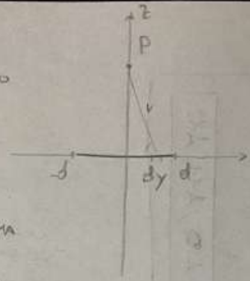
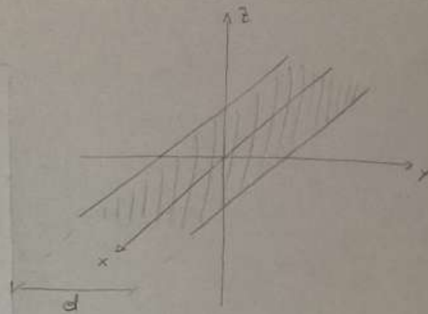
ESERCIZI DI ELETTRICITÀ E MAGNETISMO

FOGLIO EM - 10, 11, 12

$\boxed{1}$ $d = 6\,cm$ $I = 4{,}5\,A$

LI TRATTO COME UN FOGLIO DI FILI INDEFINITI





$$dB = \frac{\mu_0 di}{2\pi r}\hat{\phi}$$

MA LA CORRENTE INFINITESIMA È $di = \frac{I}{d}dy$

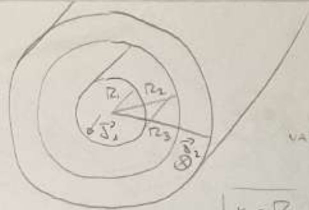
$$dB = \frac{\mu_0 I}{2\pi}\frac{dy}{r} = \frac{\mu_0 I}{2\pi d}\frac{dy}{z^2+y^2}\hat{\phi}$$

$$\vec{B} = 2\frac{\mu_0 I}{2\pi d}\operatorname{arctg}\left(\frac{y}{z}\right)\Big|_0^{d/2} = \boxed{\frac{\mu_0 I}{\pi d}\operatorname{arctg}\left(\frac{d}{2z}\right)} \rightsquigarrow \boxed{B(10\,cm) = 8{,}74\,\mu T}$$

SE FOSSE UN FILO $B_{FILO} = \frac{\mu_0 i}{2\pi r} \rightsquigarrow B_{FILO}(10\,cm) = B(10\,cm)$

$$\Rightarrow i = \frac{2\pi r\, B(10\,cm)}{\mu_0} = \frac{2\pi r}{\mu_0}B = \boxed{4{,}37\,A}$$

$\boxed{2}$



DEVO USARE LA LEGGE DI AMPERE PER CALCOLARE IL CAMPO $\vec{B}$ DATO DA [illegible] CONTRIBUTI

$$\oint B \cdot dl = \mu_0 i_{conc}$$

VARRÀ $\vec{J}_1 = \frac{i}{\pi R_1^2}$, $\vec{J}_2 = \frac{i}{\pi(R_3^2 - R_2^2)}$

$\boxed{r<R_1}$ $B 2\pi r = \mu_0 J_1 \pi r^2 \Rightarrow \vec{B} = \frac{\mu_0 r}{2} \vec{J}_1$

$$\Rightarrow \boxed{\vec{B}(r) = \frac{\mu_0 i}{2\pi R_1^2} r}$$

$\boxed{R_1<r<R_2}$ $B 2\pi r = \mu_0 i \Rightarrow \boxed{B(r) = \frac{\mu_0 i}{2\pi r}}$

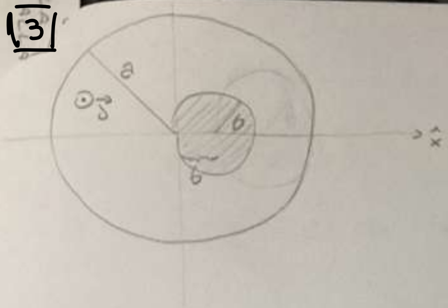
$\boxed{R_2<r<R_3}$ $B(r) 2\pi r = \mu_0 \left(i - J_2 \pi (r^2 - R_2^2)\right)$

$$\Rightarrow B(r) = \frac{\mu_0}{2\pi r} i \left(1 - \frac{\pi(r^2-R_2^2)}{\pi(R_3^2-R_2^2)}\right) = \frac{\mu_0 i}{2\pi r}\frac{R_3^2 - R_2^2 - r^2 + R_2^2}{R_3^2-R_2^2}$$

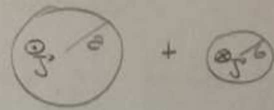
$$\Rightarrow \boxed{B(r) = \frac{\mu_0 i}{2\pi r}\frac{R_3^2 - r^2}{R_3^2-R_2^2}}$$

$\boxed{r>R_3}$ $B(r)2\pi r = \mu_0(i - i) \Rightarrow \boxed{B(r)=0}$

3

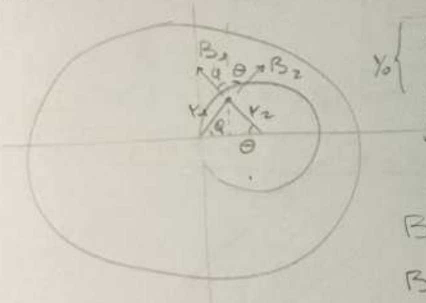


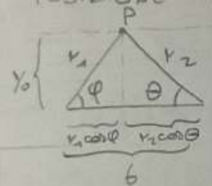
LO TRATTO COME



CON $\vec{J} = \frac{i}{\pi(a^2-b^2)}$

LO FACCIO IN UNA POSIZIONE GENERICA





PER CIASUN CILINDRO AVRÒ

$$B(r_i) = \frac{\mu_0 r_i}{2} \vec{J}\,\hat{z}$$

SI PUÒ VEDERE CHE I 2 CAMPI HANNO COMPONENTE x OPPOSTA

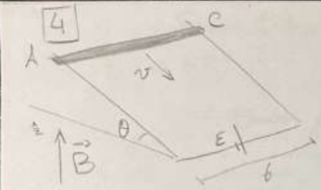
$$B_x(r_1) = \frac{\mu_0 \vec{J} r_1}{2} \sin\varphi \qquad B_x(r_2) = \frac{-\mu_0 \vec{J} r_2}{2} \sin\theta$$

$$B_y(r_1) = \frac{\mu_0 \vec{J} r_1}{2} \cos\varphi \qquad B_y(r_2) = \frac{-\mu_0 \vec{J} r_2}{2} \cos\varphi$$

$$B_x = \frac{\mu_0 J}{2}(\underbrace{-r_1 \sin\varphi}_{y_0} + \underbrace{r_2 \sin\theta}_{y_0}) = 0$$

$$B_y = \frac{\mu_0 J}{2}(r_1 \cos\varphi + r_2 \cos\theta) = \frac{\mu_0 \vec{J}}{2} b = \boxed{\frac{\mu_0 i b}{2(a^2-b^2)}\hat{y}}$$

$\boxed{4}$



$b = 20\ cm$

$\Sigma = 1\ cm^2$

$d = 3000\ kg/m^3$

$\rho = 2 \cdot 10^{-9}\ \Omega m$

$\theta = 30°$

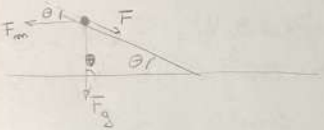
$B = 0,3\ T$

LA SBARRA SENTIRÀ LA [illegible] DELLA FORZA PESO E LA FORZA MAGNETICA DOVUTA ALLA CORRENTE INDOTTA

$$m = d\Sigma b = 6\ kg$$

$$\vec{F}_g = -mg\,\hat{z}$$

$$F = F_g \sin\theta = -mg\sin\theta = 29,43\ N$$



SCENDERÀ A VELOCITÀ v QUINDI AVRÒ

$$d\Phi = \underbrace{B b v\, dt}_{d\Sigma} \cos\theta \Rightarrow \frac{d\Phi}{dt} = B b v \cos\theta$$

QUINDI SCORRERÀ $\varepsilon_i = -\frac{d\Phi}{dt} = -Bbv\cos\theta \Rightarrow i_i = \frac{\varepsilon_i}{R} = \frac{Bbv}{\rho b}\Sigma\cos\theta$

LA i SCORRE DA A A C IN MODO DA OPPORSI ALLA VARIAZIONE DI FLUSSO. PER COLPA DI i SENTIRÀ UNA FORZA MAGNETICA (LA i DA CONSIDERARE È ANCHE QUELLA DATA DA ε)

$F_m = \left(i_i - \frac{\varepsilon}{\rho b}\Sigma\right) bB$ DI CUI CONSIDERO $F_m = \left(i_i - \frac{\varepsilon}{\rho b}\Sigma\right) bB\cos\theta$

VOGLIO L'EQUILIBRIO $F_m = F \Rightarrow \cos\theta\, bB\left(i_i - \frac{\varepsilon}{\rho b}\Sigma\right) = mg\sin\theta$ E AVRÒ $v = 0$

$$\Rightarrow \varepsilon = \frac{mg\sin\theta}{bB}\frac{\rho b}{\Sigma} = \frac{d\Sigma b \rho b g}{bB\Sigma}tg\theta = g\frac{d\rho b}{B}tg\theta = \boxed{0,227\ V}$$

$\mathcal{E} = 0$ AVRÒ $F_{m} = \left(i - \frac{\mathcal{E}}{\rho b} \Sigma \right) b B \cos\theta = i\, b B \cos\theta$

$$\Rightarrow F_{m} = \frac{B^2 b \Sigma}{\rho} v \cos^2\theta$$

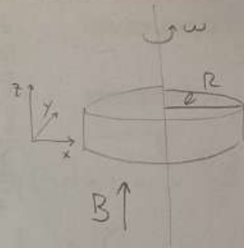
AVRÒ v_{LIM} SE $F_{m} = F \Rightarrow \frac{B^2 b \Sigma}{\rho} v_{LIM} \cos^2\theta = mg \sin\theta$

$$\Rightarrow v_{LIM} = \frac{d \cancel{b\Sigma} g \,\mathrm{tg}\theta}{B^2 \cancel{b\Sigma} \cos\theta} \rho = \frac{d g \rho \,\mathrm{tg}\theta}{B^2 \cos\theta} = \boxed{4,36 \ m/s}$$

$$W = i^2 R = \left(\frac{B v_{LIM}}{\rho} \Sigma \cos\theta \right)^2 \rho \frac{b}{\Sigma} = \left(B v_{LIM} \cos\theta \right)^2 \frac{b \Sigma}{\rho} = \boxed{1,28 \ W}$$

$\boxed{5}$ $\ell = 20\ cm$ $\quad \omega = 50\ rad/s$ $\quad R = 100\ \Omega$

$B = 0{,}3\ T$



— o —

$$i = -\frac{1}{R}\frac{d\Phi}{dt}$$

MA NON HO VARIAZIONE DI FLUSSO, DEVO USARE LA FORZA DI LORENTZ

$$\vec{E} = \vec{v} \times \vec{B} = r\vec{\omega} \times \vec{B} = r\omega B\,\hat{x}$$

$$\mathcal{E} = \oint E\, d\ell = \int_0^\ell \omega B r\, dr = \frac{\ell^2 \omega B}{2}$$

$$\Rightarrow i = \frac{\mathcal{E}}{R} = \frac{\ell^2 \omega B}{2R} = 3 \cdot 10^{-3}\ A = \boxed{3\ mA}$$

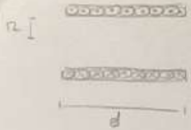
AVRÒ $\quad dF = i\, dr \times \vec{B} = i B\, dr\,(-\hat{y}) \quad \Rightarrow dM = r \times dF = i B r\, dr\,(-\hat{z})$

$$\Rightarrow P = \omega M = \omega i B \int_0^\ell r\, dr = \frac{\omega i B \ell^2}{2} = 9 \cdot 10^{-4}\ W = \boxed{0{,}9\ mW}$$

NOTA: È UN GENERATORE ⇒ FORNISCO ENERGIA MECCANICA E MI RESTITUISCE ENERGIA ELETTRICA E SO CHE TUTTO QUELLO CHE FORNISCO DALL'ESTERNO È DISSIPATO SU R, INFATTI

$$P_R = i^2 R = 0{,}9\ mW$$

$\boxed{6}$



$d = 2\ m$

$R = 1\ m$

$P = 1{,}5\ MW \qquad i = 5kA$

$\rho = 2{,}8 \cdot 10^{-8}\ \Omega m$

$\vec{J} = 8{,}55\ A/mm^2$

$P' = 0{,}2\ MW$

SICURAMENTE $\quad i = JS \rightarrow S = \dfrac{i}{J}$

$$R = \rho\frac{l}{S} = \rho\frac{2\pi R}{S} = \rho\frac{2\pi R j}{i}$$

$$P_R = i^2 R = 2\pi R \rho j i \qquad P_{sol_{diss}} = N P_R = 2\pi N R \rho j i$$

$$P = P' + P_{sol_{diss}} \Rightarrow P_{sol_{diss}} = P - P'$$

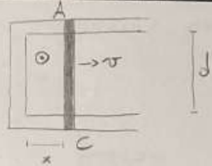
$$\Rightarrow N = \frac{(P-P')}{2\pi R\rho j i} \qquad \text{MA} \qquad n = \frac{N}{d} \Rightarrow N = nd$$

$$\Rightarrow n = \frac{(P-P')}{2\pi d R\rho j i}, \quad \text{so} \quad \vec{B}(x) = \frac{\mu_0 n i}{2}\left[\frac{d-x}{\sqrt{R^2+(d-x)^2}} + \frac{x}{\sqrt{R^2+x^2}}\right]$$

$$B(d/2) = \frac{\mu_0 n i}{2}\left[\frac{d/\cancel{2}}{\sqrt{4R^2+d^2}}\cancel{2} + \frac{d/\cancel{2}}{\sqrt{4R^2+d^2}}2\right] = \frac{\mu_0 n i d}{\sqrt{4R^2+d^2}} \qquad \text{(AL CENTRO)}$$

$$\Rightarrow \vec{B} = \frac{\mu_0 i d}{\sqrt{4R^2+d^2}}\frac{(P-P')}{2\pi d R\rho j i} = \frac{\mu_0(P-P')}{2\pi R\rho j\sqrt{d^2+4d^2}} = \boxed{0{,}384\ T}$$

1



$R = 5\,\Omega$

$v = 10\,m/s$

$B = 0{,}2\,T$

$d = 5\,cm$

LA CORRENTE INDOTTA SARÀ $i = -\frac{1}{R}\frac{d\phi}{dt} = -\frac{1}{R}\frac{d}{dt}(Bdx) = -\frac{Bd}{R}\frac{dx}{dt}$

$\Rightarrow \boxed{i = \frac{Bdv}{R} = 0{,}02\,A}$ CHE SCORRE DA A A C

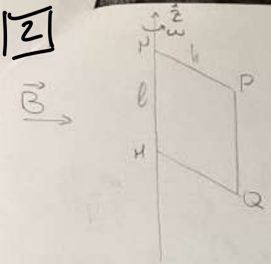
LA POTENZA SPESA PER MANTENERE LA SBARRA IN MOVIMENTO SARÀ $F_m \cdot v$ DOVE F_m È LA FORZA CHE SENTE DI ORIGINE MAGNETICA, MA ESSENDO CONSIDERABILE COME UN GENERATORE SARÀ UGUALE ALLA POTENZA DISSIPATA SULLA RESISTENZA

$\vec{F}_m = -i\,d\,B\,\hat{x}$ $\quad \vec{v} = v\,\hat{x}$

$P = \vec{F}_m \cdot \vec{v} = iBvd = \boxed{2\cdot 10^{-3}\,W = 2\,mW}$

E $P = Ri^2 = 2\cdot 10^{-3}\,W$

$\boxed{2}$

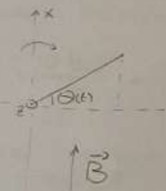


$\overline{MN} = \ell = 20\,cm \qquad \overline{NP} = h = 10\,cm$

$\omega = 150\ rad/s$

$\vec{B} = 0{,}5\,T\ \hat{x}$

- PER CALCOLARE LA FEM INDOTTA POSSO USARE FARADAY-NEUMANN-LENTZ



$\omega = \dfrac{d\theta}{dt} \Rightarrow \theta(t) = \omega t$, DALL'ALTO HO

IL FLUSSO DI B SARÀ $\quad \phi_B(t) = B\ell h \cos(\theta(t))$
$\qquad = B\ell h \cos(\omega t)$

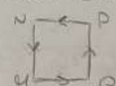
IN QUESTO MODO $\quad \dfrac{d\phi}{dt} = -\omega B\ell h \sin(\omega t)$

$\Rightarrow \mathcal{E}_i = -\dfrac{d\phi}{dt} = \omega B\ell h \sin(\omega t) \Rightarrow \mathcal{E}_{MAX} = \omega B\ell h = 1{,}5\,V$

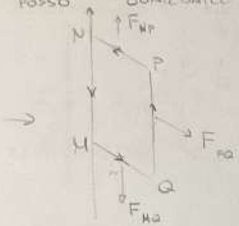
- OPPURE PER TROVARE LA FEM POTREI USARE LA FORZA DI LORENTZ

$\theta = \omega t \qquad F = qE = qv \times B \Rightarrow \vec{E} = v \times B = vB(\hat{\theta} \times \hat{x}) = vB\sin\theta\ \hat{z}$
$\qquad = \omega h B \sin(\omega t)\ \hat{z}$

COSÌ CAPISCO CHE LA i CIRCOLA



POSSO GUARDARE LE FORZE CHE AGISCONO SUI LATI



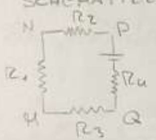
L'UNICA CHE NON SI ELIDE È SU PQ (LA $\mathcal{E}$ SARÀ LÌ)

$$\mathcal{E} = \oint E \cdot dl = \int_P^Q \omega h B \sin(\omega t)\, dl = \omega h l B \sin(\omega t)$$

$$\mathcal{E}_{MAX} = \omega h l B = 1,5\,V$$

PERÒ NON POSSO DIRE CHE IL CIRCUITO ABBIA $R_{TOT} = 0$ (SARÀ $\neq 0$ SOLO PERCHÈ ESISTE)

↳ SCHEMATIZZO



IPOTIZZANDO I = COST NEL CIRCUITO AVRÒ

$R_1 = R_4$, $R_2 = R_3$

QUINDI CON KIRCHOFF ALLA MAGLIA

$$\mathcal{E} = 2(R_1 + R_2)\, i$$

$$\begin{cases} R_1 = \rho \dfrac{l}{\Sigma} \rightsquigarrow \dfrac{\rho}{\Sigma} = \dfrac{R_1}{l} \\ R_2 = \rho \dfrac{h}{\Sigma} \end{cases} \Rightarrow R_2 = \frac{h}{l} R_1$$

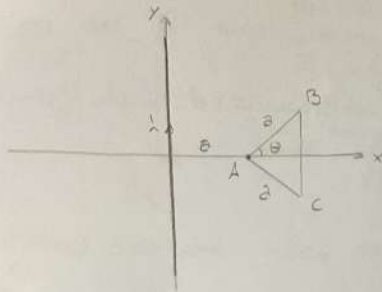
QUINDI $\mathcal{E} = 2R_1 \left(1 + \frac{h}{l}\right) i$

$$\Rightarrow \mathcal{E} = 2R_1 \frac{l+h}{l}\, i$$

ORA DEVO CALCOLARE $V_Q + \mathcal{E} - R_1 i = V_P$

$$V_P - V_Q = \mathcal{E} - R_1 i = \mathcal{E} - \frac{l\,\mathcal{E}}{2(l+h)} = \mathcal{E}\left(1 - \frac{l}{2(h+l)}\right) = \mathcal{E}\,\frac{2h + 2l - l}{2(h+l)} = \mathcal{E}\,\frac{2h+l}{2(h+l)} = \boxed{1\,V}$$

$\boxed{3}$ $a = 0{,}1\ m$



PER IL FILO CONDUTTORE INDEFINITO VALE

$$\vec{B}(x) = \frac{\mu_0 i}{2\pi x}\hat{\phi}$$

SO IL TRIANGOLO EQUILATERO

$$\theta = 30°$$

PER CALCOLARMI IL FLUSSO DEVO FARE UN INTEGRALE DOPPIO

$$\phi = \int dx \int dy\, B(x) \qquad x \in [a,\ a + a\cos\theta]$$

$tg\theta = \frac{y}{x}$ IN UN GENERICO PUNTO DEL LATO AB

$tg\theta = \frac{y}{x-a} \rightsquigarrow y = (x-a)\,tg\theta$

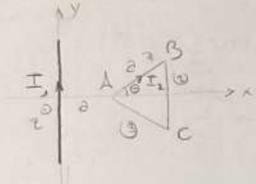
$$\phi = 2\int_a^{a+a\cos\theta} B(x)dx \int_0^{(x-a)tg\theta} dy = 2\frac{\mu_0 i}{2\pi}\int_a^{a+a\cos\theta} \frac{1}{x}(x-a)\,tg\theta\, dx = 2\frac{\mu_0 i}{2\pi} tg\theta\left[\int_a^{a+a\cos\theta} dx - \int_a^{a+\cos\theta} \frac{a}{x} dx\right]$$

$$= 2\frac{\mu_0 i}{2\pi} tg\theta\left[a\cos\theta - a\log\left(\frac{a+\cos\theta}{a}\right)\right]$$

POI SO $M = \frac{\phi}{i} = \frac{\mu_0}{\pi}\, a\, tg\theta\left(\cos\theta - \log\left(\frac{a+a\cos\theta}{a}\right)\right) = 5{,}59 \cdot 10^{-9}\ H = \boxed{5{,}59\ mH}$

ORA CONSIDERO $\quad I_1 = 2A$

$I_2 = 0{,}1 A$



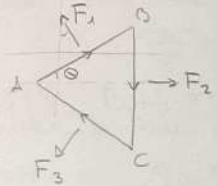
$$d\vec{F}_1 = I_2\, d\vec{l} \times \vec{B} = I_2 B\, dl\, (\hat{e} \times -\hat{z})$$

$$= -I_2 B\, dl\, (\hat{x}\cos\theta + \hat{y}\sin\theta) \times \hat{z}$$

$$\vec{F}_1 = I_2 B \int dl\, (\hat{y}\cos\theta - \hat{x}\sin\theta) \qquad dl = \frac{dx}{\cos\theta}$$

$$= \frac{\mu_0 I_1 I_2}{2\pi}\left[\int_a^{a+a\cos\theta} \hat{y}\,\frac{dx}{x} - \int tg\theta\, \frac{dx}{x}\,\hat{x}\right]$$

$$= \frac{\mu_0 I_1 I_2}{2\pi}\left(\log\left(\frac{a+a\cos\theta}{a}\right)\hat{y} - tg\theta \log\left(\frac{a+a\cos\theta}{a}\right)\hat{x}\right)$$



$$\vec{F}_2 = \frac{\mu_0 I_1 I_2}{2\pi(a+a\cos\theta)}\int_{-a/2}^{a/2} dy\, \hat{x} = \frac{\mu_0 I_1 I_2}{2\pi(1+\cos\theta)}\hat{x}$$

F_3 VEDO CHE AVRÀ COMPONENTE y OPPOSTA

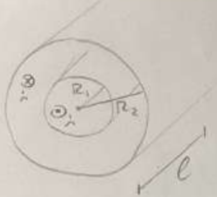
$$\vec{F}_3 = \frac{\mu_0 I_1 I_2}{2\pi}\left(-\log(1+\cos\theta)\,\hat{y} - tg\theta \log(1+\cos\theta)\,\hat{x}\right)$$

SE GUARDO LA RISULTANTE AVRÒ

$$\vec{F} = \frac{\mu_0 I_1 I_2}{2\pi}\left(-2tg\theta\log(1+\cos\theta) + \frac{1}{1+\cos\theta}\right)\hat{x} = (-7{,}38 \cdot 10^{-9}\, N)\,\hat{x}$$

$$\boxed{= (-7{,}38\ nN)\,\hat{x}}$$

4



DEVO TROVARE $\frac{dL}{dl}$

SO $L = \frac{\phi}{i}$ MI SERVE $d\phi$

LA CORRENTE È SOLO SUPERFICIALE

$r < R_1 |$ $B(r) = 0$

$R_1 < r < R_2 |$ $2\pi r B = \mu_0 i \Rightarrow \boxed{B = \frac{\mu_0 i}{2\pi r}}$

$r > R_2 |$ $2\pi r B = \mu_0 (i - i) \Rightarrow \boxed{B = 0}$

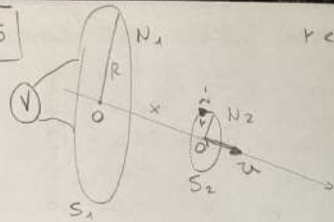
MI CALCOLO L'ELEMENTO DI FLUSSO INFINITESIMO SU UNA $dI = dl\,dr$ (GIÀ SU dl)

$$\frac{d^2\phi}{dl} = \frac{B(r)\,dl\,dr}{dl} = B(r)\,dr \Rightarrow \frac{d\phi}{dl} = \frac{\mu_0 I}{2\pi}\int_{R_1}^{R_2}\frac{dr}{r} = \frac{\mu_0 I}{2\pi}\ln\left(\frac{R_2}{R_1}\right)$$

MA VALE $\frac{dL}{dl} = \frac{d\phi}{dl}\frac{1}{I} = \boxed{\frac{\mu_0}{2\pi}\ln\left(\frac{R_2}{R_1}\right)}$

POI SO $U_m = \frac{1}{2} L I^2 \Rightarrow \frac{dU_m}{dl} = \frac{1}{2} I^2 \frac{dL}{dl} = \boxed{\frac{\mu_0 I^2}{4\pi}\ln\left(\frac{R_2}{R_1}\right)}$

5



$r \ll R$

POICHÈ $r \ll R$ POSSO CONSIDERA[RE] LA SECONDA SPIRA COME QUASI PUNTIFORME SU $\hat{x}$ (ASSE DELLA SPIRA R) E FACILITARE I CONTI PERCHÈ SO $M_{12} = M_{21} \equiv M$ QUINDI MI CALCOLO M CHE INDURREBBE R SU r

CAMPO SPIRA SUL SUO ASSE (R = RAGGIO, x = DISTANZA DAL CENTRO)

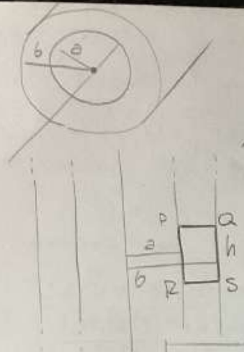
$$\vec{B} = \frac{\mu_0 i}{2} \frac{R^2}{(R^2+x^2)^{3/2}} \hat{x} \rightsquigarrow \text{HO } N_1 \text{ SPIRE} \Rightarrow \vec{B}_1(x) = \vec{B} N_1$$

$$\Phi_{S_2}(\vec{B}_1) = B_1 N_2 \pi r^2 \Rightarrow M = \frac{\Phi_{S_2}(B_1)}{i} = \frac{B_1 N_2 \pi r^2}{i} = \boxed{\frac{\mu_0 \pi r^2 R^2 N_1 N_2}{2(R^2+x^2)^{3/2}}}$$

MUOVENDOSI A VELOCITÀ v AVRÒ $\frac{d\Phi}{dt} \neq 0$

$$\frac{d\Phi}{dt} = \underbrace{\frac{\mu_0 N_1 N_2 \pi i r^2 R^2}{2}}_{\alpha} \frac{d}{dt}\left(\frac{1}{(R^2+x^2)^{3/2}}\right) = \alpha\left(-\frac{3}{2}\frac{2x}{(R^2+x^2)^{5/2}}\frac{dx}{dt}\right)$$

$$\Rightarrow -\frac{d\Phi}{dt} = \boxed{\frac{3x\mu_0 N_1 N_2 \pi i r^2 R^2 v}{2(R^2+x^2)^{5/2}} = \varepsilon}$$



$i = 5A$

$a = 3cm$

$b = 5cm$

$\mu_r = 400$

$h = 10cm$

UTILIZZO LA LEGGE DI AMPERE

$\underline{r<a}$ $B(r) = \frac{\mu_0 i}{2\pi r}\hat{\phi}$

VALE SEMPRE $H = \frac{B}{\mu}$

$\underline{r<a}$ $\boxed{H(r) = \frac{i}{2\pi r}}$ MA È IDENTICO IN $\underline{a<r<b}$ E $\underline{r>b}$ NON DIPENDENDO DALLE CORRENTI DI MAGNETIZZAZIONE

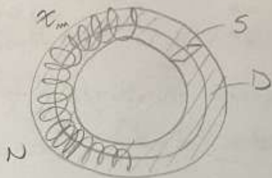
QUINDI CALCOLO $\boxed{B(r<a) = \frac{\mu_0 i}{2\pi r}\hat{\phi}}$ $\boxed{B(a<r<b) = \frac{\mu_0 \mu_r i}{2\pi r}\hat{\phi}}$

$\boxed{B(r>b) = \frac{\mu_0 i}{2\pi r}\hat{\phi}}$

POI SO $M = \chi H \Rightarrow \vec{M}(a<r<b) = \frac{\chi i}{2\pi r}\hat{\phi}$

$$\phi_{PQRS}(M) = \frac{\chi i}{2\pi}\int_a^b \frac{dr}{r}\int_0^h dh = \frac{\chi i h}{2\pi}\ln\left(\frac{b}{a}\right) = \boxed{16.22 \ Am}$$

$\boxed{2}$ $N = 500$ SPIRE
$i = 8\ A$
$S = 4\ cm^2$
$D = 132\ cm$
$\chi_m = 60$



$\sqrt{S} << D$ POSSO CONSIDE I CAMPI COSTAN

USO AMPERE PER TROVARE H : $\oint H \cdot dl = DH = Ni \Rightarrow H = \frac{Ni}{D} = \boxed{3 \cdot 10^3\ A/m}$
CALCOLATO SULLA LUNGHEZZA MEDIA

AVRÒ $B = \mu H = \mu_0 (\chi + 1) H = \boxed{0,23\ T}$

$M = \chi H = \boxed{1,8 \cdot 10^5\ A/m}$

HO $S = l^2 \Rightarrow l = \sqrt{S} = 2\ m$

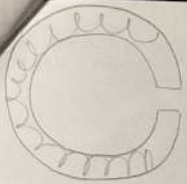
QUINDI SE $B \sim cost \Rightarrow \Phi(B) = NBS \boxed{= 0,046\ T\,m^2}$

SE ESPLICITO TUTTO $\Phi(B) = NS\mu_0(\chi+1)\frac{Ni}{D} = \frac{N^2 S \mu_0}{D}(\chi+1)i$

$\Rightarrow L = \frac{\Phi}{i} = \frac{N^2 S \mu_0}{D}(\chi+1) = \boxed{5.8 \cdot 10^{-3}\ F}$

QUINDI $U = \frac{1}{2} L i^2 = \boxed{0,186\ J}$

HO M UNIFORME $\Rightarrow \vec{J}_{M,S} = \vec{M} \times \hat{n} = \vec{M} \Rightarrow I_A = JD = MD \boxed{= 2,37 \cdot 10^5\ A}$



$d = 2\ cm$

PARTO DA

$$\oint H\cdot dl = H(D-d) + H_0 d = Ni$$

SO $B_t = cost \Rightarrow \mu_0 H_0 = \mu_0 \mu_r H \Rightarrow H_0 = \mu_r H = (\chi + 1)H$

$$H\{D - d + \chi d + d\} = Ni$$

$$H\{D + \chi d\} = Ni$$

$$\Rightarrow H_2 = \frac{Ni}{D+\chi d}$$ PRIMA $$H = \frac{Ni}{D}$$

QUINDI $$H_2 = \boxed{\frac{D}{D+\chi d} H} \Rightarrow B_2 = \mu_0 \mu_r H_2 = \frac{D}{D+\chi d}\mu_0\mu_r H = \boxed{\frac{D}{D+\chi d} B}$$

$$M_2 = \chi H_2 = \boxed{\frac{D}{D+\chi d} M}$$

$$\phi(B_2) = NSB_2 = NSB\frac{D}{D+\chi d} = \boxed{\frac{D}{D+\chi d}\phi(B)}$$

$$L_2 = \frac{\phi_2}{i} = \frac{D}{D+\chi d}\frac{\phi(B)}{i} = \boxed{\frac{D}{D+\chi d} L}$$

$$U_2 = \frac{1}{2} L_2 i^2 = \frac{D}{D+\chi d}\frac{1}{2} L i^2 = \boxed{\frac{D}{D+\chi d} U}$$

$$\frac{D}{D+\chi d} \simeq = \frac{11}{21} \sim 0{,}52$$

4 $\sqrt{5}$ SC D

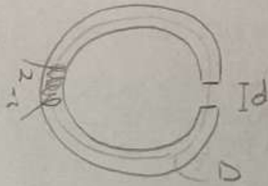
$D = 80\ cm$

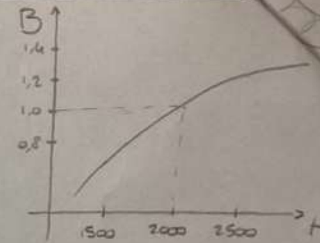
$N = 30$ SPIRE

$d = 1\ cm$

$B_0 = 1\ T$

$d' = 2\ cm$





HO UNA RELAZIONE NON LINEARE DI H, B

$$\oint H\, dl = H(D-d) + H_0 d = Ni$$

PERÒ NEL VUOTO $B_0 = \mu H_0 = \mu_0 H_0$

IN GENERE $B_n = cost$ $\mu_0 H_0 = \mu_0 \mu_r H \Rightarrow H_0 = \mu_r H$

$$\Rightarrow H(D - d + \mu_r d) = Ni \Rightarrow \boxed{H = \frac{Ni}{(D - d + \mu_r d)}}$$

PERÒ $B = \mu_0 \mu_r H = \frac{\mu_0 \mu_r N i}{(D - d + \mu_r d)}$

$$\Rightarrow \boxed{i = \frac{B(D + d(\mu_r - 1))}{\mu_0 \mu_r N}}$$

MI SERVE μ_r, MA DAL CICLO VEDO CHE $B = 1\ T \Rightarrow H = 2000\ A/m$

$$\Rightarrow \mu_r = \frac{B}{\mu_0 H} = 397{,}8 \Rightarrow \boxed{i = 317{,}9\ A} \quad E \quad \boxed{i' = 582{,}5\ A}$$

5

$R = 10$ cm

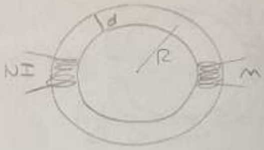
$d = 1$ cm

$N = 100$ SPIRE

$I = 2$ A

$n = 10$ SPIRE

$\mu_r = 5000$



LA SEZIONE SARÀ

$$S = \pi \frac{d^2}{4} = 7{,}85 \cdot 10^{-5} \ m^2$$

$$\ell = 2\pi R = 0{,}63 \ m$$

QUINDI $\sqrt{S} \ll \ell$

POSSO CONSIDERARE B COST ALL'INTERNO DELL'ANELLO

$$\oint H \cdot d\ell = \ell H = NI \Rightarrow H = \frac{NI}{\ell}$$

COSÌ $B = \mu_0 \mu_r H = \mu_0 \mu_r \dfrac{NI}{\ell}$

E IL FLUSSO SUL SECONDO AVVOLGIMENTO SARÀ

$$\phi = nBS = \frac{\mu_0 \mu_r N n I S}{\ell} = \boxed{1{,}56 \cdot 10^{-3} \ T m^2}$$