Magnetismo

- Il campo magnetico
- Campo magnetico e correnti
- **Induzione elettromagnetica (auto e mutua)**
- Campi magnetici nella materia

Autoinduzione

$\mathbf{B} \sim i$ (Legge di Biot e Savart)

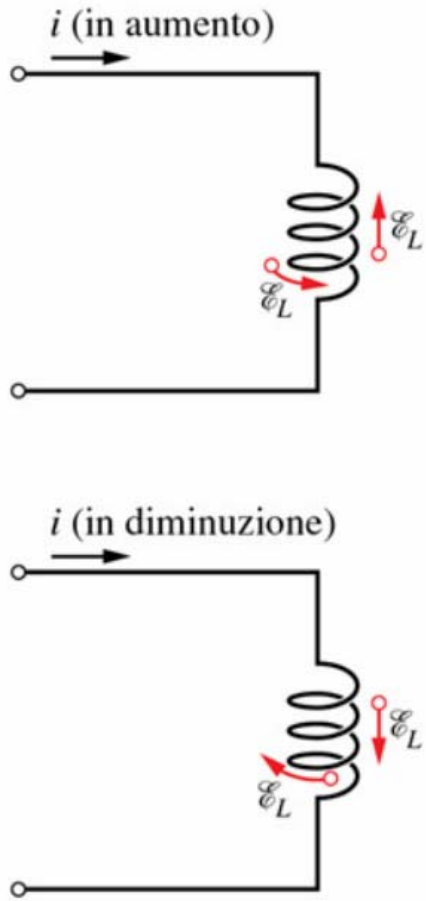
$$\Phi_B = \int \mathbf{B} \cdot d\mathbf{S} \quad \Rightarrow \quad \Phi_B \sim i$$

$$\Phi_B = Li$$ Coefficiente di autoinduzione

$$f.e.m_L = -L\frac{di}{dt} \qquad [H] = \left[\frac{Vs}{A}\right]$$

Bobina $\Rightarrow$ $$f.e.m_L = -N\frac{d\Phi_B}{dt} = -L\frac{di}{dt}$$

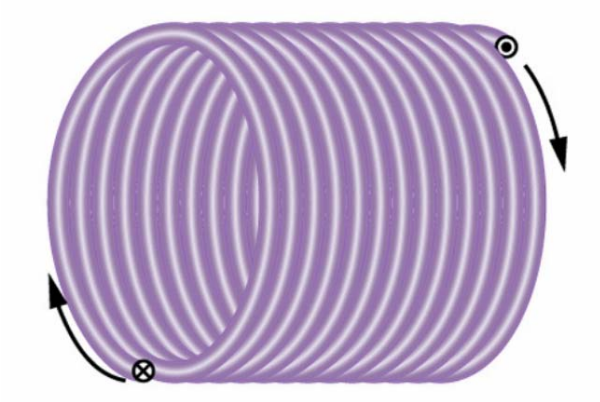
$$N\Phi_B = Li$$



Induttanza di un solenoide

$$B = \mu_0 n i$$

$$\Phi_B = \int \mathbf{B} \cdot d\mathbf{S} = BS = \mu_0 n i S$$

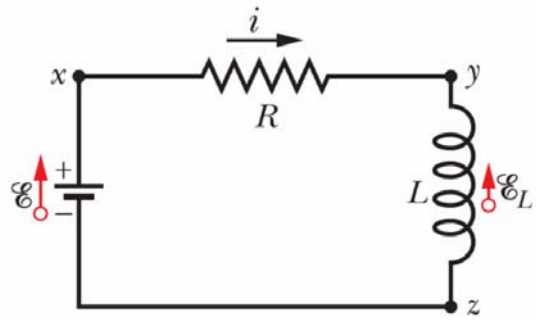


$$N = nl \qquad N\Phi_B = \mu_0 n^2 S l i$$

$$L = \mu_0 n^2 S l$$

Circuito LR

$$(V_x - V_z) + (V_y - V_x) + (V_z - V_y) = 0$$



$$E_0 - Ri - L\frac{di}{dt} = 0 \qquad L\frac{di}{dt} + Ri = E_0$$

$$\frac{di}{i - \frac{E_0}{R}} = -\frac{R}{L}dt$$

$$\ln\left(i - \frac{E_0}{R}\right) = -\left(\frac{R}{L}\right)t + \ln K$$

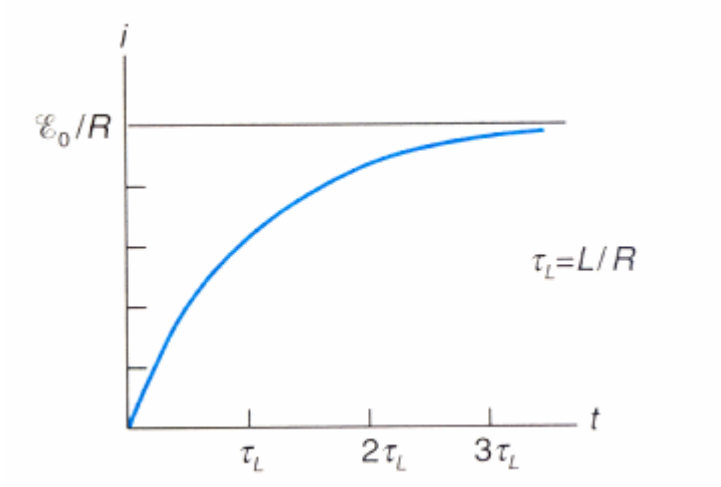
$$i(t) - \frac{E_0}{R} = Ke^{-\frac{R}{L}t} \qquad i(0) = 0 \rightarrow K = -\frac{E_0}{R}$$

$$i(t) = \frac{E_0}{R}\left(1 - e^{-t/\tau_L}\right)$$

$$\tau_L = L/R$$

Circuito LR

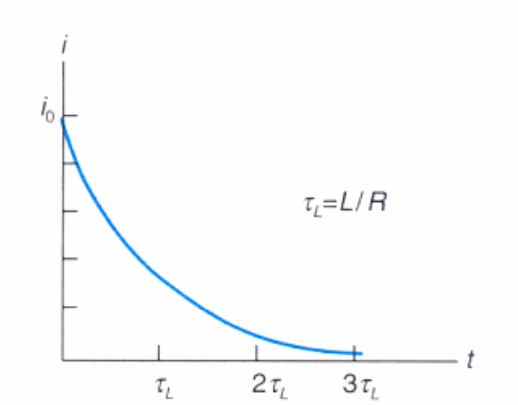
$$i(t) = \frac{E_0}{R}\left(1 - e^{-t/\tau_L}\right)$$

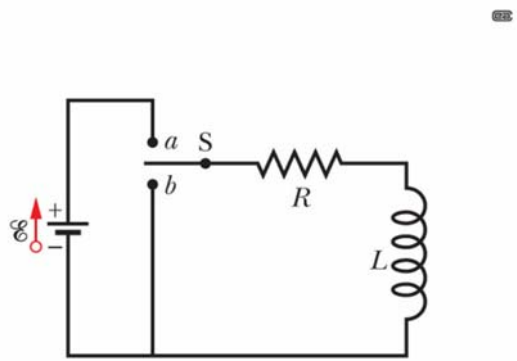


$$\tau_L = L/R$$

$$-L\frac{di}{dt} - Ri = 0$$

$$i(t) = Ke^{-t/\tau_L}$$





Energia nel circuito RL

$$V = L\frac{di}{dt} \qquad P = Vi = i\left(L\frac{di}{dt}\right) = Li\frac{di}{dt} \qquad P = \frac{dU}{dt}$$

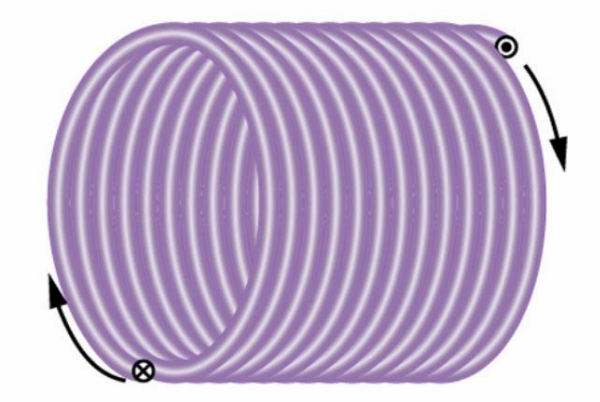
$$dU = Pdt = Li\left(\frac{di}{dt}\right)dt \quad \Rightarrow \quad dU = Lidi \qquad \boxed{U = \frac{1}{2}Li^2}$$

Campo elettrico

$$U = \frac{1}{2}\frac{Q^2}{C} \qquad u_E = \frac{1}{2}\varepsilon_0 E^2$$

Energia del campo magnetico

$$L = \mu_0 n^2 S l \qquad B = \mu_0 n i$$

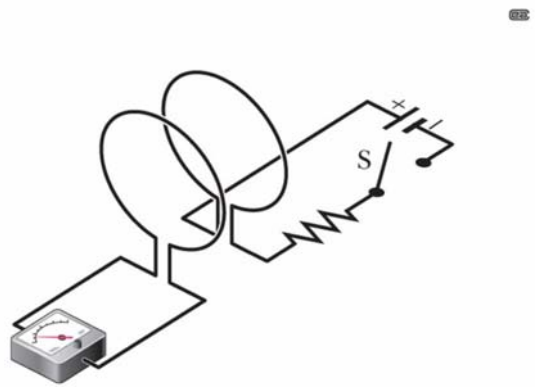


$$U = \frac{1}{2} L i^2 = \frac{1}{2} \mu_0 n^2 S l i^2$$

$$i = \frac{B}{\mu_0 n} \qquad U = \frac{B^2}{2\mu_0} S l \quad \Rightarrow \quad \boxed{u_B = \frac{B^2}{2\mu_0}}$$

Induttanza mutua

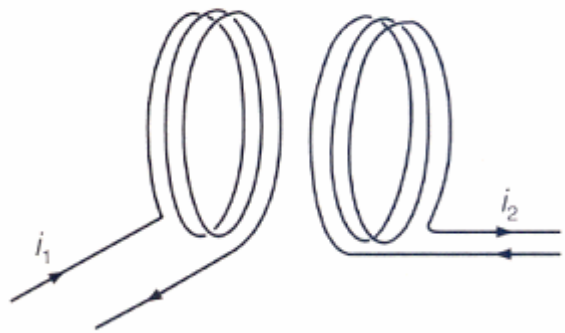
Φ_{21} flusso conc. con una spira della bobina 2 dovuto al campo della bobina 1



$$N_2\Phi_{21} \sim i_1 \qquad N_2\Phi_{21} = M_{21}i_1$$

$$E = -\frac{d\Phi_{21}}{dt} \qquad E_{21} = -N_2\frac{d\Phi_{21}}{dt} = -\frac{d}{dt}\left(N_2\Phi_{21}\right) = -\frac{d}{dt}\left(M_{21}i_1\right) = -M_{21}\frac{di_1}{dt}$$

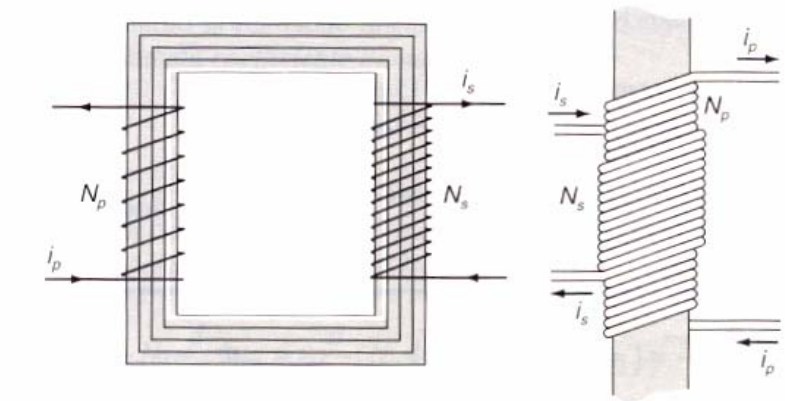
$$E_{12} = -M_{21}\frac{di_2}{dt} \qquad M_{12} = M_{21} = M$$



Trasformatori

$$V_S = N_S E = -N_S \frac{d\Phi_B}{dt}$$

$$V_P = N_P E = -N_P \frac{d\Phi_B}{dt}$$



$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$i_p V_p = i_s V_s$$

$$\frac{i_s}{i_p} = \frac{N_p}{N_s}$$