

Progetto Manhattan: spettrometro di massa

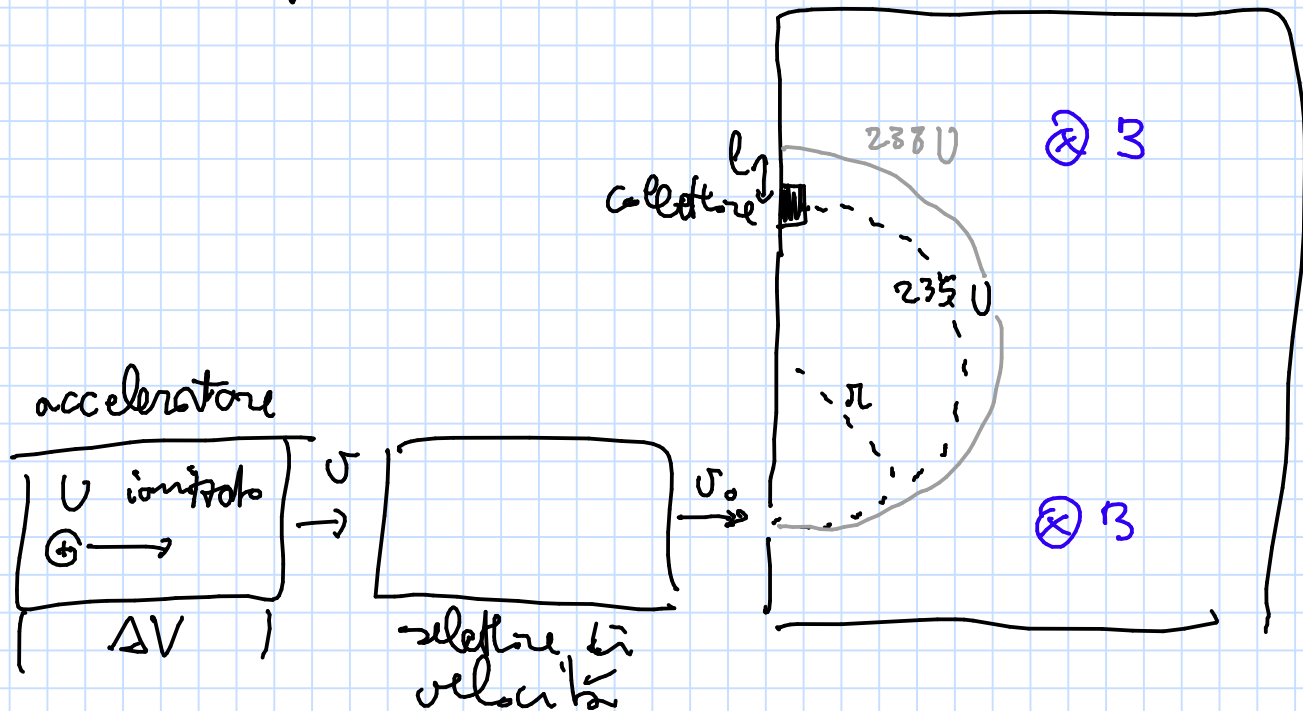
1939, > 100 000 persone

bombe atomiche: arricchimento uranio

^{235}U 0,7% ←

^{238}U comune

→ Trinity test 1944



$l = 20 \text{ cm}$ tra collettore e ^{238}U
 ^{235}U

acceleratore: $\Delta V = 10^4 \text{ V}$

$$v \simeq \sqrt{\frac{2 e \Delta V}{m_0}} \simeq \sqrt{\frac{2 e \Delta V}{238 m_p}} \simeq 10^5 \text{ m/s}$$

$v_0 = 10^5 \text{ m/s}$ per ^{235}U e ^{238}U

$$r = \frac{m v}{e B} \quad \begin{cases} 238: & r' = 238 \frac{m_p v_0}{e B} \\ 235 & r = 235 \frac{m_p v_0}{e B} \end{cases}$$

$$L = 2(r' - r)$$

$$r' - r = \frac{L}{2} = 10 \text{ cm}$$

$$r' - r = (238 - 235) \frac{1.67 \cdot 10^{-27} \text{ kg} \cdot 10^5 \text{ m/s}}{1.6 \cdot 10^{-19} \cdot B}$$

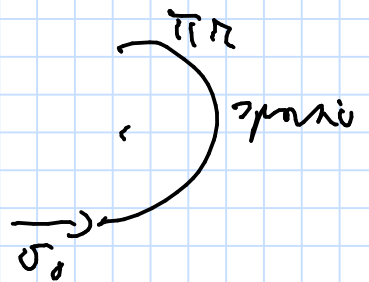
$$\rightarrow B = 0.031 \text{ T}$$

$$\rightarrow r = \frac{\dots}{\dots} = 7.9 \text{ m}$$

tempo nel $\vec{B}$

$$t = \frac{T}{2} = \frac{1}{2} \frac{2\pi m}{e B} \approx 0.25 \text{ m/s}$$

$$t = \frac{\text{spazio}}{\text{veloc.}} = \frac{\pi r}{v_0} = 0.25 \text{ m/s}$$

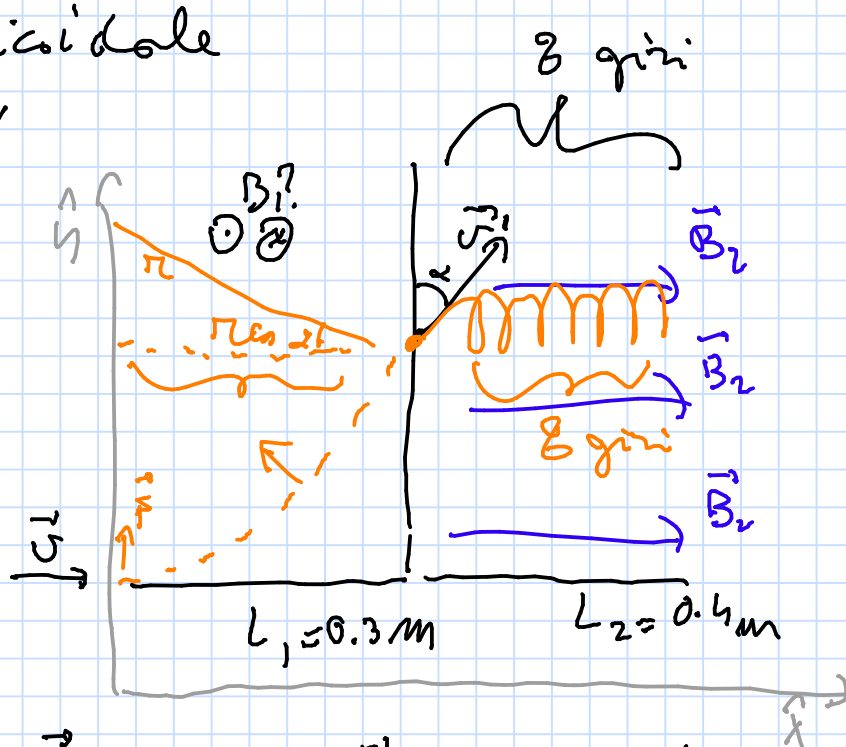


esercizio moto elicoidale

e^- accel. da $\Delta V = 2 \text{ kV}$

$$\alpha = \pi / 5$$

- 1) $|\vec{v}|$
- 2) $\vec{B}_1$?
- 3) $\vec{B}_2$?
- 4) π_2 in $\vec{B}_2$?



1) $\vec{B}_1$ uscente f.c. $\vec{F} = (-e) \vec{v}' \times \vec{B}$ verso alto

$$|\vec{v}'| = |\vec{v}|$$

$$\frac{1}{2} m_e v^2 = |-e \Delta V|$$

$$|\vec{v}| = \sqrt{\frac{2e \Delta V}{m_e}} = 2.65 \cdot 10^7 \text{ m/s}$$

$$2) L_1 = \pi \cos \alpha$$

$$\pi = \frac{m_e v}{e B_1} = \frac{L_1}{\cos \alpha}$$

$$\cos \alpha = 0.81$$

$$\Rightarrow B_1 = \frac{m_e v \cos \alpha}{e L_1} = 0.4 \text{ mT}$$

$$\vec{B}_1 = (0.4 \text{ mT}) \hat{x}$$

3) moto elicoidale

$$v_{//} = v \sin \alpha = v \cdot 0.59 = 1.56 \cdot 10^7 \text{ m/s}$$

$$v_{\perp} = v \cos \alpha = v \cdot 0.81 = 2.15 \cdot 10^7 \text{ m/s}$$

$$\text{in } t_2 = \frac{L_2}{v_{//}} \quad \text{ci sono 8 giri}$$

$$t_2 = 8 \tau_2$$

$$\tau_2 = 2\pi \frac{m_e}{e B_2}$$

$$\Rightarrow \tau_2 = \frac{t_2}{8} = \frac{L_2}{8 v_{//}} \quad \text{...}$$

$$\Rightarrow B_2 = 2\pi \frac{m_e}{e} \frac{8 v_{//}}{L_2} = \dots = 11 \text{ mT}$$

4) r_2 determinato da $\vec{v}_{\perp}$

$$r_2 = \frac{m_e v_{\perp}}{e B_2} = 11 \text{ mm}$$

⚠ sempre rapporto $\frac{m_e}{e}$ o $\frac{e}{m_e}$

Forza magnetica su conduttori percorsi da corrente

consideriamo $q > 0$

(anche $q = -e$
 $\vec{v}_d \parallel -j$)

$$\vec{j} = q n \vec{v}_d$$

su una q :
$$\vec{F}_L = q \vec{v} \times \vec{B}$$

per un insieme di cariche q , media $\langle \dots \rangle$

$$\begin{aligned} \langle \vec{F}_L \rangle &= q \langle \vec{v} \rangle \times \vec{B} \\ &= q \vec{v}_d \times \vec{B} \end{aligned}$$

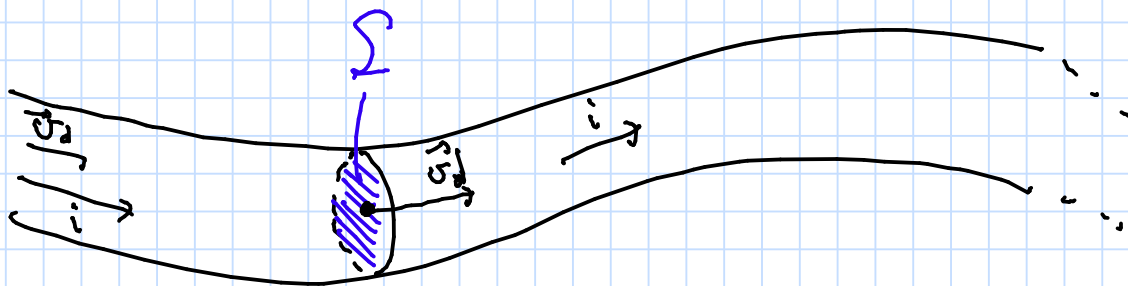
n : n° di q / m^3

$\vec{F}_L$ per unità di vol

$$\vec{F}_L = n \langle \vec{F}_L \rangle$$

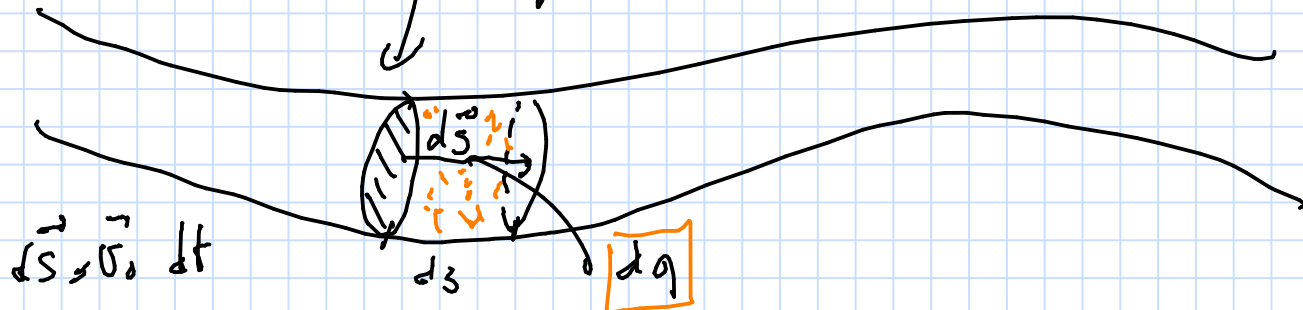
$$= n q \vec{v}_d \times \vec{B}$$

$$\boxed{\vec{F}_L = \vec{j} \times \vec{B}}$$

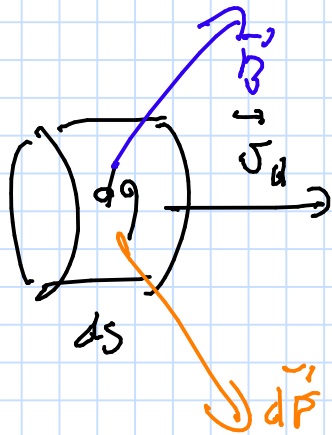


$q > 0$

dopo tempo dt



dq nel tratto di lunghezza ds



$$d\vec{F} = dq \vec{r}_d \times \vec{B}$$

come se
dq fosse
puntiforme

$$= dq \frac{d\vec{s}}{dt} \times \vec{B}$$

$$= \frac{dq}{dt} d\vec{s} \times \vec{B}$$

forza su tratto
di filo $d\vec{s}$

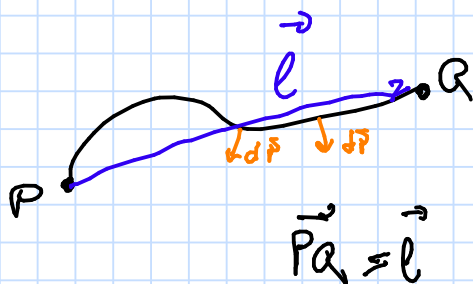
$$\boxed{d\vec{F} = i d\vec{s} \times \vec{B}} \quad \text{2ª Legge di Laplace}$$

dc volume
 $dc = \sum ds$

$$= \vec{F}_c \cdot d\vec{z}$$

su un filo in campo $\vec{B}$ omogeneo

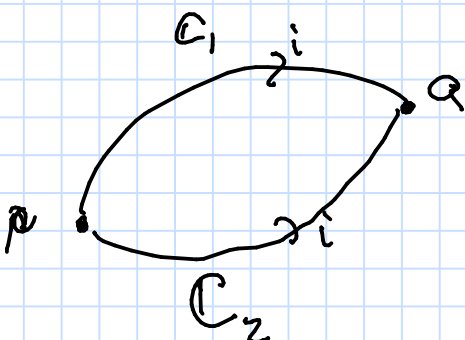
$$\vec{F}_{\text{filo}} = \int d\vec{F} = i \int_P^Q d\vec{s} \times \vec{B} = i \underbrace{\vec{PQ}}_{\vec{B} \text{ omogeneo}} \times \vec{B}$$



$$\boxed{\vec{F}_{\text{filo}} = i \vec{l} \times \vec{B}}$$

⚠ dipende solo da estremi!

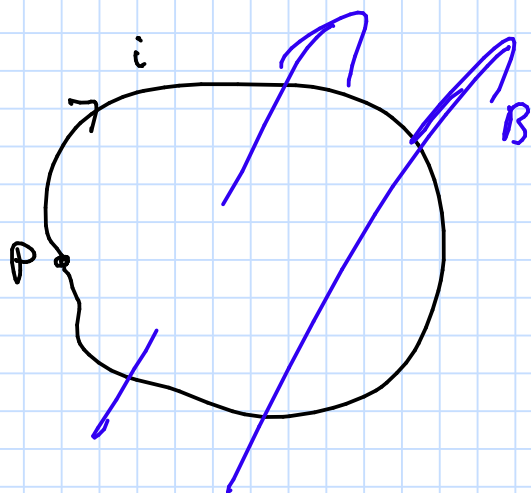
$$\vec{P}_{C_1} = \vec{P}_{C_2} = \dots$$



per circuito chiuso

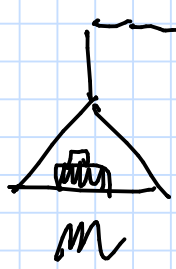
$$\vec{P} \equiv \vec{Q}$$

$$\vec{M}_{\vec{P}} = 0$$



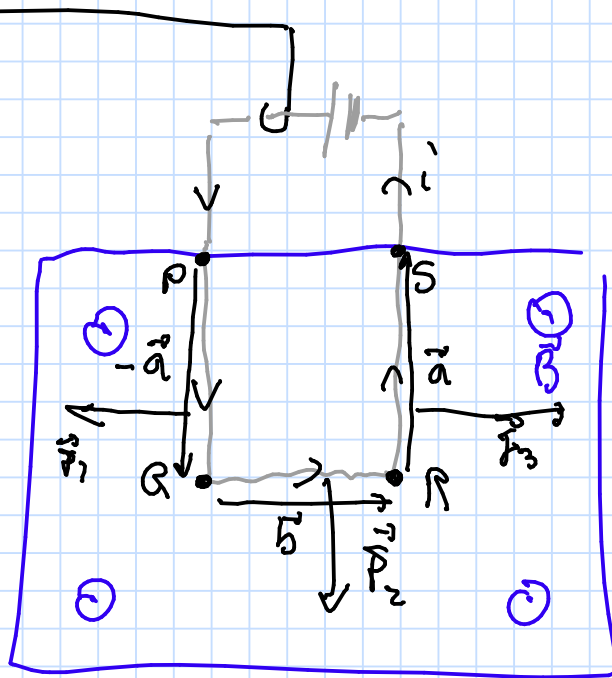
Esercizio 2.1

Dinamometro



$$\vec{r} = \vec{RS} = -\vec{PQ}$$

$$\vec{b} = \vec{QR}$$



$$\vec{F}_1 = i (-\vec{a}) \times \vec{B}$$

$$\vec{F}_3 = i \vec{a} \times \vec{B}$$

$\vec{F}_1$ diretta da regola mano dx

$$\vec{F}_1 + \vec{F}_3 = \vec{0}$$

$$\vec{F}_2 = i \vec{b} \times \vec{B} = i b B (-\hat{y})$$

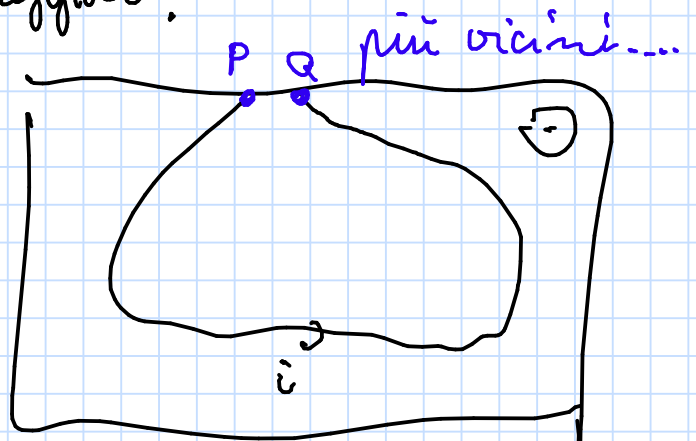
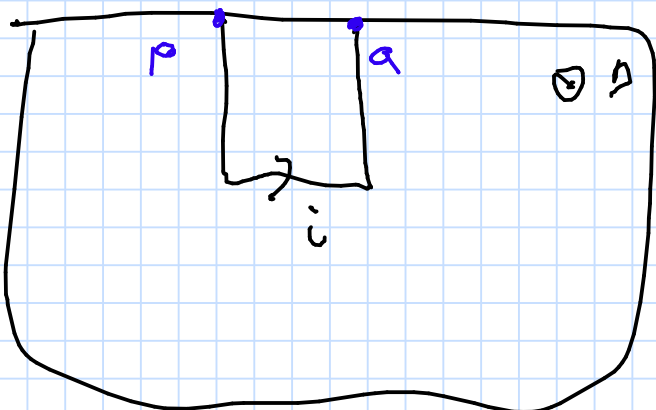
$$\vec{F}_{\text{res}} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{F}_2$$

bastava guardare

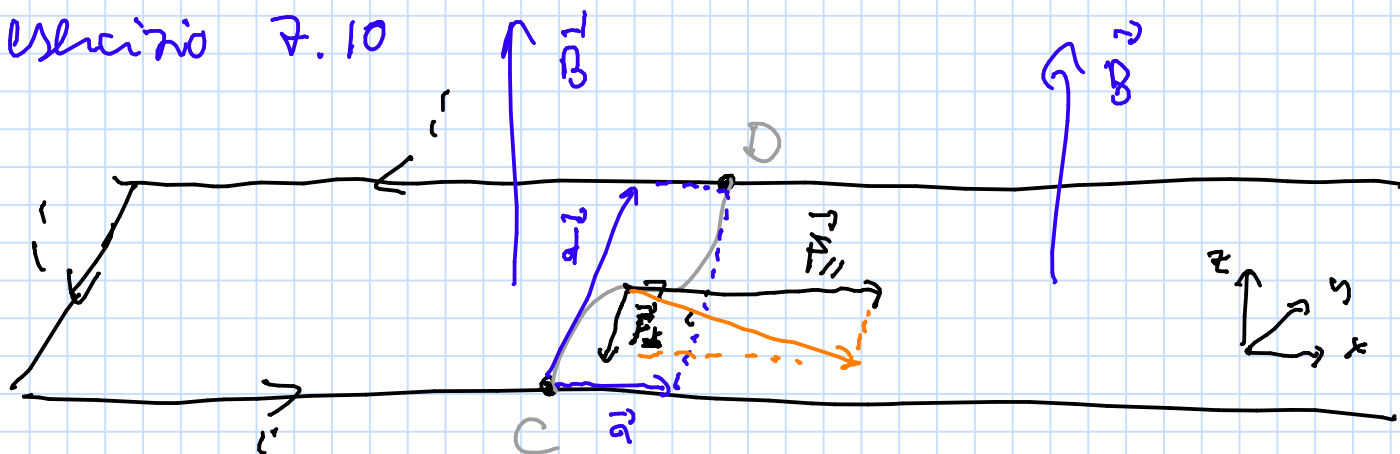
$$\vec{PS}$$

Dinamometro: $Mg = i b B$

quale circuito subisce F maggiore?



Esercizio 7.10



$$\vec{CD} = \vec{d} + \vec{a}$$

$$\vec{F}_{CD} = i \vec{CD} \times \vec{B}$$

$$= i (\vec{d} + \vec{a}) \times \vec{B}$$

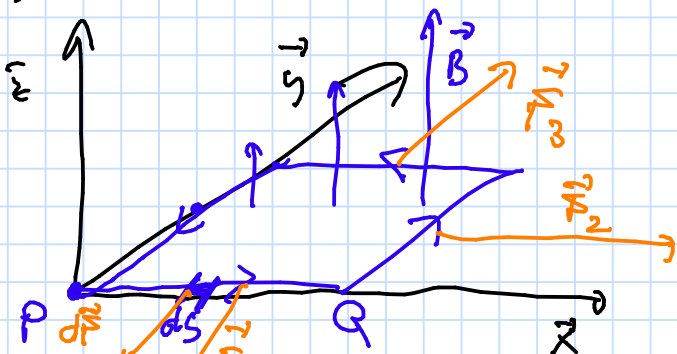
$$= i \vec{d} \times \vec{B} + i \vec{a} \times \vec{B}$$

è quella che
fa accelerare
filo // binari

per def. $\vec{F}_{||}$ consideriamo
comp. $\vec{d}$ di $\vec{CD}$ che
è $\perp$ binari, forma
del filo non è
importante

7.12

spira quadrata, lato a



$$\vec{B} = \alpha \times \hat{z}$$

non omogeneo $\Rightarrow \vec{M}_{ris} \neq 0$

$$\vec{P}_1 = \int_P^Q d\vec{P} = i \alpha \frac{a^2}{2} (-\hat{y})$$

$$\vec{M}_1 = -\vec{M}_2$$

$$\vec{M}_2 = i a \alpha a \hat{x} = i a^2 \alpha \hat{x}$$

$$\vec{M}_1 = 0$$

$$B(x=0) = 0$$

$$\vec{M}_{ris} = \vec{P}_2 = (0.4 N) \hat{x}$$