q}{C}$

$\Rightarrow Q = C\varepsilon(1 - e^{-\frac{t}{RC}})$

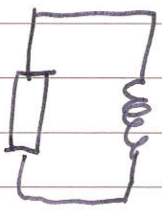
Inductors

$\mathcal{E} = -\frac{d\phi_B}{dt}$ But we also have $\phi_B = LI$ by definition.

$\uparrow$ self-inductance.

$\therefore \mathcal{E} = -L\frac{dI}{dt}$

↳ stores energy in the field: $W = \frac{1}{2}LI^2$



In an RL circuit, $-IR - L\frac{dI}{dt} = 0$

$\Rightarrow I(t) = I(0)\,e^{-\frac{tR}{L}}$

i.e exponential decay with characteristic $\tau = \frac{L}{R}$.