

Ex. Spira e dipolo



$$\theta = \omega t$$

coefficiente di mutua induzione
tra dipolo 1 e circuito 2?

principio di equivalenza di Ampère

$$\vec{m} = \oint \vec{r} \times i \vec{dl} \quad B = \frac{\mu_0 i}{2R} \quad (\text{in } t)$$

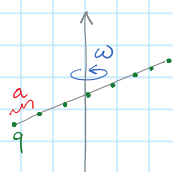
superficie
piatta spira

$$\phi_{12} = B \cdot S = \left(\frac{\mu_0 S}{2R} \right) i \rightarrow M = \frac{\mu_0 S}{2R}$$

$$\phi_{21}^{\max} = M i_m$$

$$\phi_{21}(t) = \frac{\mu_0 S}{2R} i_m \cos(\omega t) = \frac{\mu_0 m}{2R} \cos(\omega t)$$

Ex.



$$T = \frac{2\pi}{\omega} \Rightarrow i_q = \frac{q}{T} = \frac{q\omega}{2\pi}$$

$$\Rightarrow m_q = \sum i_q = \pi a^2 q \omega$$

$$\vec{m} = 14 a^2 q \vec{\omega}$$

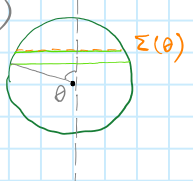
6 cariche
(2 con $r=a$
2 con $r=2a$
...)

Ex. q distribuita sulla superficie di una sfera



$$\sigma = \frac{q}{4\pi R^2}$$

(di lato:)



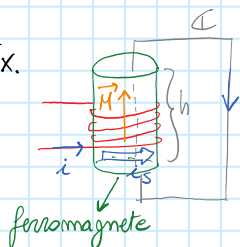
$$di = \frac{q \text{ nella striscia}}{T}$$

$$d\vec{m}(\theta) = \Sigma(\theta) \cdot di(\theta)$$

$$\oint \vec{m} = \frac{4\pi \vec{\omega} \sigma R^4}{3} = \frac{1}{3} q R^2 \vec{\omega}$$

una conica su un
esterno avrebbe un
 $\vec{m}$ maggiore?

Ex.



ferromagnete

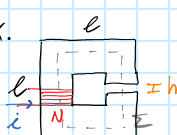
$$\oint \vec{H} \cdot d\vec{s} = N i \rightarrow \text{dei fili}$$

$$\oint \vec{M} \cdot d\vec{s} = M h = i_s \rightarrow \text{corrente superficiale}$$

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 \oint (\vec{H} + \vec{M}) \cdot d\vec{s} = \mu_0 (N i + h M)$$

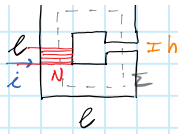
$$M = \chi H$$

Ex.



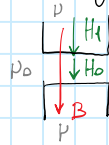
senza traferro:

$$\text{Ampère } \oint \vec{H} \cdot d\vec{s} = \oint \vec{H} \cdot d\vec{s} = \oint \vec{H} \cdot d\vec{s} = N i \Rightarrow H = \frac{N i}{l} \Rightarrow B = \mu_0 H = \mu H$$



Ampère $\oint \vec{H} \cdot d\vec{s} = \oint l H = Ni \Rightarrow H = \frac{Ni}{4l} \Rightarrow B = \mu_0 \mu_r H = \mu H$
 $(\sqrt{\epsilon} \ll l)$ $B = \frac{\mu_0 \mu_r Ni}{4l}$

con traferro

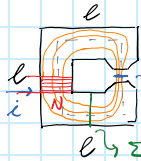


$B \perp \text{sup.} \Rightarrow$ rimane costante

Ampère: $\oint \vec{H} \cdot d\vec{s} = (4l-h)H_1 + hH_0 = Ni$

$\Rightarrow B = \frac{\mu_0 Ni}{\frac{1}{\mu_r} (4l-h) + h} \approx \frac{\mu_r \mu_0 Ni}{4l + \mu_r h}$

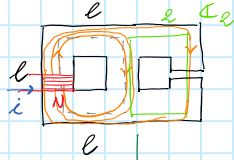
$\hookrightarrow$ correva. rispetto al caso senza traferro
 Nota: $\mu_r \approx 10^5$



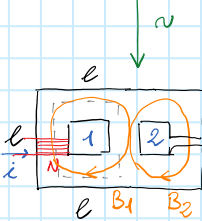
B si "addensa" per mantenere costante il flusso $\rightarrow \Phi_B$ è costante nel "circuito magnetico"

$\Phi_B = \Sigma B = \Sigma' B' \rightarrow B' = \frac{B \Sigma}{\Sigma'} > B$

Ex.



$\oint_{C_2} \vec{H} \cdot d\vec{s} = 0$



1. $4l \frac{B_1}{\mu} - \frac{l B_2}{\mu} = Ni$

B_2 controcorrente sul lato in comune

} sistema

2. $(4l-h) \frac{B_2}{\mu} - \frac{l B_1}{\mu} + \frac{h B_2}{\mu_0} = 0$
 B_1 controcorrente sul lato comune
 μ_0 spazio vuoto

$B_2 = \frac{\mu Ni}{15l + 4\mu_r h}$



$\vec{E}_i = \vec{E} = -\frac{d\phi}{dt}$ $\theta \neq 0 \quad t=0 \quad \hat{m} \perp \vec{B}$
 $\theta(t) = \omega t - \frac{\pi}{2}$ (spira tangente a B)

$\phi(t) = \Sigma B \cos \theta = \Sigma B \sin(\omega t)$

$\vec{E} = -\omega B \cos(\omega t) (\pi a^2) N$

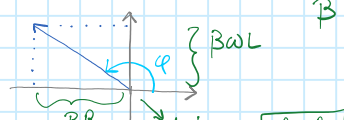
$\hat{E} = -\omega B \pi a^2 N e^{i\omega t}$

ciruito RL: $\vec{E} - L \frac{d\vec{I}}{dt} = R \vec{I}$

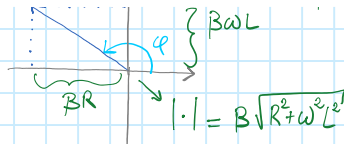
$\hat{I} = \hat{I}_0 e^{i\omega t}$
 m. complesso (contiene la fase)

$\hat{I}_0 = -\frac{\pi a^2 \omega N B}{i\omega L + R} = \frac{\pi a^2 \omega N B}{\sqrt{\omega^2 L^2 + R^2}} e^{i\varphi}$
 fase

$= \frac{-\alpha(i\omega L - R)}{(i\omega L + R)(i\omega L - R)} = + \frac{\alpha}{\omega^2 L^2 + R^2} (i\omega L - R)$



$\cos \varphi = -\frac{R}{(\omega^2 L^2 + R^2)^{1/2}}$
 $\sin \varphi = \frac{L}{(\omega^2 L^2 + R^2)^{1/2}}$



$$\cos \varphi = -\frac{R}{(\omega^2 L^2 + R^2)^{\frac{1}{2}}}$$

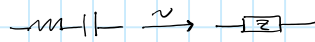
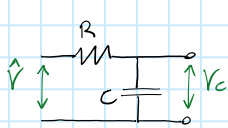
$$\sin \varphi = \frac{L}{(\omega^2 L^2 + R^2)^{\frac{1}{2}}}$$

$$\Rightarrow I(t) = \frac{\pi a^2 \omega N B}{(\omega^2 L^2 + R^2)^{\frac{1}{2}}} \cos(\omega t + \varphi) \quad \langle I(t) \rangle = 0$$

$I_{\max}$

$$I_1(t_1 = \frac{6\pi}{\omega}) = I_{\max} \cos(\varphi)$$

circuito passa-basso



$$Z = R + \frac{1}{i\omega C}$$

$$\hat{V} = Z \hat{I} \quad \hat{V}_C = Z_C \hat{I} = \frac{1}{i\omega C} \hat{I}$$

$$\hat{I} = \frac{1}{Z} \hat{V} = \frac{Z_C}{Z} V = \frac{\frac{1}{i\omega C}}{R + \frac{1}{i\omega C}} V$$

$$\frac{|V_C|}{|V|} = \frac{1}{(1 + (\omega RC)^2)^{\frac{1}{2}}}$$

con un'induttanza $\rightarrow$ filtro passa-alto_f