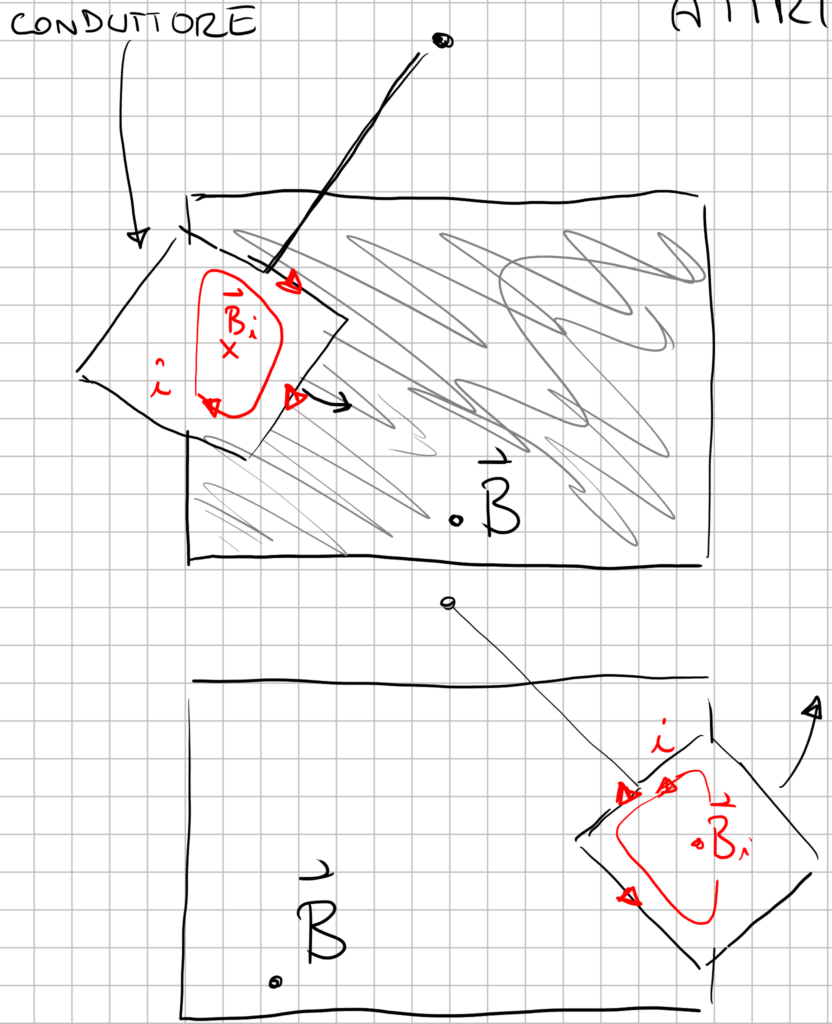
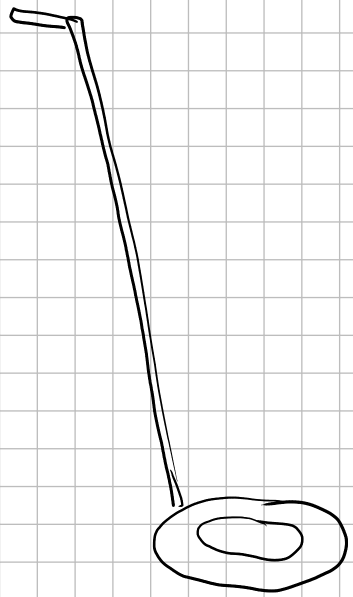
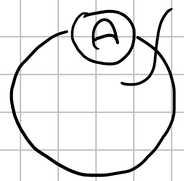
ATTRITO ELETTROMAGNETICO





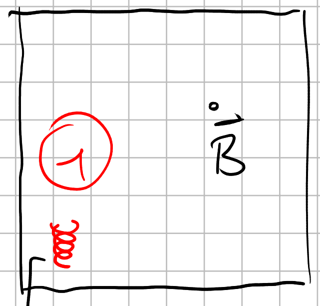
MISURE DI CAMPO MAGNETICO

SUPERFICIE Σ

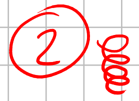


$$\int_{t_1}^{t_2} i(t)\,dt = q \qquad \left[i = \frac{dq}{dt} \right] \qquad \mathcal{E}_i = -\frac{d\Phi}{dt} \Rightarrow i = -\frac{1}{R}\frac{d\Phi}{dt}$$

$$\Rightarrow \int_{t_1}^{t_2} i(t)\,dt = -\int_{t_1}^{t_2} \frac{1}{R}\frac{d\Phi}{dt}\,dt = -\frac{1}{R}\int_{\Phi_1}^{\Phi_2} d\Phi = \underbrace{\frac{\Phi_1 - \Phi_2}{R} = q}_{\text{LEGGE DI FELICI}}$$



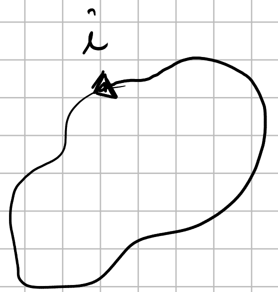
N' SPIRE



$$q = \frac{\Phi_1 - \Phi_2}{R} = \frac{\Phi_1}{R} = \frac{B\Sigma N}{R} \Rightarrow B = \frac{qR}{N\Sigma}$$

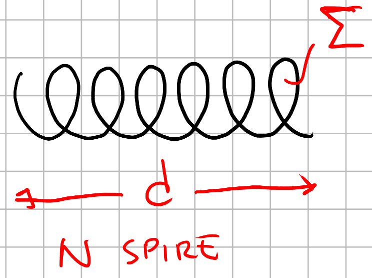
Con una misura di q otteniamo B

AUTOINDUZIONE



$$\vec{B} = \frac{\mu_0 i}{4\pi} \oint_{\text{CIRCUITO}} \frac{d\vec{l} \times \hat{r}}{r^2} \,, \quad \Phi_{\text{CIRCUITO}}(\vec{B}) = \int_{\Sigma(\text{CIRCUITO})} \frac{\mu_0 \boxed{i}}{4\pi} \left(\oint_{\text{CIRUITO}} \frac{d\vec{l} \times \hat{r}}{r^2} \right) \cdot \hat{n} \, d\Sigma = L i$$

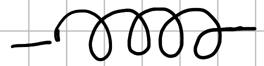
L INDUTTANZA O COEFFICIENTE DI AUTOINDUZIONE



$$B = \mu_0 n i = \mu_0 \underbrace{\frac{N}{d}}_{n} i \Rightarrow \Phi(B) = \frac{\mu_0 N i}{d} N \Sigma = \frac{\mu_0 N^2 i}{d} \Sigma =$$

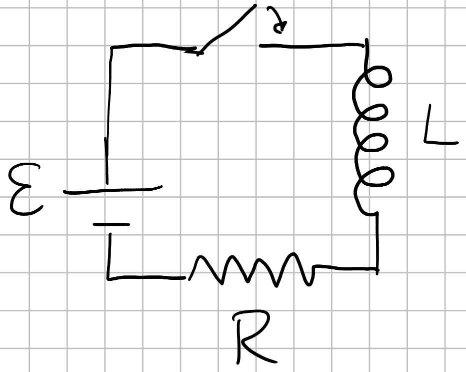
$$= \underbrace{\mu_0 n^2 \Sigma d}_{L} \, i$$

$[L] = H$ Henry

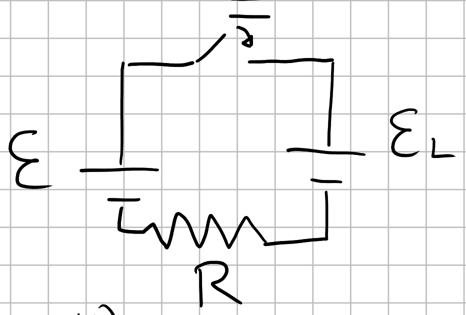


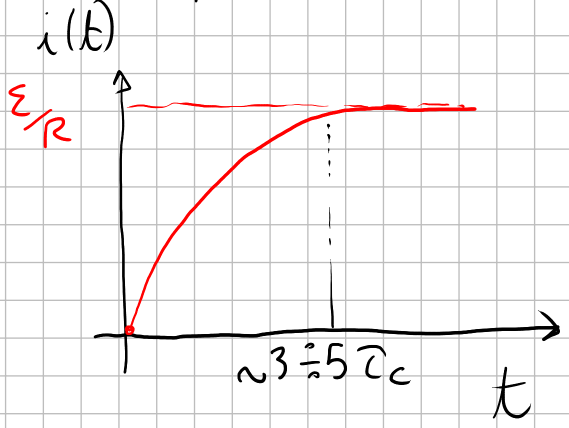
SIMBOLO

$\Phi(\vec{B}) = L i$, se $i = i(t) \Rightarrow$ $\mathcal{E}_L = -\frac{d\Phi}{dt} = -L \frac{di}{dt}$ se il circuito è indeformabile



" = "





EXTRACORRENTI DI APERTURA E CHIUSURA

$$\mathcal{E}_{TOT} = Ri = \mathcal{E} + \mathcal{E}_L = \mathcal{E} - L\frac{di}{dt} \Rightarrow$$

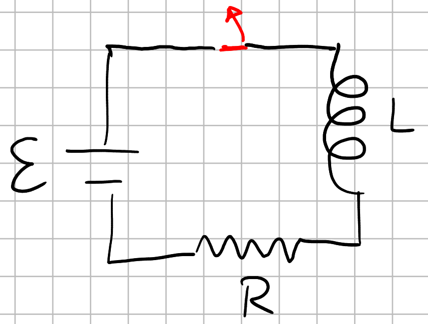
$$Ri = \mathcal{E} - L\frac{di}{dt} \Rightarrow \frac{di}{i - \mathcal{E}/R} = -\frac{R}{L}\,dt \Rightarrow$$

$$\int_0^{i(t)} \frac{di}{i - \mathcal{E}/R} = -\frac{R}{L}t \Rightarrow \log\left[\frac{i(t) - \mathcal{E}/R}{-\mathcal{E}/R}\right] = -\frac{R}{L}t \Rightarrow$$

$$\frac{i(t) - \mathcal{E}/R}{-\mathcal{E}/R} = e^{-\frac{R}{L}t} \Rightarrow i(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-\boxed{\frac{R}{L}}t}\right)$$

$\rightarrow \frac{1}{\tau_c}$ TEMPO CARATTERISTICO

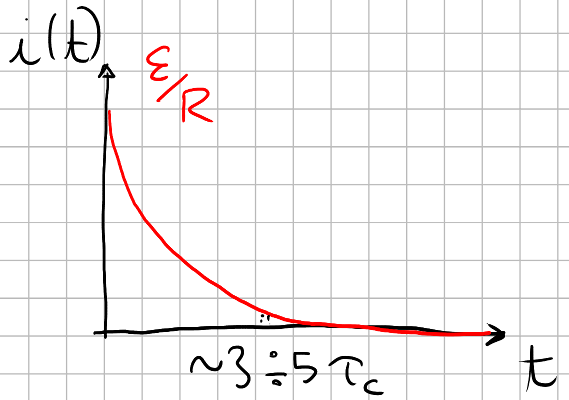
$$\tau_c \equiv \frac{L}{R}$$



$i(0) = \frac{\mathcal{E}}{R}$, $R' \gg R \longrightarrow$ ASSUMIAMO CHE $|\mathcal{E}_L| \gg |\mathcal{E}|$ $\Rightarrow$

facciamo la seguente approssimazione

$$\mathcal{E}_L = R' i \Rightarrow -L\frac{di}{dt} = R' i \Rightarrow i(t) = \frac{\mathcal{E}}{R} e^{-\underbrace{\frac{L}{R'}}_{\frac{1}{\tau_c'}} t}$$



$$\mathcal{E}_L = -L\frac{di}{dt} = \frac{R'}{R}\mathcal{E} e^{-\frac{t}{\tau_c'}} \xrightarrow[t \to 0]{} \frac{R'}{R}\mathcal{E} \gg \mathcal{E}$$

BILANCIO ENERGETICO

$$P = \mathcal{E}i = Ri^2 - \mathcal{E}_L i = \underbrace{Ri^2}_{} + \underbrace{Li\frac{di}{dt}}_{} \Rightarrow dW = \mathcal{E}i\,dt = Ri^2dt + Li\,di$$

studiamo il secondo termine

$$W_L(t) = \int_{t_1}^{t_2} Li\,di = \int_{i_1}^{i_2} Li\,di = \frac{1}{2}Li_2^2 - \frac{1}{2}Li_1^2 \equiv U_L^{(2)} - U_L^{(1)} \Rightarrow$$

$$\underbrace{U_L = \frac{1}{2}Li^2}_{} \longrightarrow \text{l'energia può essere associata al campo } \vec{B}\,!$$

vediamolo per un solenoide : $B = \mu_0 n i$, $L = \mu_0 n^2 \Sigma d \Rightarrow$

$$U_L = \frac{1}{2}Li^2 = \frac{1}{2}\mu_0 n^2 \Sigma d\, i^2 = \frac{1}{2}\frac{B^2}{\mu_0}\underbrace{\Sigma d}_{\tau} = \underbrace{\frac{1}{2}\frac{B^2}{\mu_0}}_{u_L\ \text{DENSITÀ DI ENERGIA}}\tau \equiv u_L\tau$$

$$u_L = \frac{1}{2}\frac{B^2}{\mu_0}$$