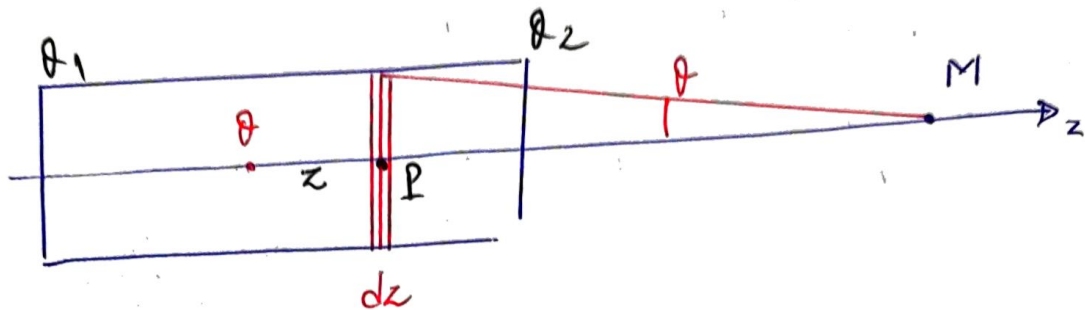


$$\vec{B}_{\text{bobine}} = \frac{\mu_0 n i}{2} (\cos \theta_1 - \cos \theta_2) \vec{e}_z$$



$$\vec{B} = \frac{\mu_0 I}{2R} \sin^3 \theta \vec{e}_z \Rightarrow \vec{dB} = \frac{\mu_0 i n}{2R} \sin^3 \theta dz \vec{e}_z$$

$$\frac{d\theta}{dP} = \frac{R}{P^2} \Rightarrow \left( \frac{P}{R} \right) = \frac{R}{d\theta}$$

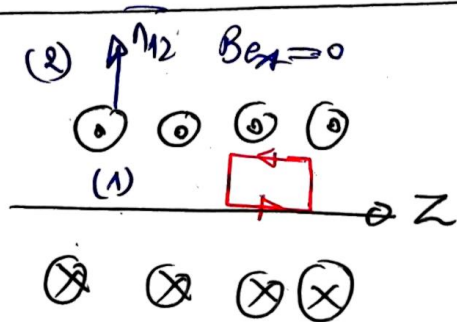
$$\overline{OM} = \overline{OP} + \overline{PM} \Rightarrow d(\overline{OM}) = 0 = dz + d(PR)$$

$$d(PR) = R d(\cot \theta) = -\frac{R d\theta}{\sin^2 \theta} = -dz$$

Solenoid infinite

$$\oint \vec{B} \cdot d\vec{l} = 0$$

$$\Rightarrow B_{\text{int}} = \text{const}$$



$$\vec{B}_{\text{ext}} - \vec{B}_{\text{int}} = \mu_0 \int_S \vec{n}_{12}$$

$$\vec{0} - \vec{B}_{\text{int}} = \mu_0 j_s \vec{e}_\theta \wedge \vec{e}_z \quad \left| \quad \vec{B}_{\text{int}} = \mu_0 j_s \vec{e}_z \right.$$

$$I = \int j_s d\vec{n} = j_s l = j_N i$$

$$\vec{j}_s = \left( \frac{N}{L} \right) \vec{i} = n \vec{i}$$

$$\vec{B}_{\text{soln}} = \begin{cases} \mu_0 n i \vec{e}_z & r < R \\ 0 & r > R \end{cases}$$

Plan

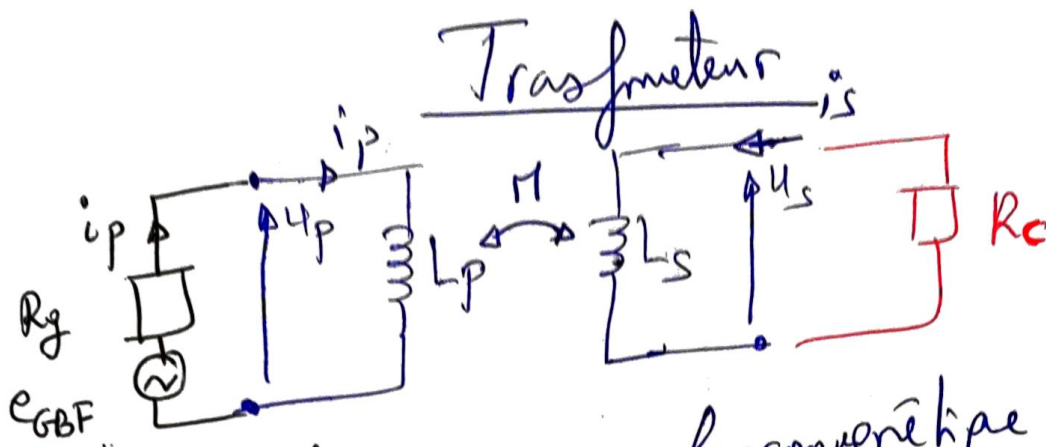
$$\vec{B}_2(z > 0) - \vec{B}_1(z < 0) = \mu_0 \vec{j}_s \wedge \vec{n}_{1,2}$$

$\vec{B}(z) \rightarrow$   
 $\vec{B}(-z) \rightarrow$   
 $B(z) - B(-z)$

$$2 \vec{B}(z > 0) = \mu_0 \vec{j}_s \wedge \vec{e}_z$$

$$\boxed{\vec{B} = \mu_0 \frac{\vec{j}_s \wedge \vec{e}_z}{2}}$$

|                                                                       |                                                                                                                                                   |
|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| $\oint \vec{B} \cdot d\vec{l} = \mu_0 \oint \vec{j}_v \cdot d\vec{S}$ | $\oint \vec{B} \cdot d\vec{l} = \mu_0 \oint \vec{j}_v \cdot d\vec{S} + \mu_0 \oint \frac{\epsilon_0 \partial \vec{E}}{\partial t} \cdot d\vec{S}$ |
| $\nabla \times \vec{B} = \mu_0 \vec{j}_v$                             | $\nabla \times \vec{B} = \mu_0 \left[ \vec{j}_v + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right]$                                         |

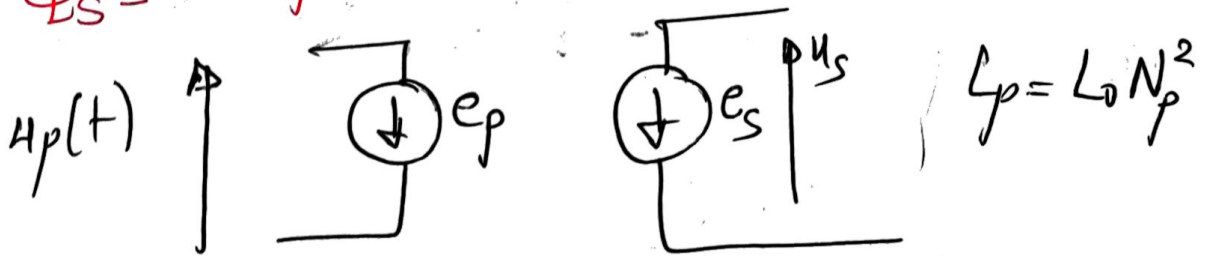


$$0 \leq k = \frac{|M|}{\sqrt{L_p L_s}} \leq 1$$

ferr magnétique pour  
canaliser les lignes de  $\vec{B}$

$$\begin{aligned}\Phi_p &= \Phi_{prop} + \Phi_{mutuelle} \\ &= L_p i_p + M i_s\end{aligned}$$

$$\Phi_s = \Phi_p + \Phi_m = L_s i_s + M i_p$$



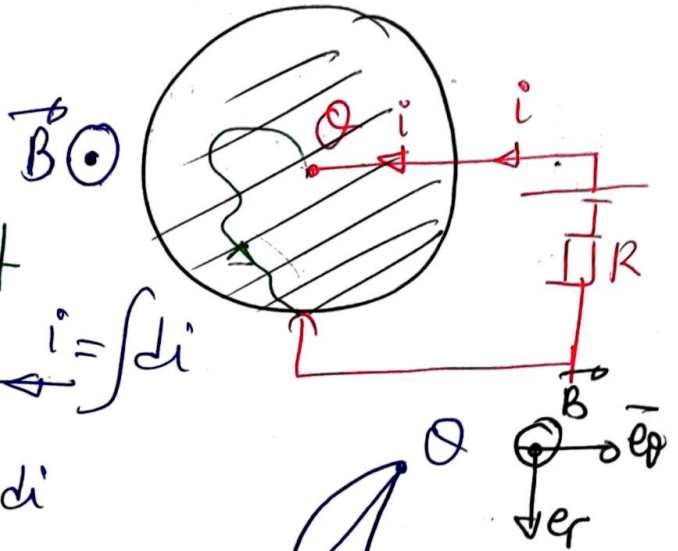
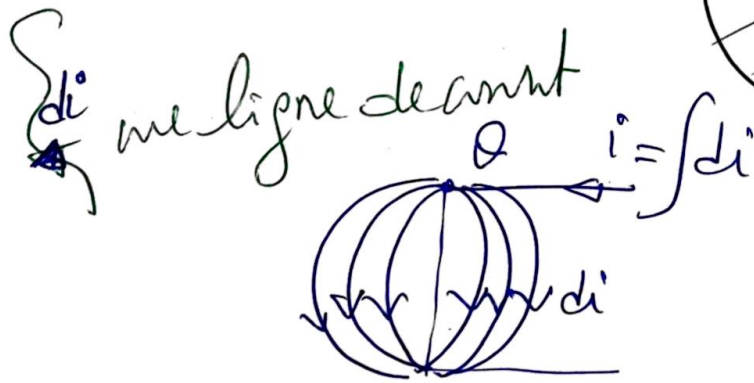
$$u_p = - \frac{e(t)}{p} = \frac{d\Phi_p}{dt} = L_p \frac{di_p}{dt} + M \frac{di_s}{dt}$$

$$u_s = -e_s(t) = L_s \frac{di_s}{dt} + M \frac{di_p}{dt}$$

$$\frac{u_s}{u_p} = \frac{N_s}{N_p} ; \frac{i_s}{i_p} = - \frac{N_p}{N_s}$$

Lorentz:

Ponce de Barbon



$$\vec{F}_{Lap} = di \vec{dl} \wedge \vec{B}$$

$$= di [dr \vec{e}_r + r d\theta \vec{e}_\theta] \wedge B \vec{e}_z$$

$$\vec{F}_{Lap} = di B dr (-\vec{e}_\theta) + di B r d\theta (\vec{e}_r)$$

$$\vec{M}_{Lap} = \vec{r} \wedge \vec{F}_{Lap}$$

$$\vec{M}_{Lap} = r \vec{e}_r \wedge di B dr (-\vec{e}_\theta)$$

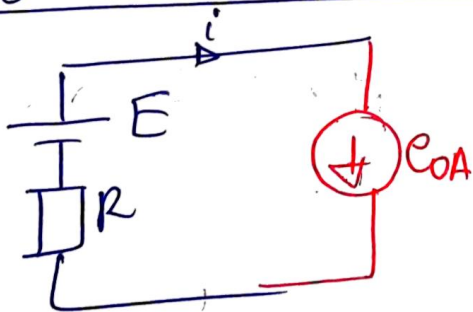
$$\vec{M}_{Lap} = -B \int_0^a r dr \int di \vec{e}_z$$

$$\vec{M}_{Lap} = -\frac{B a^2 i}{2} \vec{e}_z$$

Lorentz.  $P_{Lap} + e i = 0$

$$e = - \frac{\overline{M} \cdot \vec{\omega}}{i} = + \frac{B a^2}{2} \omega$$

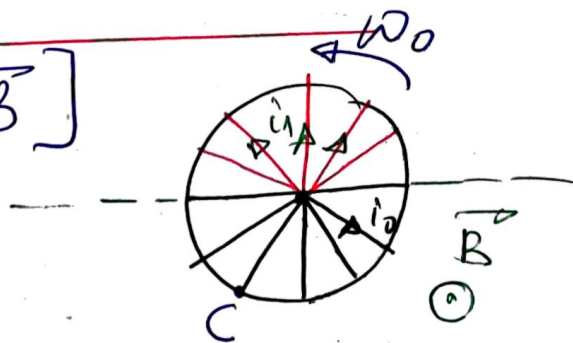
$$\boxed{J \frac{d\omega}{dt} = - \frac{B a^2}{2} i}$$



$$E + e0A = R i$$

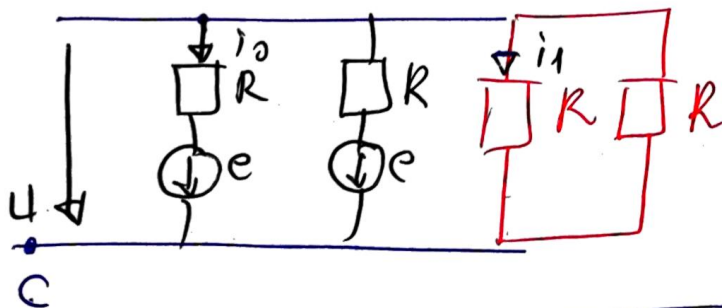
$$d\overline{M}_{Lap} = r \overline{e} \wedge [i_0 \overline{dL} \wedge \vec{B}]$$

$$\frac{N}{2} (i_0 + i_1) = 0$$



$$U = e - R i_0$$

$$U = -R i_1$$



$$i_0 = \frac{e - U}{R}$$

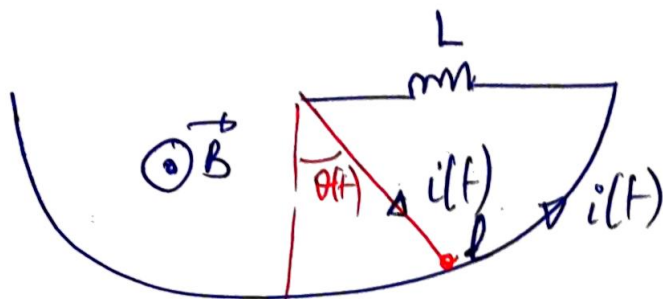
$$\Rightarrow \boxed{e = 2U}$$

$$\boxed{e = - \frac{P_{Lap}}{i_0}}$$

$$i_1 = - \frac{U}{R}$$

$$\Rightarrow i_0 = \frac{e}{R} - \frac{e}{2R} = \frac{e}{2R}$$

B<sub>g</sub>



$$\vec{\Gamma} = \vec{r} \wedge \vec{B} \quad \left. \begin{array}{l} B \text{ uniforme} \\ \text{indéformable} \end{array} \right\}$$

$$\vec{M}_{\text{sup}} = \int_0^L \vec{OM} \wedge (i d\vec{r} \wedge B \vec{e}_z)$$

$$= - \frac{B l^2 i}{2} \vec{e}_z$$

$$d\hat{\Phi}_c = B \vec{e}_z \cdot \left[ \begin{array}{l} \text{déplacement} \wedge \text{sens ant} \\ \downarrow \\ r d\theta \vec{e}_\theta \wedge dr \vec{e}_r \end{array} \right]$$

$$d^2 \hat{\Phi}_c = r dr d\theta B (\vec{e}_z) (-\vec{e}_z)$$

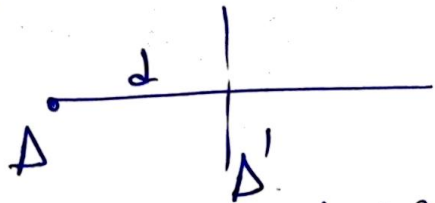
$$d\hat{\Phi}_c = - \frac{B d\theta l^2}{2}$$

$$e = - \frac{d\hat{\Phi}_c}{dt} = \frac{B l^2}{2} \frac{d\theta(t)}{dt} = L \frac{di(t)}{dt}$$

$$\frac{B l^2}{2L} (\theta(t) - \theta_0) = i(t)$$

$$J \frac{d\vec{\omega}}{dt} = \vec{M}_{\text{Lap}} + \vec{M}_I$$

$$\downarrow \frac{ml^2}{3} = -\frac{Bl^2}{2} \vec{e}_z - \frac{mgl}{2} \sin\theta$$

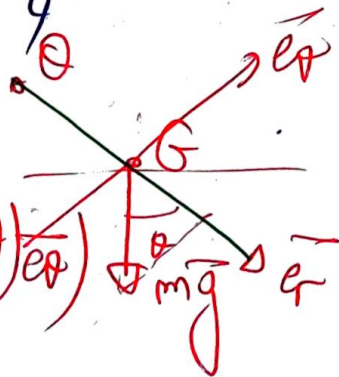


$$I_D = I_{D'} + m \left( \frac{l}{2} \right)^2 = \frac{ml^2}{12} + \frac{ml^2}{4}$$

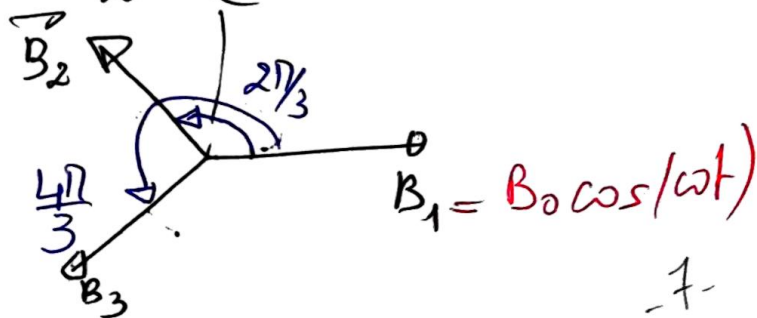
$$\vec{M}_I = \vec{OG} \wedge m\vec{g}$$

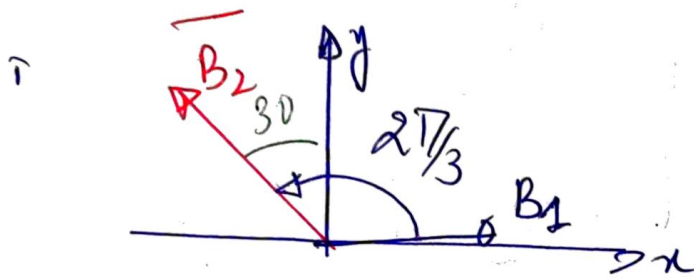
$$= \frac{l}{2} \vec{e}_r \wedge mg(-\sin\theta) \vec{e}_\theta$$

$$= -\frac{mgl}{2} \sin\theta \vec{e}_z$$



$$\vec{B} = \frac{3B_0}{2} (\cos(\omega t) \vec{e}_x + \sin(\omega t) \vec{e}_y)$$





$$\vec{B}_2 = k I_0 \cos(\omega t - \frac{2\pi}{3}) \left[ \cos\left(\frac{2\pi}{3}\right) \vec{e}_x + \sin\left(\frac{2\pi}{3}\right) \vec{e}_y \right]$$

↓ affixe

$$b_2 = \frac{k I_0}{2} \left[ e^{j(\omega t - \frac{2\pi}{3})} + e^{j(\frac{2\pi}{3} - \omega t)} \right] e^{j\frac{2\pi}{3}}$$

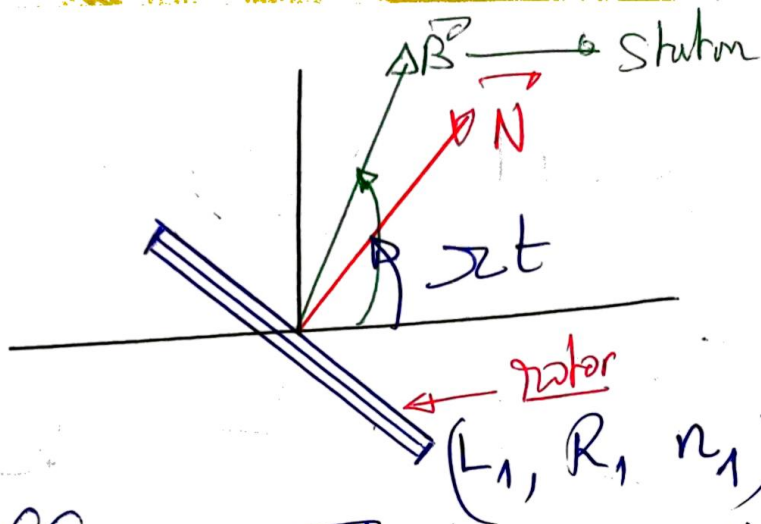
$$b_3 = \frac{k I_0}{2} \left[ e^{j(\omega t - \frac{4\pi}{3})} + e^{j(\frac{4\pi}{3} - \omega t)} \right] e^{j\frac{4\pi}{3}}$$

$$b_1 = \frac{k I_0}{2} \left[ e^{j\omega t} + e^{-j\omega t} \right] e^{j0}$$

$$b = \frac{k I_0}{2} 3 \times e^{j\omega t}$$

$$\vec{B} = \frac{3}{2} k I_0 (\cos(\omega t) \vec{e}_x + \sin(\omega t) \vec{e}_y)$$

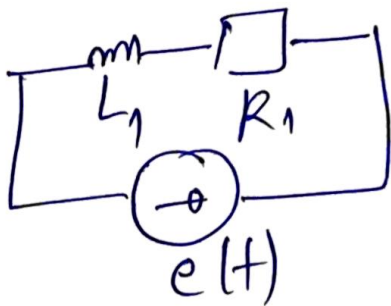
$$e^{j\frac{2\pi}{3}} + e^{j\frac{4\pi}{3}} + 1 = 0$$



$$\Phi = \int \vec{B}(t) \cdot d\vec{S} n_1 = (n_1 B_0 S) \cos[(\omega - \omega_0)t]$$

$$\Phi = \Phi_0 \cos[(\omega - \omega_0)t]$$

$$e(t) = + \Phi_0 (\omega - \omega_0) \sin[(\omega - \omega_0)t]$$



$$e = R_1 i(t) + L_1 \frac{di(t)}{dt}$$

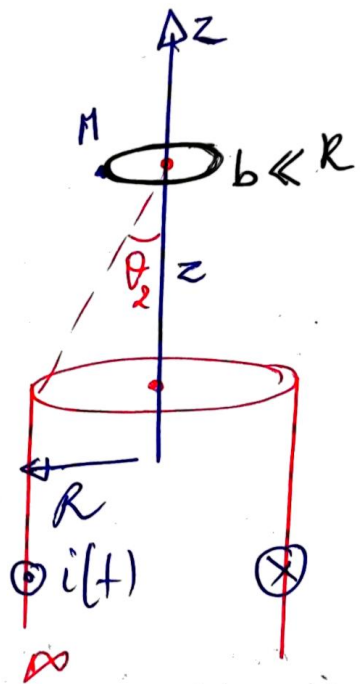
$$e = R_1 i + j L_1 (\omega - \omega_0) i$$

$$i = \frac{e}{R_1 + j L_1 (\omega - \omega_0)} = I_0 e^{j[(\omega - \omega_0)t - \varphi]}$$

$$I_0 = \frac{\Phi_0 (\omega - \omega_0)}{\sqrt{R_1^2 + L_1^2 (\omega - \omega_0)^2}} ; \varphi = \arctan \frac{L_1 (\omega - \omega_0)}{R_1}$$

# Zéróhalm magnehp

DT2 2012  
1122 2017



$$\vec{B} = \frac{\mu_0 n i}{2} (1 - \cos \theta_2) \vec{e}_z$$

$$\cos \theta_2 = \frac{z}{\sqrt{R^2 + z^2}}$$

$$i(t) = I_0 \cos(\omega t)$$

$$\vec{B}(z, t) = \frac{\mu_0 n I_0}{2} \left(1 - \frac{z}{\sqrt{R^2 + z^2}}\right) \cos(\omega t) \vec{e}_z$$

$$\vec{B}(z, t) = \frac{B_m}{n} \cos(\omega t) \vec{e}_z$$

si  $\nabla \cdot \vec{B} = 0$ :  $(\nabla_r \cdot \vec{B}_r) \perp \vec{e}_z$ ;  $\vec{B} \in$

$$\vec{B} = \begin{cases} B_r(r, z) \\ B_z(r, z) \approx B_z(r, z) \end{cases} \longrightarrow \boxed{B_r = -\frac{r}{2} \frac{\partial B_z}{\partial z}}$$

$$\oint \vec{B} \cdot d\vec{s} = 0$$

$$\Phi = \iint (\vec{B}_r + \vec{B}_z) \cdot d\vec{S}_{\text{spire}} \vec{e}_z$$

$$= B_z(0, z, t) \pi b^2$$

$$e = - \frac{d\Phi}{dt} = \pi b^2 \omega B_m(z) \sin(\omega t)$$

$$\underline{e} = (R + jL\omega) \underline{i}$$



$$*d\vec{F}_{\text{Lap}} = i d\vec{\ell} \wedge \vec{B}$$

$$= i b d\varphi \vec{e}_\varphi \wedge [B_r \vec{e}_r + B_z \vec{e}_z]$$

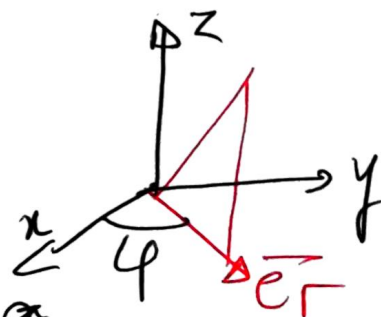
$$\vec{F}_{\text{Lap}} = - i b d\varphi B_r(b, z, t) \vec{e}_z + i b d\varphi B_z(0, z, t) \vec{e}_r$$

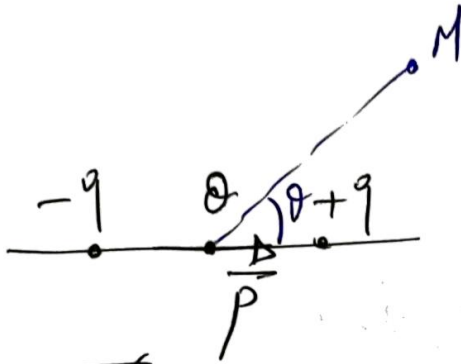
$$\vec{F}_{\text{Lap}} = - i(t) b 2R \left( - \frac{b}{2} \frac{\partial B_z(0, z, t)}{\partial z} \right) \vec{e}_z$$

$$\int_0^{2R} d\varphi \vec{e}_r = 0$$

$$\downarrow$$

$$(\cos\varphi \vec{e}_x + \sin\varphi \vec{e}_y)$$





$$\vec{p} = qN\vec{e}$$

$$V = \frac{p \cos \theta}{4\pi\epsilon_0 r^2}$$

$$\vec{E} = -\text{grad} V = \frac{p}{4\pi\epsilon_0 r^3} (2\cos\theta \vec{e}_r + \sin\theta \vec{e}_\theta)$$

$$d\vec{e}_r \wedge \vec{E} = \vec{0}; \quad \frac{dr}{r} = \frac{r d\theta}{E_\theta}$$

$$d\vec{e}_r = \frac{1}{r} \frac{dr}{d\theta} d\theta$$

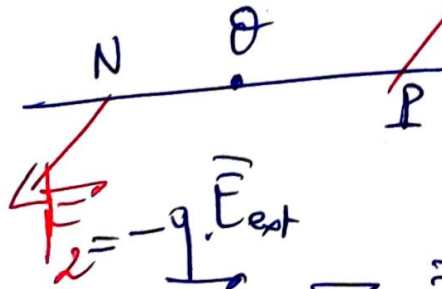
$$\Rightarrow \boxed{\Gamma = r_0 \sin^2 \theta}$$

achem  $\vec{E}_{\text{ext}}$  pour un dipôle  
 $\Downarrow$  uniforme

$$\vec{F}_{\text{tot}} = \vec{0}$$

$$\mathcal{M}(\vec{F}_1) = \vec{OP} \wedge \vec{F}_1$$

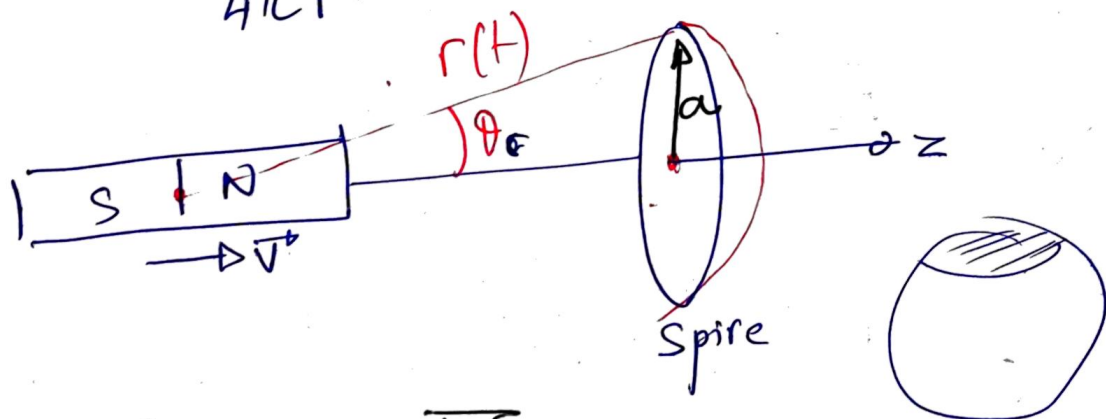
$$\mathcal{M}(\vec{F}_2) = \vec{ON} \wedge \vec{F}_2$$



$$\vec{\Gamma} = \vec{p} \wedge \vec{E}_{\text{ext}}$$

$$\begin{aligned}
 W_{\text{dipole}} &= +q[V(L) - V(N)] = q \, dV \\
 &= q \left[ \left( \frac{q}{4\pi\epsilon_0} \right) \cdot d\ell \right] \\
 &= q \left[ -\vec{E}_{\text{ext}} \cdot \vec{NL} \right] = -\vec{p} \cdot \vec{E}_{\text{ext}}
 \end{aligned}$$

$$\vec{B}_{\text{dipole}} = \frac{\mu_0 M}{4\pi r^3} (2\cos\theta \vec{e}_r + \sin\theta \vec{e}_\theta)$$



$$\Phi = \iint \vec{B}_{\text{dipole}} \cdot d\vec{S}_{\text{spire}}$$

$$= \iint \left( \frac{\mu_0 M}{4\pi r^3} 2\cos\theta \vec{e}_r \right) (r^2 \sin\theta d\theta d\phi) \vec{e}_r$$

$$= \frac{\mu_0 M}{4\pi r^3} 2r^2 \int_0^{\theta_c} \sin\theta \cos\theta d\theta \int_0^{2\pi} d\phi$$

$$\Phi = \frac{2\mu_0 M}{4\pi r} \left( \frac{\sin^2\theta_c}{2} \right) \times 2\pi$$

Atomic H<sub>2</sub>

$$\vec{F}_G = -\frac{G M m}{r^2}$$

$$\vec{F}_e = \frac{-e^2}{4\pi\epsilon r^2}$$

$$\frac{\|\vec{F}_G\|}{\|\vec{F}_e\|} = 10^{-40} \ll 1$$

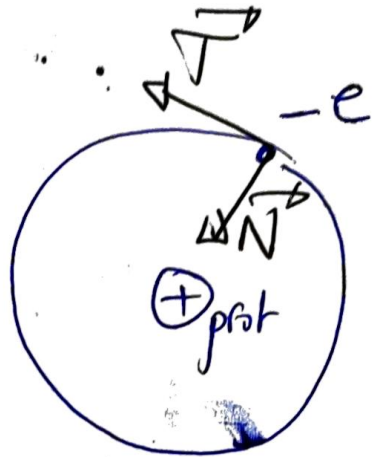
$$\sum \vec{F}_{\text{ext}} = \vec{F}_e = m \vec{a}$$

$$\frac{-e^2}{4\pi\epsilon r^2} \vec{e}_r = m \left[ \frac{dv}{dt} \underbrace{\vec{T}}_{\vec{e}_\theta} + \frac{v^2}{r} \underbrace{\vec{N}}_{-\vec{e}_r} \right]$$

$$\frac{dv}{dt} = 0, \quad v = \text{const}$$

$$v^2 = \frac{e^2}{4\pi\epsilon r m}$$

$$\frac{d(v\vec{T})}{dt} = \frac{dv}{dt} \vec{T} + v \frac{d\vec{T}}{d\theta} \cdot \frac{d\theta}{dt}$$



$$\bar{E}_c = \frac{1}{2} m v^2 = \frac{e^2}{8\pi\epsilon_0 r}$$

$$\bar{E}_p = - \int \vec{F}_e d\vec{l} = + \int \frac{e^2}{4\pi\epsilon_0 r^2} dr$$

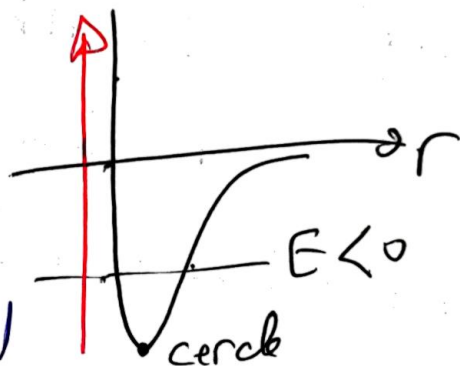
$$\boxed{\bar{E}_p = - \frac{e^2}{4\pi\epsilon_0 r}}$$

$$\boxed{E_p = -2\bar{E}_c}$$
  
viriel

$$E = -\bar{E}_c$$

$$\bar{E} = - \frac{e^2}{8\pi\epsilon_0 r}$$

$$E(r=a_0=0,5\text{\AA}) = -13,6 \text{ eV}$$



$$P_{\text{rayonnée}} = \frac{e^2}{6\pi\epsilon_0 c^3} \gamma^2 \underline{\text{Larmor}}$$

$$P_{\text{rayonnée}} = - \frac{dE}{dt} = \frac{e^2}{6\pi\epsilon_0 c^3} \left( \frac{v^2}{r} \right)^2$$

$$\frac{dU_{\text{em}}}{dt} + P_{\text{ray}} + P_{\text{ext}} = 0$$

$$\oplus \left( \frac{1}{r} \right) = \left( \frac{8\pi\epsilon_0 \bar{E}}{-e^2} \right)$$

$$\left(\frac{v^2}{r}\right)^2 = \left[\frac{e^2}{4\pi\epsilon_0 m r^2}\right]^2 = \left[\frac{e^2}{4\pi\epsilon_0 m}\right]^2 \left(\frac{\partial \Pi \Delta E}{-e^2}\right)^2$$

$$\frac{dE}{dt} = -\alpha E^4$$

$E(t) \searrow$

Bohr:  $L_0 = n\hbar$

$L_0 = \text{moment cinétique} = \overline{mv} r$

$$L_0 = m v r = n\hbar$$

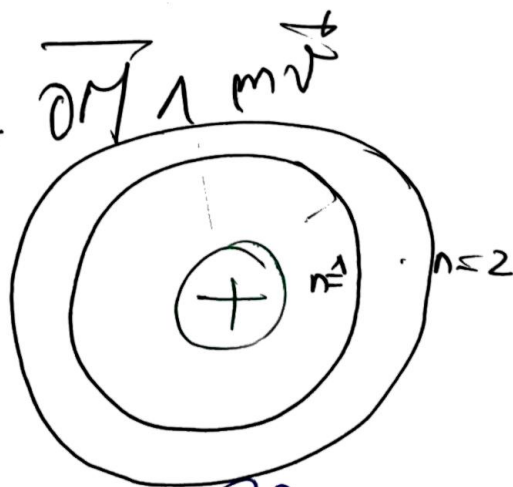
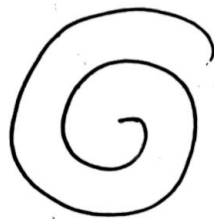
$$m^2 v^2 r^2 = n^2 \hbar^2$$

$$m^2 \cdot \left(\frac{e^2}{4\pi\epsilon_0 r_n m}\right)^2 \cdot r_n^2 = n^2 \hbar^2$$

$$r_n^2 = n^2 \hbar^2$$

$$\frac{e^2 m}{4\pi\epsilon_0} r_n = n^2 \hbar^2$$

$$r_n = a_0 n^2$$



$$E_n - E_m = h \nu_{nm} = \frac{hc}{\lambda_{nm}}$$

$$\frac{\partial}{\partial} E_n = - \frac{e^2}{8\pi\epsilon_0 n^3} = - \frac{e^2}{8\pi\epsilon_0 a_0 n^2}$$

$$E_n = - \frac{R_\infty}{n^2}$$

$$E_n - E_m = \frac{hc}{\lambda_{nm}} = - \frac{R_\infty}{n^2}$$

$$\frac{1}{\lambda_{nm}} = \frac{R_\infty}{hc n^2} = - \frac{R_H}{n^2}$$

---


$$\frac{-\hbar^2}{2m} \Delta \psi(R, \theta) + E_p(R) \psi(R, \theta) = E \psi(R, \theta)$$

$$\downarrow$$

$$\frac{1}{R^2} \frac{\partial^2 \psi(\theta)}{\partial \theta^2} + \frac{2m}{\hbar^2} (E - E_p(R)) \psi(\theta) \Rightarrow$$

$$\frac{\partial^2 \psi(\theta)}{\partial \theta^2} + \frac{2m R^2}{\hbar^2} \frac{e^2}{8\pi\epsilon_0 R} \psi(\theta) \Rightarrow$$

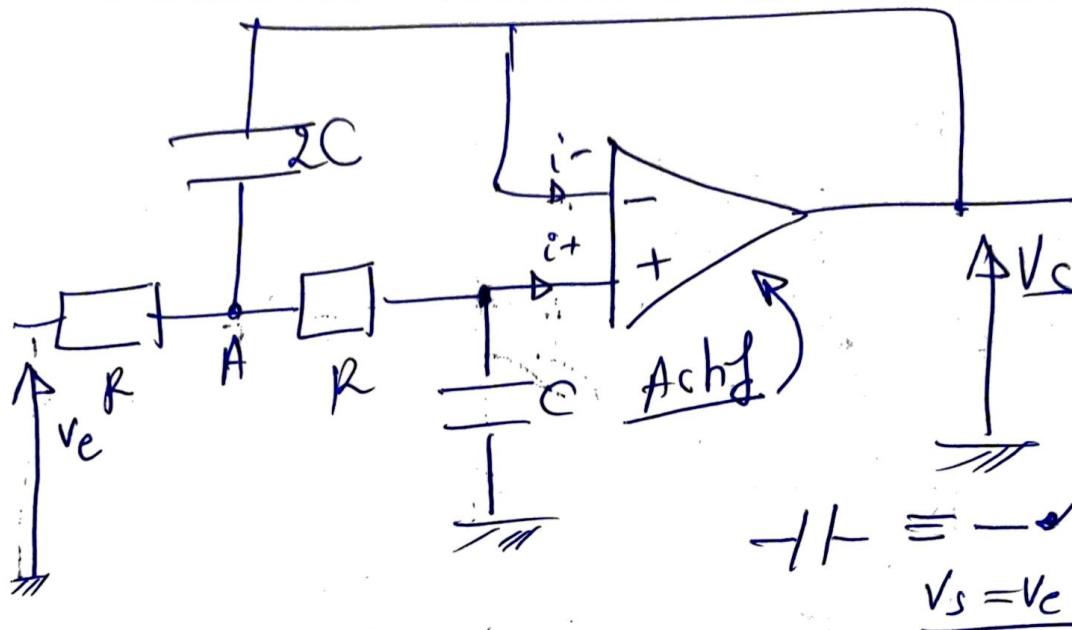
$$\varphi''(\theta) + \eta^2 \varphi(\theta) = 0$$

$$\varphi(\theta) = A \cos(\eta \theta) + B \sin(\eta \theta)$$

$$\varphi(\theta) = \varphi(\theta + 2\pi)$$

$$\cos(\eta \theta) = \cos(\theta \eta + 2\pi \eta)$$

$$\Rightarrow \eta^2 = n^2$$



$$H \equiv \frac{V_s}{V_e} \quad \omega \rightarrow \infty$$

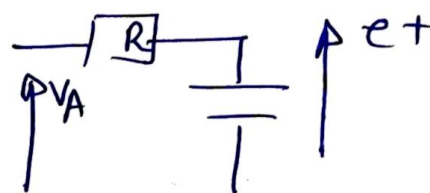
AO: idéal :  $i^+ = i^- = 0$

$$RC\omega = x$$

AO: linéaire  $e^+ = e^- = V_s$

$$V_A = \frac{\frac{V_e}{R} + \frac{V_s}{R} + j2C\omega V_s}{\frac{2}{R} + j2C\omega} = \frac{V_e + V_s + j2xV_s}{2(1 + jx)}$$

$$e^+ = \frac{Z_c}{Z_c + R} V_A$$

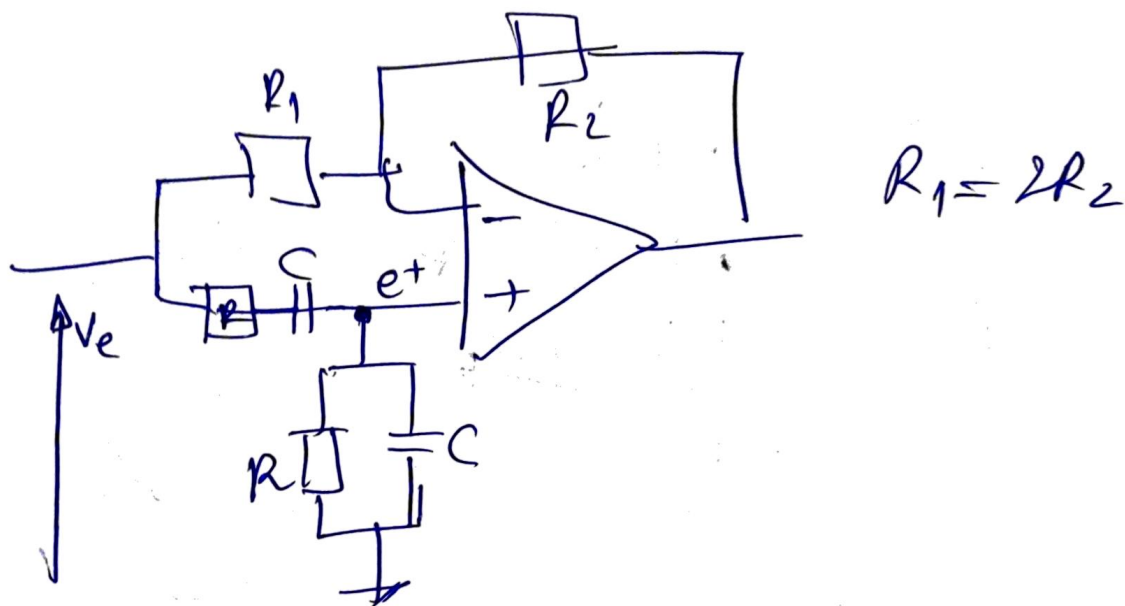


$$e^+ = \frac{1}{(1 + jx)} V_A = V_s$$

$$V_s (1 + jx)^2 \times 2 = V_e + V_s + 2jxV_s$$

$$V_s [2(1 + 2jx - x^2) - 2jx - 1] = V_e$$

$$V_s (1 + 2jx - 2x^2) = V_e$$



$$e^+ = \frac{Z_{||}}{Z_{||} + Z_s} V_e = \frac{1}{1 + (Z_s Y_{||})} V_e$$

$$e^+ = \frac{1}{1 + \left(R + \frac{1}{j\omega}\right) \left(\frac{1}{R} + j\omega C\right)} V_e$$

$$= \frac{1}{1 + 1 + 1 + \left(\frac{1}{jRC\omega} + jRC\omega\right)} V_e$$

$$e^+ = \frac{1}{3 + j\left(RC\omega - \frac{1}{RC\omega}\right)} V_e$$

$$e^- = \frac{V_s/R_2 + V_e/R_1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{R_1 V_s + R_2 V_e}{R_1 + R_2}$$

Vide:  $\vec{J}_c = 0$   $\rho = 0$

$$\Delta \vec{E} - \frac{1}{c^2} \frac{\partial \vec{E}}{\partial t^2} = \vec{0}$$

$$\vec{B} = \frac{\mu_0 \vec{E}}{\omega}$$

$$v_u = v_g = c$$

réel: réel:  $\nabla \cdot \vec{B} = \mu_0 (\nabla \cdot \vec{E})$  : ARQS

$$\Delta \vec{E} - \mu_0 \gamma \frac{\partial \vec{E}}{\partial t} = 0$$

$$\underline{k} = k' - i k''$$

$$k' = \frac{1}{\delta} = k'', \quad \delta = \sqrt{\frac{2}{\mu_0 \gamma \omega}}$$

$$\vec{E} = E_0 e^{-k'' x} e^{i(\omega t - k' x)} \vec{e}_y$$

$$v_\varphi = \frac{\omega}{k'}, \quad v_g = 2v_\varphi$$

Plasma  $\nabla \cdot \vec{B} = \mu_0 \left( \vec{J}_c + \epsilon_0 \frac{\partial \vec{E}}{\partial t} \right)$

R.F.D.:  $m \frac{d\vec{v}}{dt} = -e \vec{E} - \frac{m}{\tau} \vec{v} - m \omega_p^2 \vec{S}$

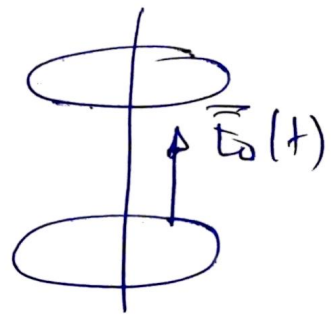
$$m \ddot{\vec{S}} + \frac{m}{\tau} \dot{\vec{S}} + \omega_p^2 m \vec{S} = -e \vec{E}$$

$$\vec{J} = n(-e) \dot{\vec{S}}$$

$$\oplus \frac{m - \omega_p^2}{m \omega_p^2} e$$

$$\vec{E}_0(t) \rightarrow \vec{B}_1 \rightarrow \vec{E}_2$$

$$\nabla \times \vec{B}_1 = \frac{1}{c^2} \frac{\partial \vec{E}_2}{\partial t} ; \nabla \times \vec{E}_2 = -\frac{\partial \vec{B}_1}{\partial t}$$



$$E_{oi} + E_{or} = E_{ot}$$

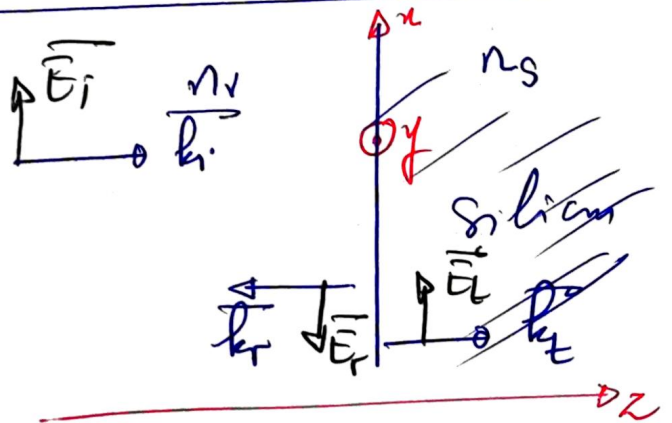
$$B_{oi} + B_{or} = B_{ot}$$

$$\vec{B}_{oi} = \frac{\vec{k}_i \wedge \vec{E}_i}{\omega}$$

$$= \frac{\omega}{c} n_v \frac{\vec{e}_z \wedge E_{oi}}{\omega} \vec{e}_n = \frac{n_v E_{oi}}{c} \vec{e}_y$$

$$\left\{ \begin{array}{l} n_v (E_{oi} - E_{or}) = n_s E_{ot} \\ E_{oi} + E_{or} = n_s E_{ot} \end{array} \right.$$

$$r = \frac{n_v - n_s}{n_v + n_s}$$



$$\vec{J} = \frac{i\hbar}{2m} \left[ \psi \frac{\partial \psi^*}{\partial x} - \psi^* \frac{\partial \psi}{\partial x} \right] \vec{e}_x$$

$$\psi = A e^{ikx} + B e^{-ikx}$$

$$\vec{J} = \frac{i\hbar}{2m} \operatorname{Re} \left[ i \psi \frac{\partial \psi^*}{\partial x} \right] \vec{e}_x$$

$$\vec{J} = \frac{\hbar}{m} \operatorname{Re} \left[ i (A e^{ikx} + B e^{-ikx}) \frac{\partial}{\partial x} (A e^{-ikx} + B e^{ikx}) \right]$$

$$\vec{J} = \operatorname{Re} \left( \frac{\hbar}{m} |A|^2 - \frac{\hbar}{m} |B|^2 + i ( \dots ) \right)$$