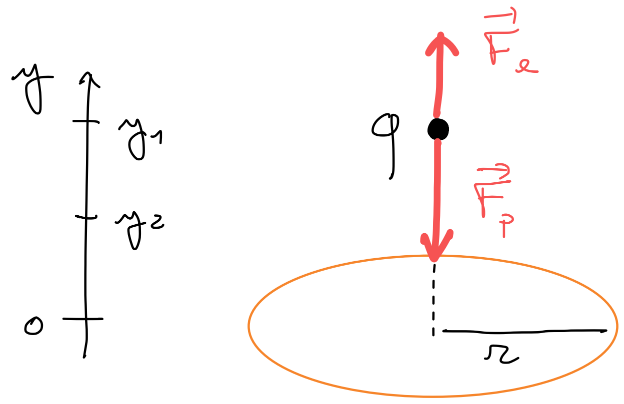
# ESERCIZIO 1

1)




$$\vec{F}_p = -mg\,\hat{y}$$

$$\vec{F}_e = +qE\,\hat{y} = \hat{y}\,\frac{qQ}{4\pi\varepsilon_0}\frac{y_1}{(y_1^2+R^2)^{3/2}}$$

$$\boxed{\vec{F} = \left(\frac{qQ}{4\pi\varepsilon_0}\frac{y_1}{(y_1^2+R^2)^{3/2}} - mg\right)\hat{y}}$$

2) L'energia potenziale iniziale vale

$$U_1 = mgy_1 + \frac{1}{4\pi\varepsilon_0}\frac{Qq}{\sqrt{y_1^2+R^2}}$$

Quando raggiunge la quota $y_2$ l'energia cinetica è nulla, quindi

$$U_2 = U_1 \iff mgy_1 + \frac{1}{4\pi\varepsilon_0}\frac{Qq}{\sqrt{y_1^2+R^2}} = mgy_2 + \frac{1}{4\pi\varepsilon_0}\frac{Qq}{\sqrt{y_2^2+R^2}}$$

Divido per m e ottengo

$$gy_1 + \frac{q/m}{4\pi\varepsilon_0}\frac{Q}{\sqrt{y_1^2+R^2}} = gy_2 + \frac{q/m}{4\pi\varepsilon_0}\frac{Q}{\sqrt{y_2^2+R^2}}$$

$$\Rightarrow \frac{q}{m} = g(y_1-y_2)\frac{4\pi\varepsilon_0}{Q}\left(\frac{1}{\sqrt{y_2^2+R^2}} - \frac{1}{\sqrt{y_1^2+R^2}}\right)^{-1}$$

Approssimo $y \gg r$

$$\frac{q}{m} \approx \frac{4\pi\varepsilon_0}{Q} g (y_1 - y_2) \frac{y_1 y_2}{y_1 - y_2}$$

$$\Rightarrow \boxed{\frac{q}{m} = \frac{4\pi\varepsilon_0}{Q} g\, y_1 y_2 \approx 1.2 \times 10^{-3}\ C/kg}$$

3) La carica è in equilibrio in $y_3$ tale che $\vec{F} = 0$

$$\frac{qQ}{4\pi\varepsilon_0} \frac{y_3}{(y_3^2 + r^2)^{3/2}} = mg$$

Approssimo $(y_3^2 + r^2)^{3/2} \approx y_3^3$

$$\frac{qQ}{4\pi\varepsilon_0} \frac{y_3}{y_3^3} = mg$$

$$\boxed{y_3 \approx \sqrt{\frac{q}{m} \frac{Q}{4\pi\varepsilon_0} \frac{1}{g}} \approx \sqrt{y_1 y_2} \approx 104\ cm}$$

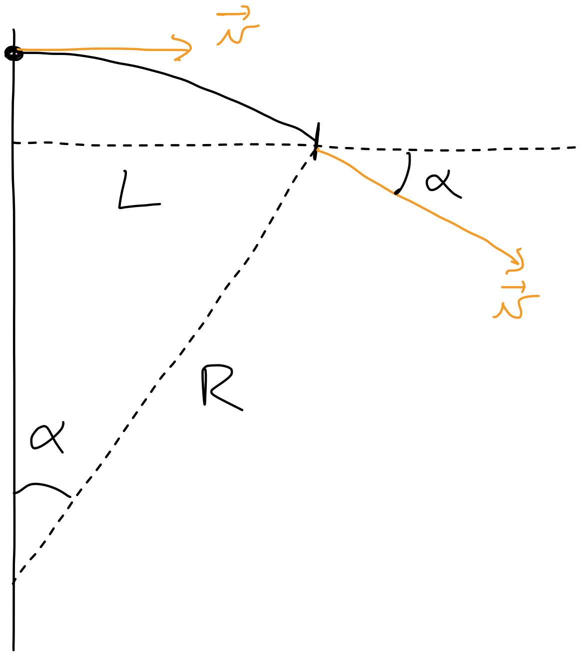
Si noti che $y_2 < y_3 < y_1$

# ESERCIZIO 2

1) $E_k = \frac{1}{2} m_p v^2 \implies v = \sqrt{\frac{2E_k}{m}}$

$$\boxed{p = mv = \sqrt{2 E_k m_p} \approx 4.3 \ \frac{MeV}{c} \approx 2.3 \times 10^{-21} \ kg \frac{m}{s}}$$

2) L'orbita è circolare, e $|\vec{v}|$ è costante




Il raggio della traiettoria nel moto circolare uniforme è dato da

$$\frac{mv^2}{R} = qvB$$

$$\implies R = \frac{mv}{qB} \approx 7.2 \ cm$$

L'angolo si ottiene da $L = R \sin\alpha$

$$\implies \boxed{\alpha = \arcsin \frac{L}{R} \approx 0.43 \ rad \approx 25^\circ}$$

3) Affinché il protone torni indietro deve essere

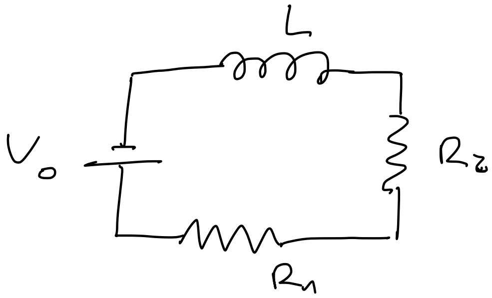
$$R < L$$

$$\frac{mv}{qB} < L$$

$$\boxed{B > \frac{mv}{qL} \approx 0.48 \ T}$$

# ESERCIZIO 3

1)




Quando chiudo il circuito

$$I(t) = I_0 \left[1 - \exp\left(-\frac{t}{\tau_L}\right)\right]$$

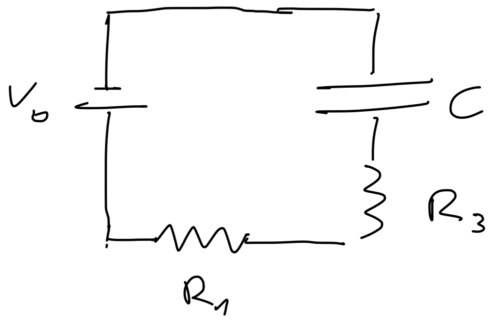
con $I_0 = \dfrac{V_0}{R_1+R_2}$ e $\tau_L = \dfrac{L}{R_1+R_2}$

A $t = t_1$

$$\exp\left(-\frac{t_1}{\tau_L}\right) = \frac{1}{2}$$

$$\Rightarrow \frac{t_1}{\tau_L} = \log 2 \quad \Rightarrow \quad \boxed{L = (R_1+R_2)\,\frac{t_1}{\log 2} \approx 3.2 \text{ mH}}$$

2) A $t_2$

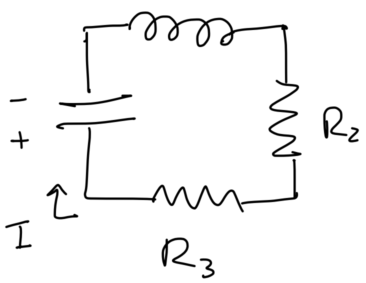



$$V_c = V_0 \left[1 - \exp\left(-\frac{t_2 - t_1}{\tau_c}\right)\right] \quad \text{con} \quad \tau_c = (R_1+R_3)C$$

$$\Rightarrow \exp\left(-\frac{t_2-t_1}{\tau_c}\right) = \frac{3}{4}$$

$$\frac{t_2-t_3}{\tau_c} = \frac{(t_2-t_1)}{(R_1+R_3)C} = \log\frac{4}{3} \quad \Rightarrow \quad \boxed{C = \frac{1}{\log 4/3}\,\frac{t_2-t_1}{R_1+R_3} \approx 7.5\,\mu\text{F}}$$

3)




$$-\frac{Q}{C} - (R_3+R_2)I - L\frac{dI}{dt} = 0$$

$$I = \frac{dQ}{dt}$$

$$\Rightarrow \quad \frac{d^2Q}{dt^2} + \frac{(R_2+R_3)}{L}\frac{dQ}{dt} + \frac{Q}{LC} = 0$$

chiamo $\Gamma = \frac{R_2+R_3}{L} \approx 6.9\times10^4\ s^{-1}$ $\qquad \omega_0 = \frac{1}{\sqrt{LC}} \approx 6.4\times10^3\ s^{-1}$

$$\boxed{\Delta = \left(\frac{\Gamma}{2}\right)^2 - \omega_0^2 \approx 1.2\times10^9\ s^{-2} > 0}$$

smorzamento sovracritico

# ESERCIZIO 4

1) $$\boxed{\langle I \rangle = \frac{P}{A} = \frac{P}{4\pi d^2} \approx 0.8 \frac{600\,W}{4\pi\,(5.0\,m)^2} \approx 1.3 \frac{W}{m^2}}$$

2) $$\langle I \rangle = \frac{E_{eff}\,B_{eff}}{\mu_0} = \frac{E_{eff}^2}{\mu_0 c} = \frac{c}{\mu_0} B_{eff}^2$$

$$\boxed{\begin{array}{l} E_{eff} = \sqrt{\mu_0 c \langle I \rangle} \approx 22 \frac{V}{m} \\ B_{eff} = \frac{E_{eff}}{c} \approx 7.3 \times 10^{-8}\,T \end{array}}$$

$$\left( \mu_0 c = \frac{1}{c\,\varepsilon_0} \right)$$

3) Nel caso di riflessione totale

$$\langle P \rangle = 2 \frac{\langle I \rangle}{c} \approx 8.5 \times 10^{-9}\,Pa$$

$$\boxed{F = \langle P \rangle \pi a^2 \approx 6.7 \times 10^{-11}\,N}$$