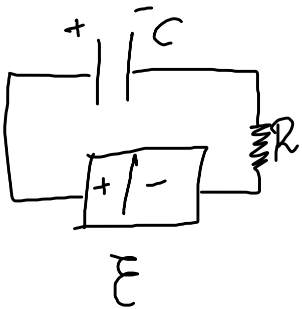
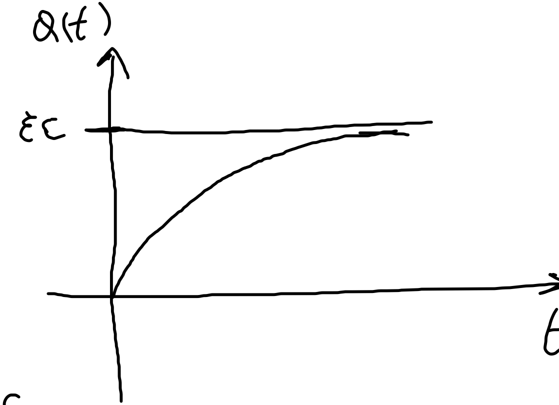


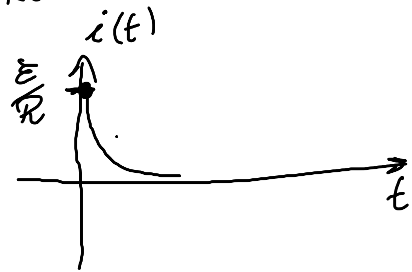
$$Q(t) = \mathcal{E} \cdot C \left(1 - e^{-t/RC}\right)$$



$$C = \frac{Q}{\Delta V} \qquad \tau = RC$$

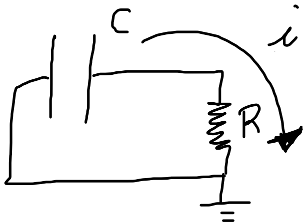
$$\Delta t > 5\tau \Rightarrow Q > 99\% \cdot \mathcal{E} C$$

$$i(t) = \frac{dQ}{dt} = \mathcal{E} \cancel{C} (-1)\, e^{-t/RC} \left(\frac{-1}{R\cancel{C}}\right) = \frac{\mathcal{E}}{R} e^{-t/RC}$$



Scarica del condensatore

C'è Q_0 sul condensatore a $t = 0$



$$\begin{pmatrix}\text{Energia fornita} \\ \text{dal condensatore}\end{pmatrix} = \begin{pmatrix}\text{Energia dissipata} \\ \text{sulla resistenza}\end{pmatrix}$$

$$C = \frac{Q}{\Delta V_C}$$

$$\Delta V_R = R \cdot i$$

$$\cancel{q}\,\Delta V_C = \cancel{q}\,\Delta V_R$$

$$\frac{Q}{C} = R \cdot i \qquad\qquad i = -\frac{dQ}{dt}$$

carica sul condensatore

Se $dQ < 0 \Rightarrow i > 0$

$$\frac{1}{C}\frac{dQ}{dt} = R\frac{di}{dt}$$

$$-\frac{i}{C} = R\frac{di}{dt}$$

$$R\frac{di}{dt} + \frac{i}{C} = 0$$

$i = i(t)$

eq. diff. I ordine lineare a coeff. costanti

$$-\frac{i}{C} = R\frac{di}{dt}\ ; \qquad -\frac{i}{\underbrace{RC}_{\tau}} = \frac{di}{dt}\ ;$$

$$-\int_0^t \frac{dt}{RC} = \int_{i_0}^{i(t)} \frac{di}{i}\ ; \qquad \underbrace{-\frac{1}{\tau}\,t} = \ln i\Big|_{i_0}^{i(t)} = \ln[i(t)] - \ln i_0 = \underbrace{\ln\left[\frac{i(t)}{i_0}\right]}$$

$$\frac{i(t)}{i_0} = e^{-t/\tau}\ ; \qquad i(t) = i_0\, e^{-t/\tau}$$

$$P(t) = R i^2 = R i_0^2\, e^{-2t/\tau}$$

Quando $i(t) = i_0/2$?

$$\frac{i_0}{2} = \cancel{i_0}\, e^{-t/\tau}\ ;$$

$$\ln\left(\frac{1}{2}\right) = -t/\tau\ ;$$

$$t = \tau \ln 2 \simeq 0.69\,\tau$$

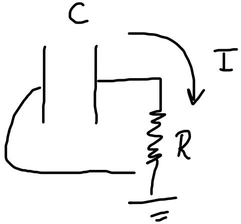
Se $t > 4\tau$ $\quad i < 1\%\, i_0$

$$i(t) = -\frac{dQ}{dt}$$

$$i(t) = i_0 e^{-t/\tau}$$

$$\Rightarrow \int_{Q_0}^{0} dQ = -\int_0^{+\infty} i(t)\,dt \Rightarrow -Q_0 = -\int_0^{+\infty} i_0 e^{-t/\tau}\,dt$$

$$= -i_0\left(-e^{-t/\tau}\right)\tau\Big|_0^{+\infty} = -i_0\tau\,(0+1)$$



all'inizio $\Delta V_C = \frac{Q_0}{C}$

$$C = \frac{Q_0}{\Delta V_C} \Rightarrow$$

$$\Rightarrow i_0 = \frac{Q_0}{\tau} = \frac{Q_0}{RC} = \frac{\Delta V_C(t=0)}{R}$$

legge di ohm

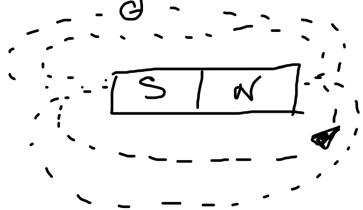
quando $\Delta V_C = \frac{Q_0}{C}$

Campi magnetici

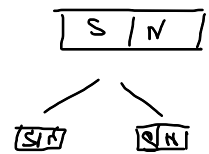
1) Esistono materiali che si attraggono tra loro: li chiamo magneti

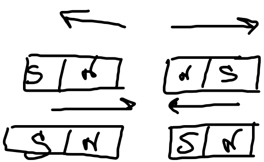
2) " " che si orientano sempre verso il nord della Terra (tipicamente piccoli aghi di ferro)

3) La limatura di ferro vicina ad un magnete si orienta a formare strutture geometriche ordinate



4) Se spezzate un magnete

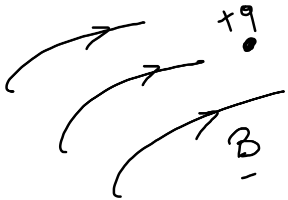


5) 

Poli di uguale tipo si respingono

" di tipo opposto " attraggono

Campo magnetico: le linee di campo magnetico sono quelle lungo cui si orienta la limatura di ferro vicino ad un magnete



Qual è la $\underline{F}$ su q?

1) Se q è fermo, $F = 0$

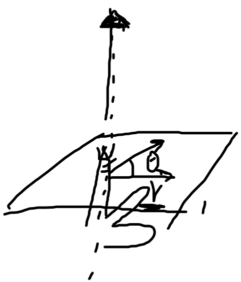
2) Se $\underline{v} \neq \underline{0}$, allora può esserci una $\underline{F} \neq \underline{0}$

$\underline{F}$ non è diretta lungo $\underline{B}$, ma in direzione $\perp$ sia $\underline{v}$, sia $\underline{B}$

3) $F \propto q, B, v$ $\quad |\underline{F}|$ dipende da come $\underline{v}$ è orientata rispetto a $\underline{B}$

$$\underline{F} = q(\underline{v} \times \underline{B})$$

per esempio se $\underline{v} \parallel \underline{B} \Rightarrow \underline{F} = 0$



$\underline{V} \times \underline{W}$ è un vettore
- direzione: $\perp$ al piano che contiene $\underline{v}$ e $\underline{w}$
- verso: regola mano dx
- modulo: $|\underline{v}| \cdot |\underline{w}| \operatorname{sen}\theta \rightarrow \theta$: angolo tra $\underline{v}$ e $\underline{w}$

Unità di misura di $\underline{B}$:

$$[F] = [q\, v \cdot B] \Rightarrow \frac{N}{C \cdot m/s} = [B] = \text{Tesla}$$

$1\ T$ campo magnetico "alto"
risonanza magnetica nucleare

$\sim 20\ T$ con magneti superconduttori
(tecnologie avanzate da laboratorio)

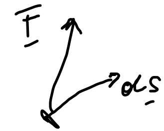
$B_{Terra} \cong \frac{1}{2}$ Gauss $\quad 1\ \text{Gauss} = 10^{-4}\ T$

$B_{magnetino} \approx$ qualche Gauss

Come si muovono le cariche in $\underline{B}$?

$$\underline{F} = q(\underline{v}\times\underline{B})$$

$\underline{F}$ non cambia l'energia cinetica delle particelle



Teorema lavoro-energia: $\delta L \overset{def}{=} \underbrace{\underline{F}\cdot d\underline{s}}$ $\overset{Th}{=} dK \qquad K=\frac{1}{2}mv^2$

$$q(\underline{v}\times\underline{B})\cdot \underbrace{d\underline{s}}_{\underline{v}=d\underline{s}/dt} = q\,\underbrace{\overbrace{(\underline{v}\times\underline{B})}^{\perp\,\underline{v}}\cdot\underline{v}}_{=0}\,dt = 0$$

$\Downarrow$

$dK = 0$

$\Rightarrow K = \text{const}$

$\Rightarrow |\underline{v}| = \text{const}$