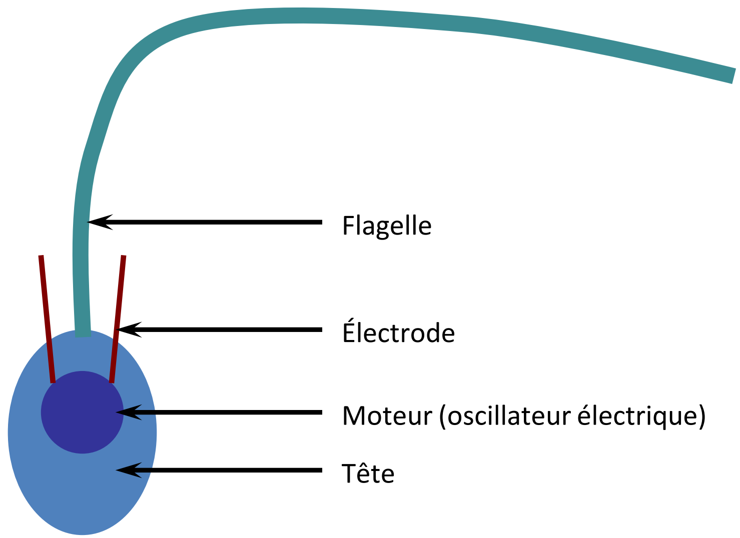
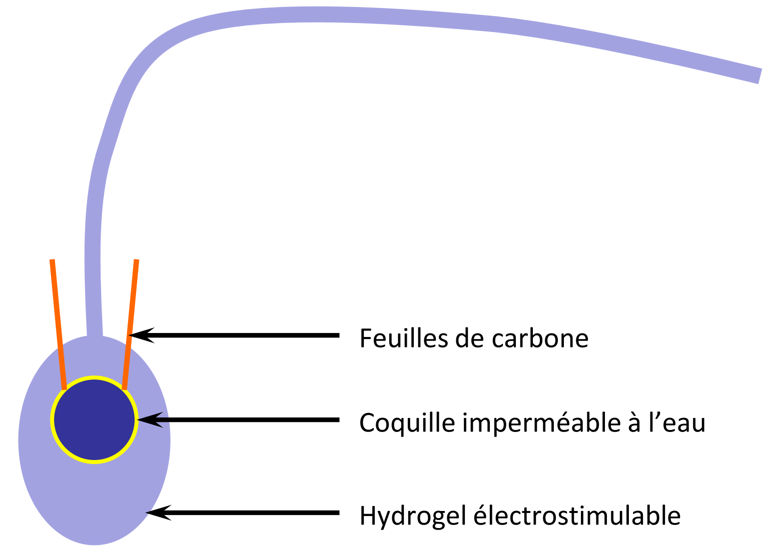
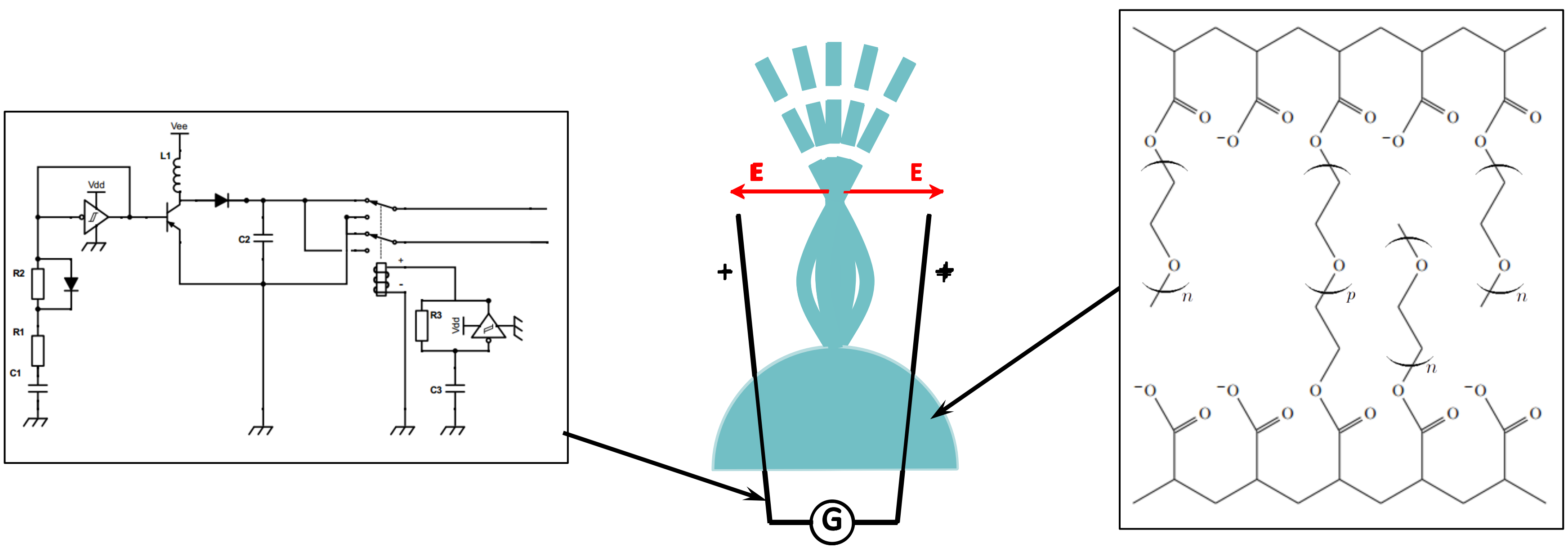
Soft Robotics : conception d’un nageur autonome en polymère électrostimulable

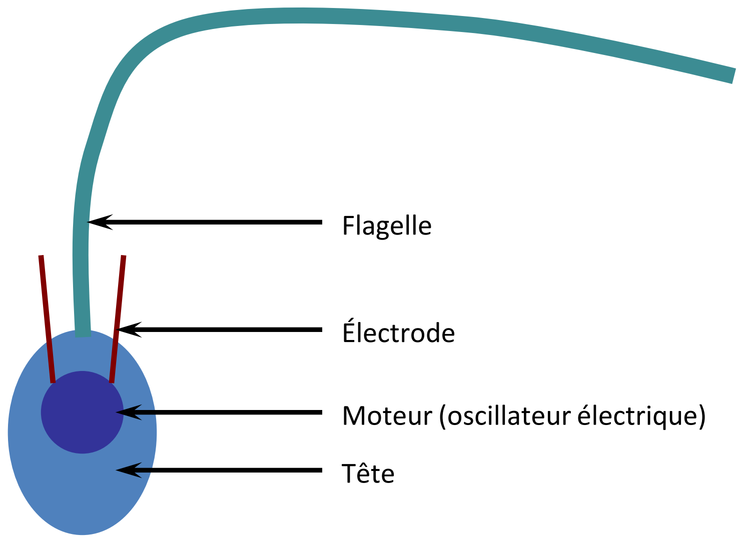
Théo Pesenti – Lucas Sixdenier – Vincent Vinel

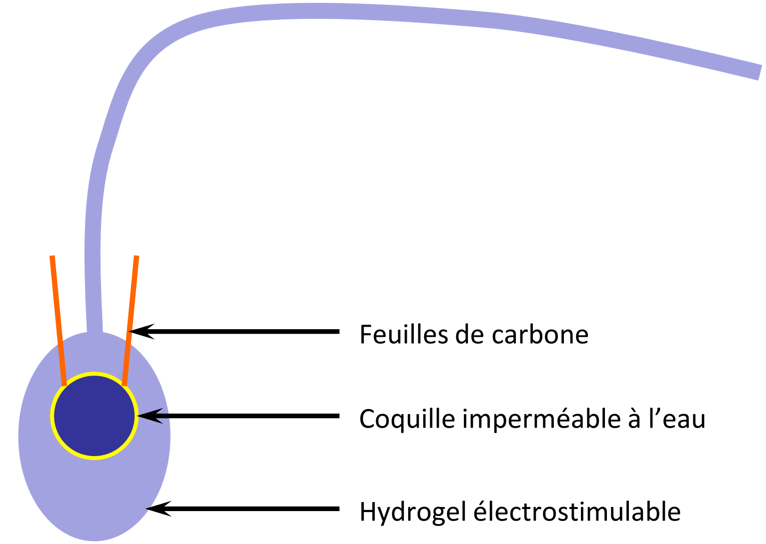




Deux axes de recherche







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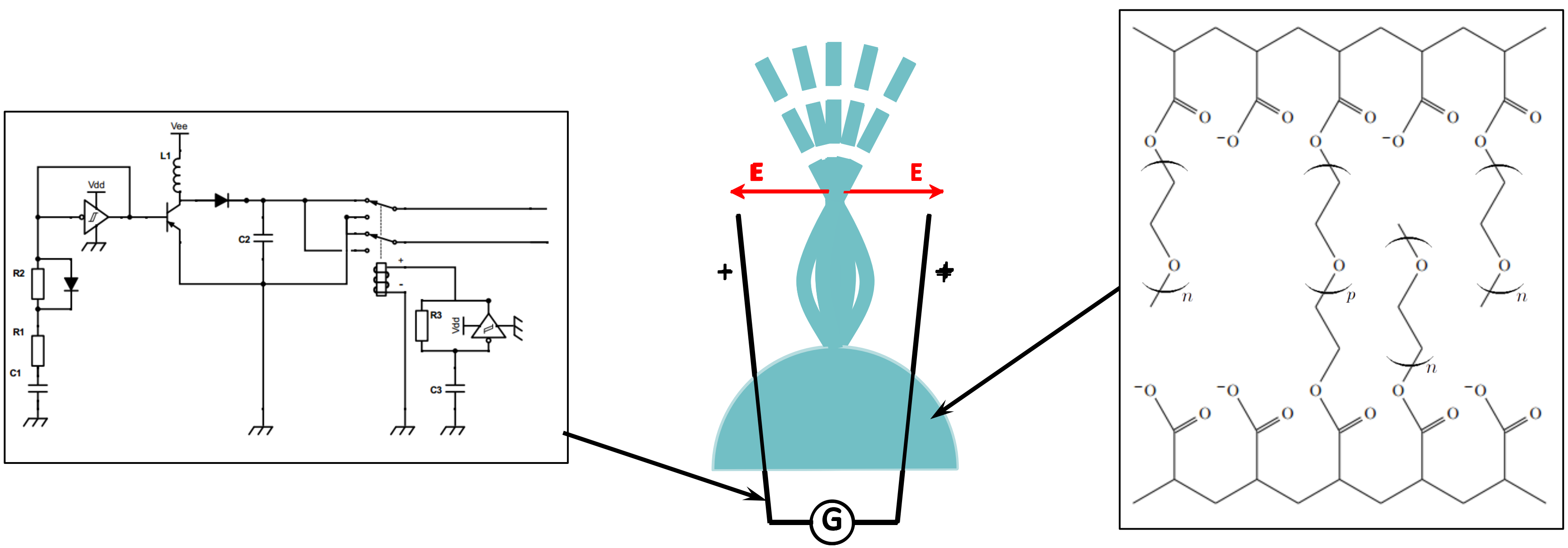
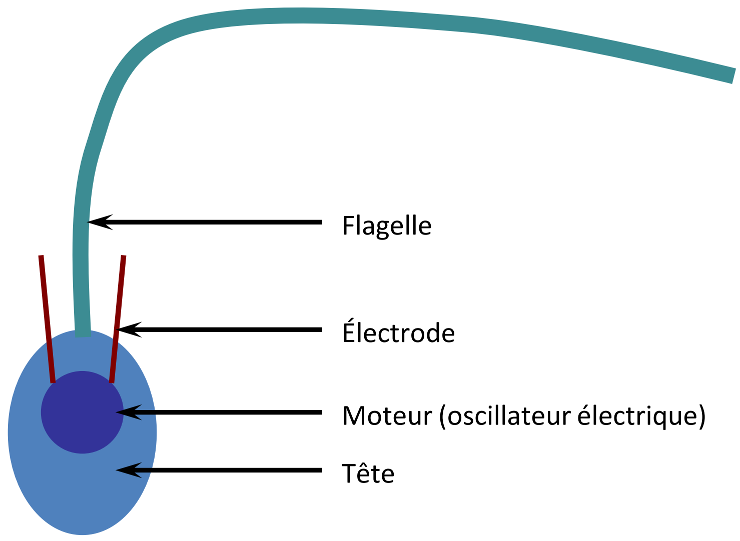
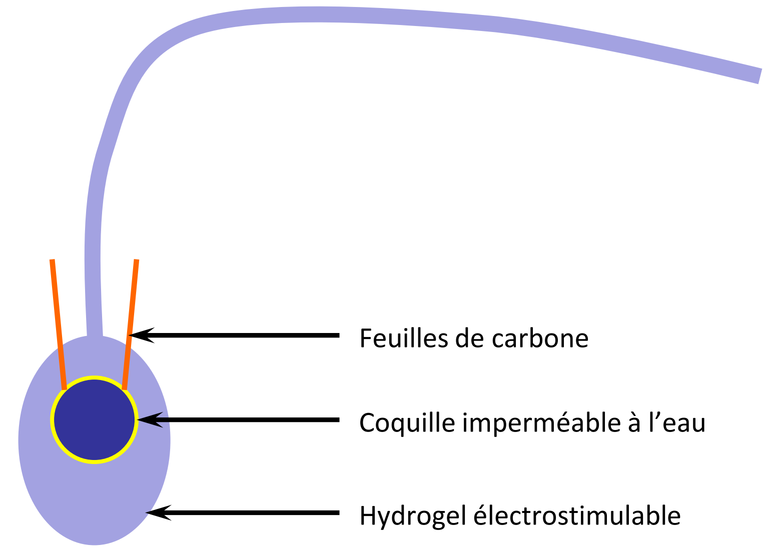
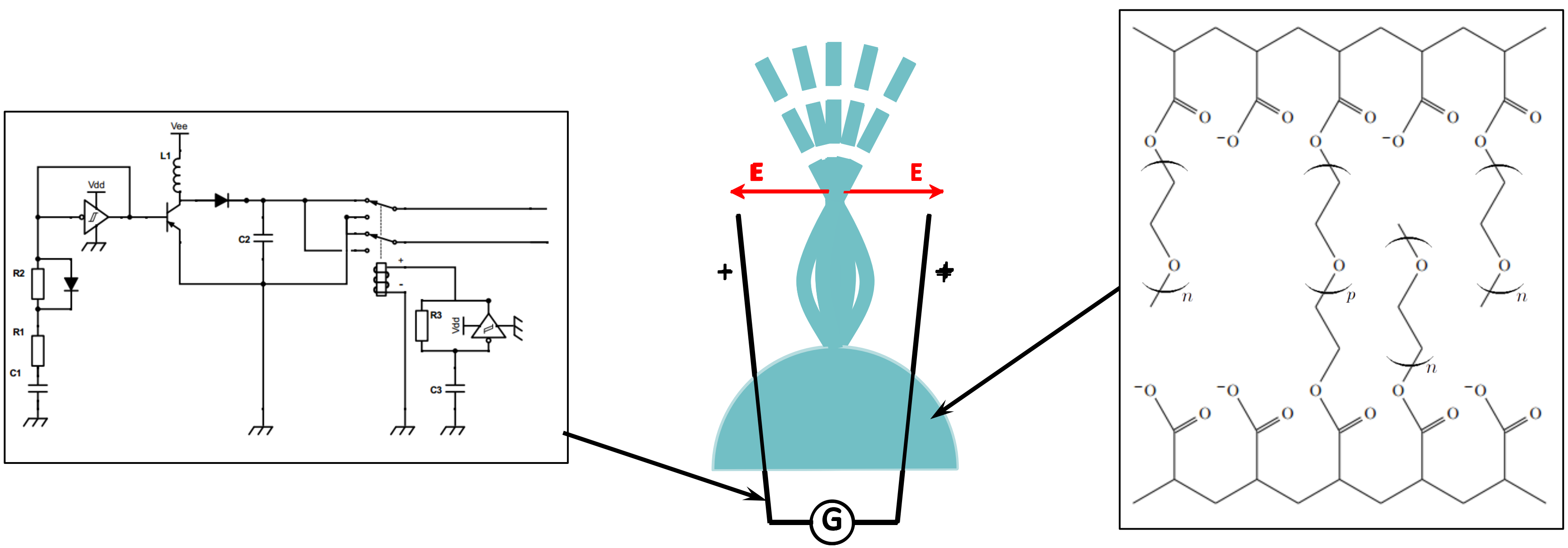


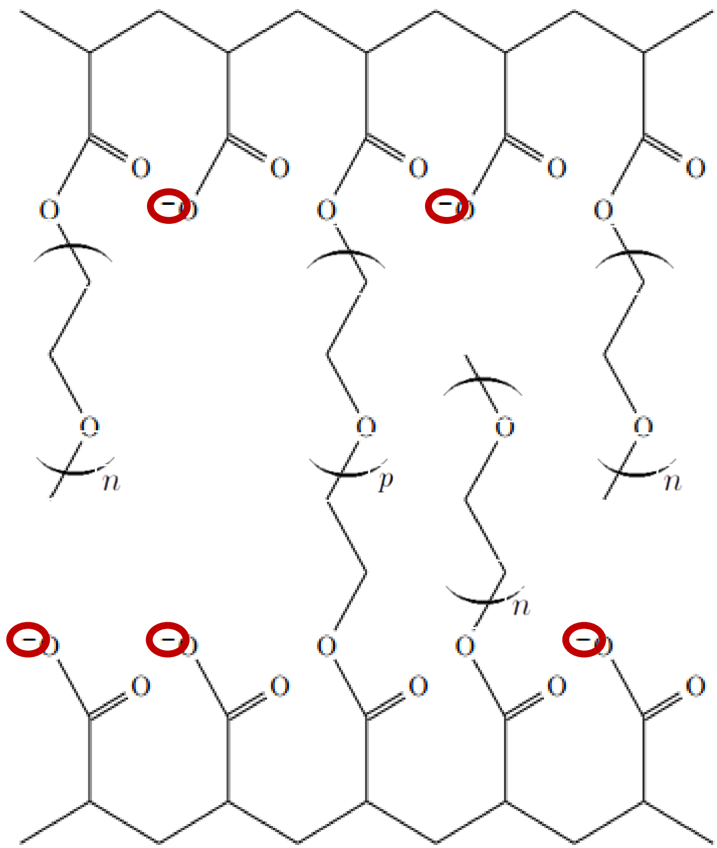




Deux axes de recherche



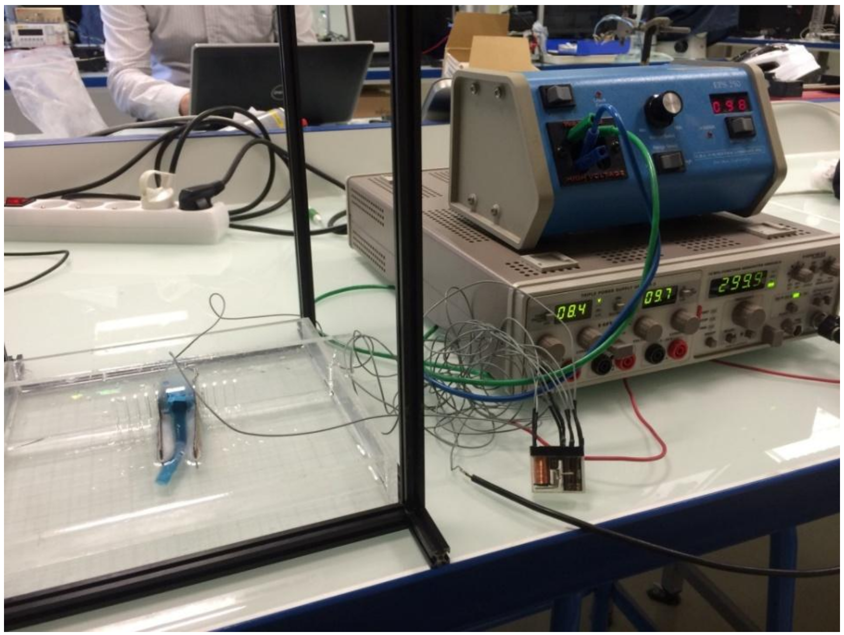
Le polymère

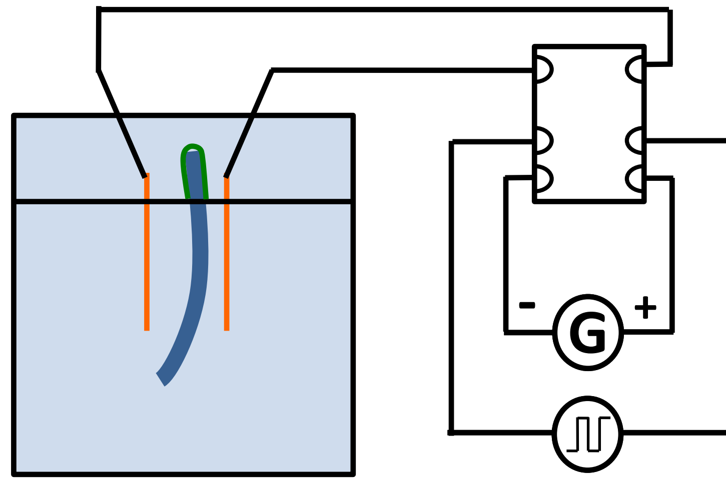


Gonflement d’un polymère AA-PEGA (70/30) après 4h

- en milieu acide (pH=2) : **118 %**
- en milieu basique (pH=13) : **135 %**
- dans l’eau pure : **160 %**

Le montage expérimental



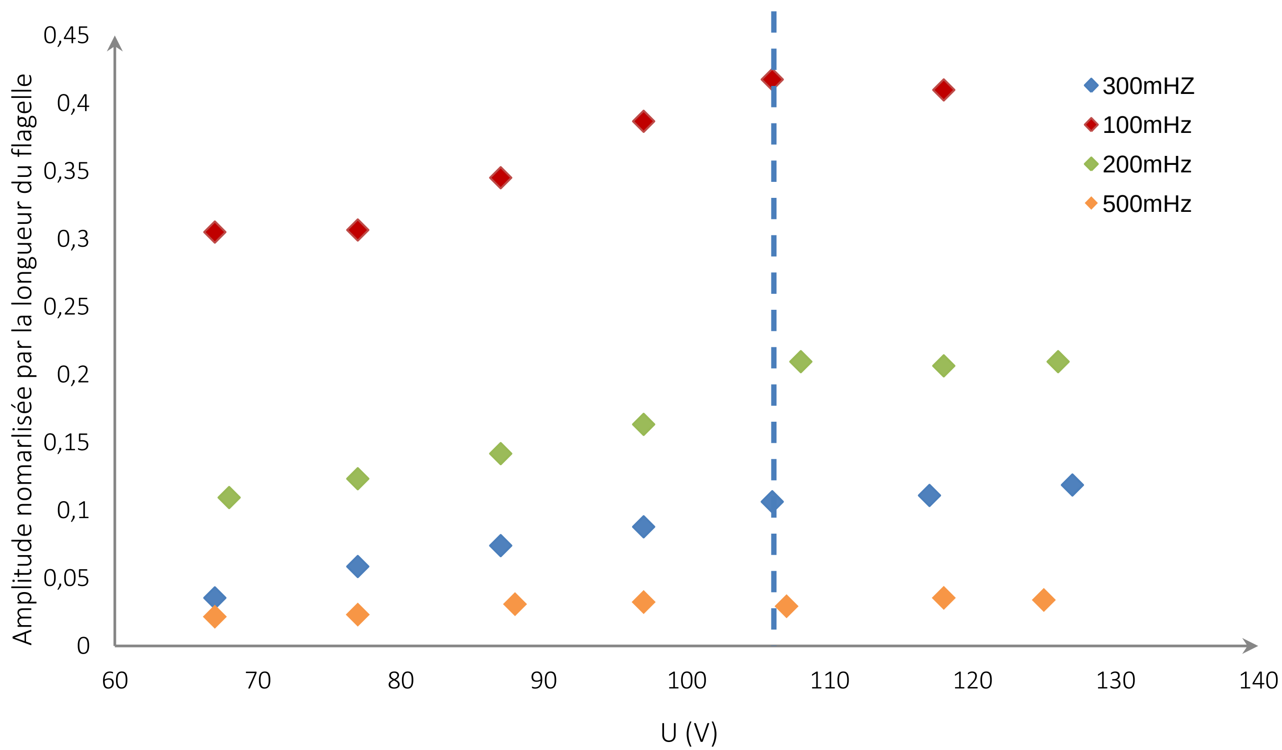


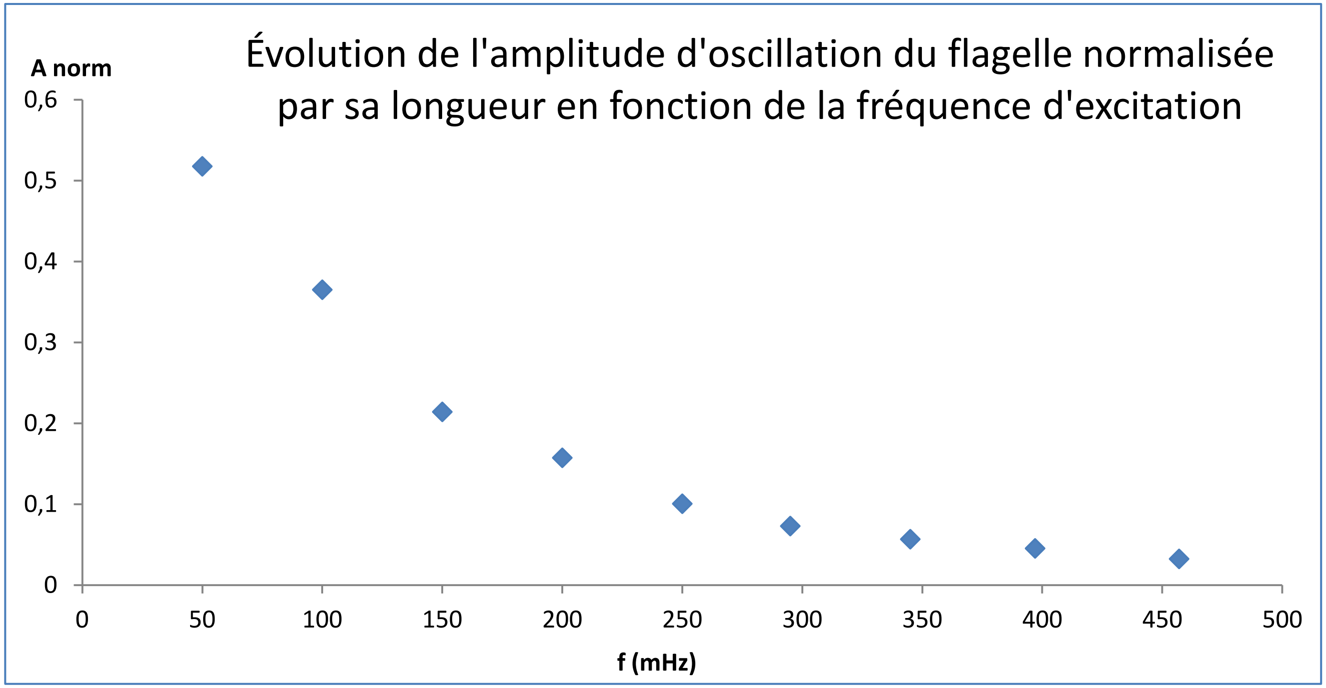
Paramètres : tension et fréquence appliquées

Mesures : vitesse, fréquence et amplitude du battement

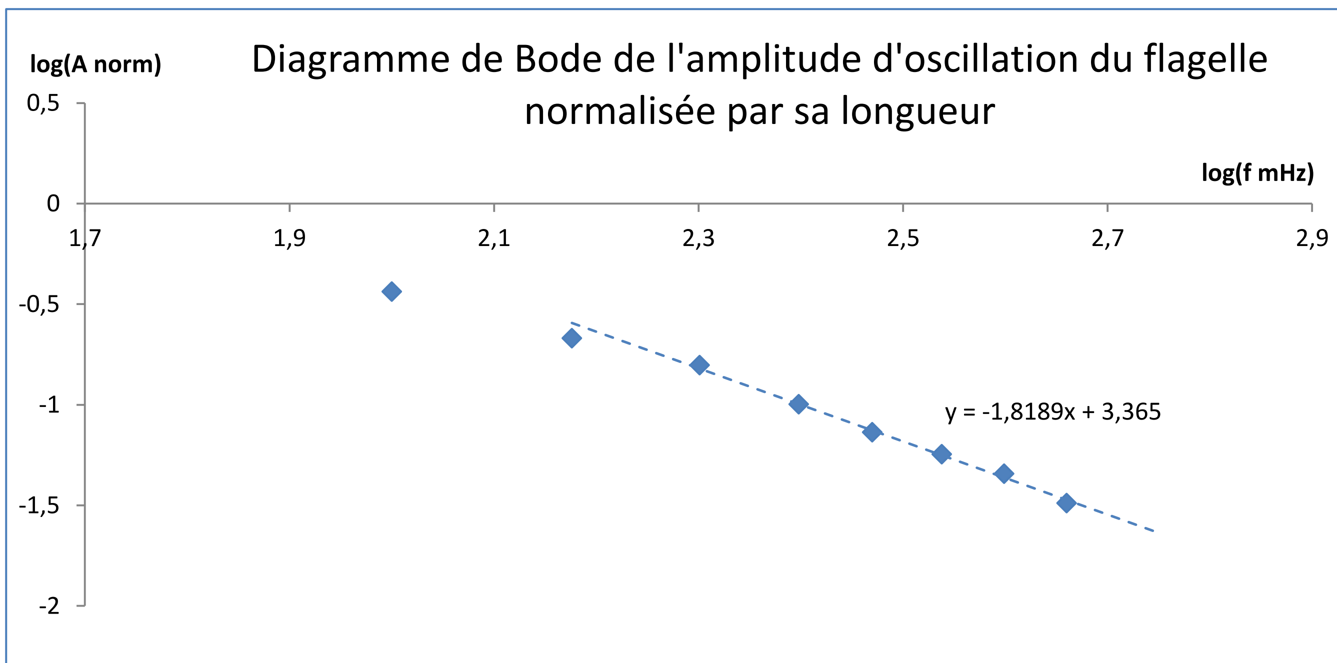
Saturation de l'amplitude pour U > 107V

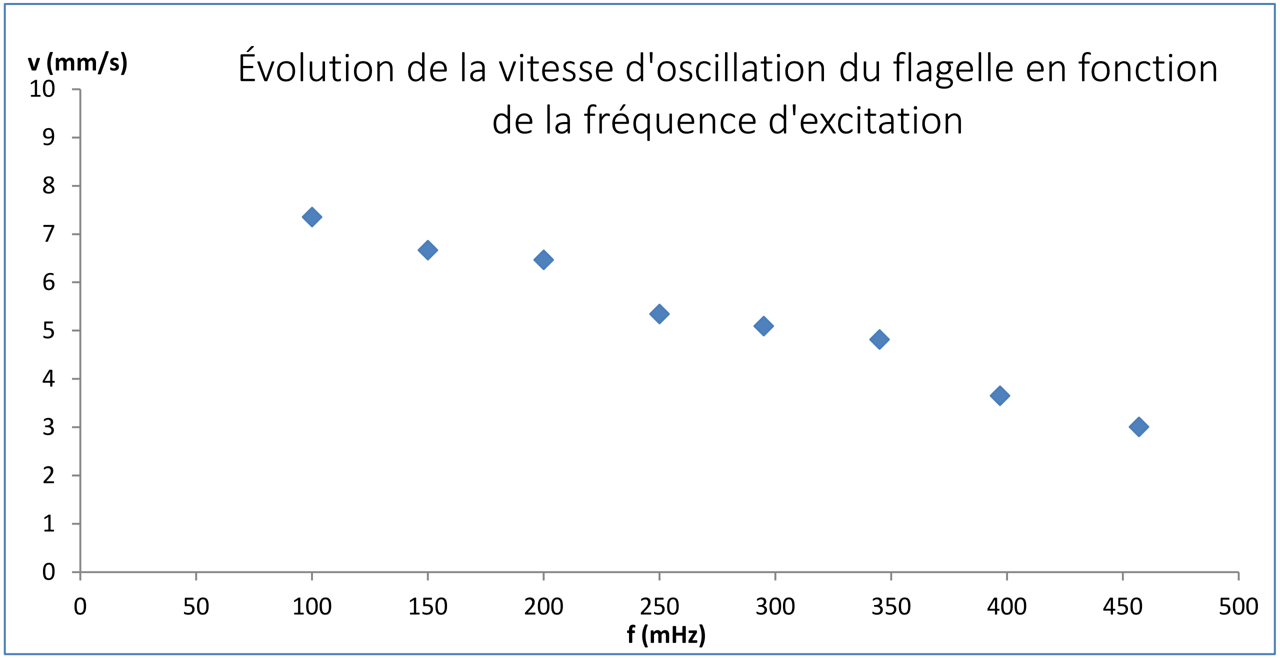
Évolution de l'amplitude d'oscillation de la flèche du flagelle normalisée par sa longueur en fonction de la tension appliquée





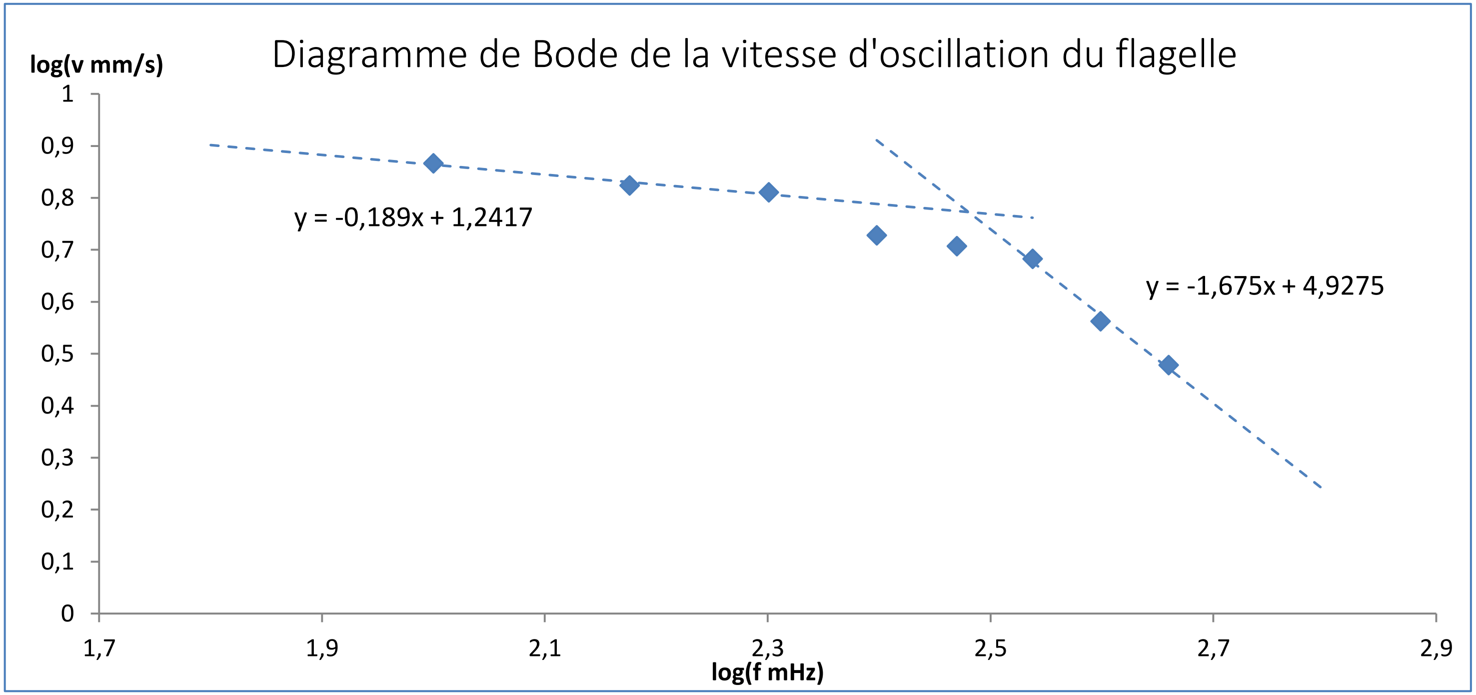
Comportement passe-bas

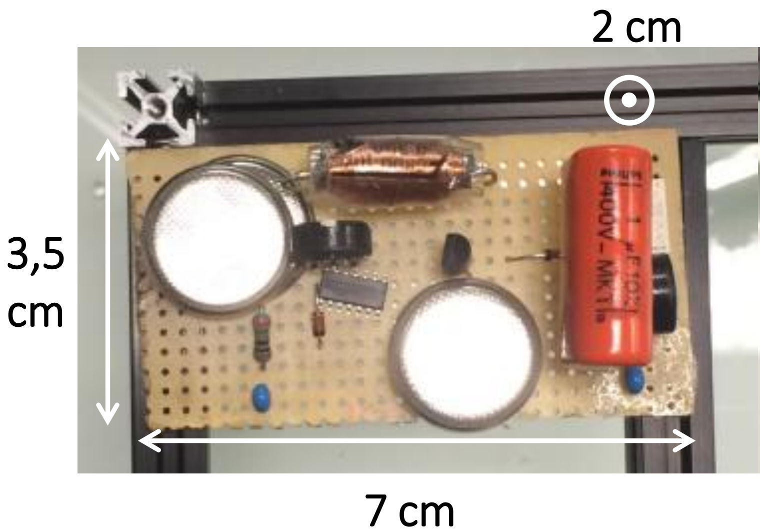


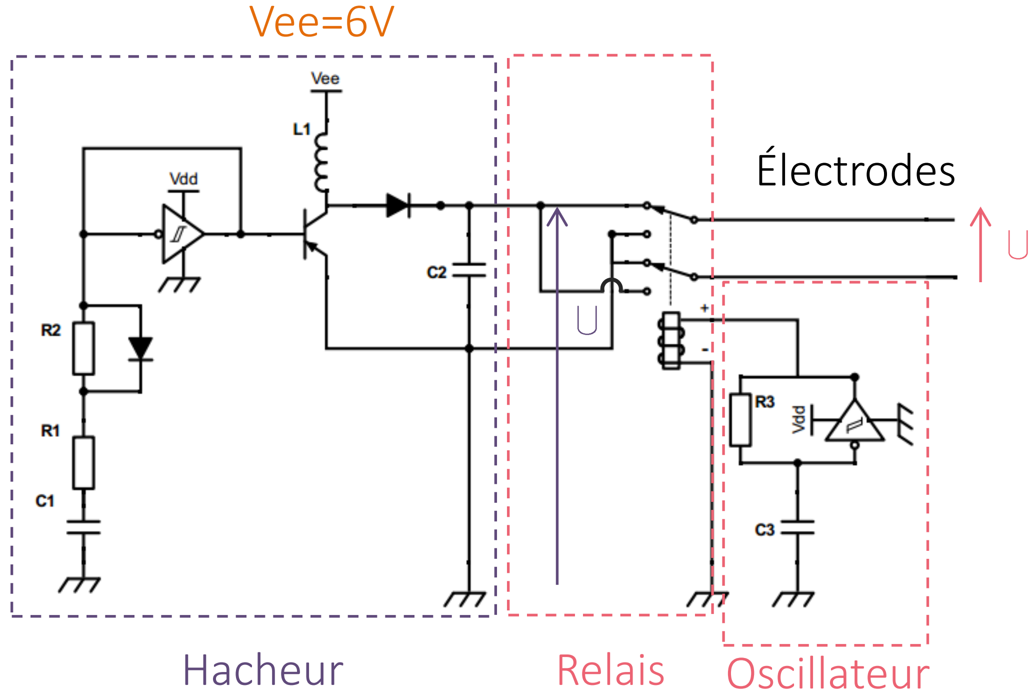


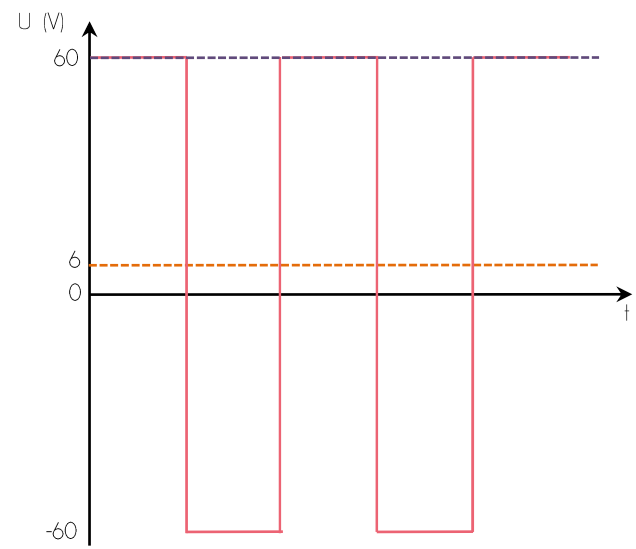
Comportement passe-bas

f_c = 302 mHz

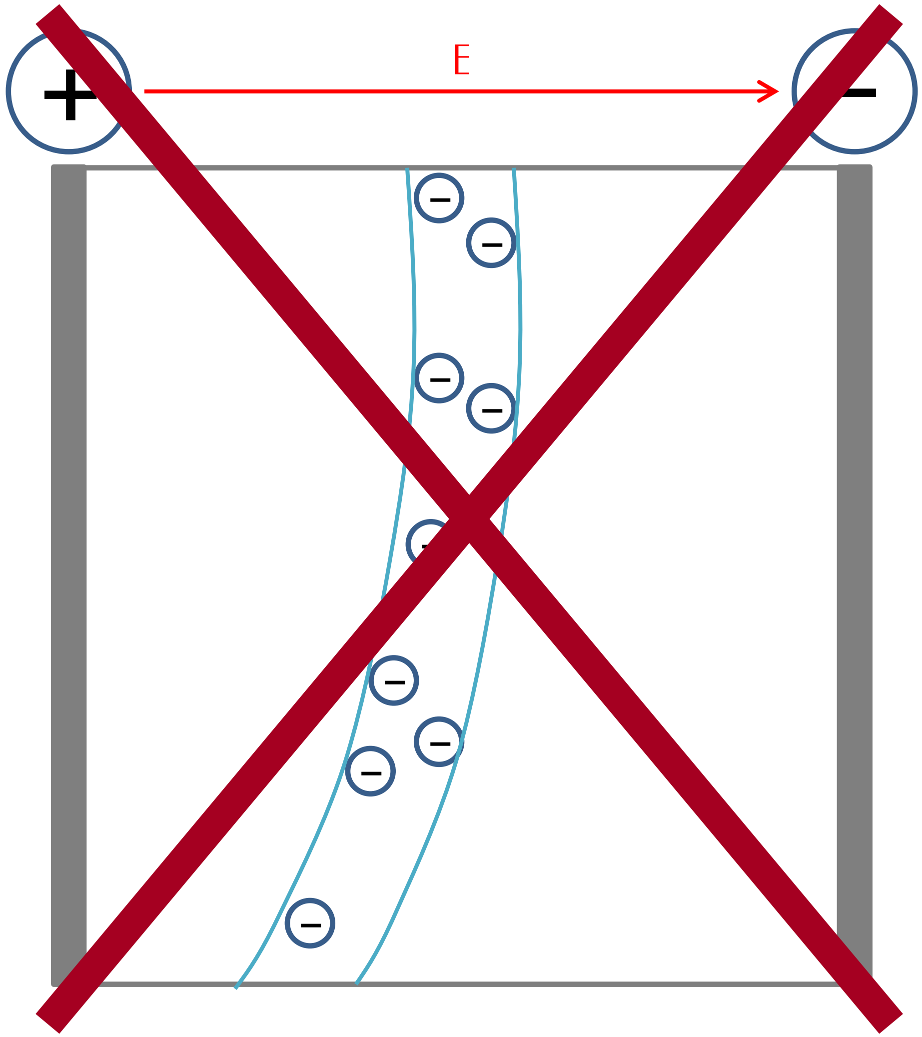


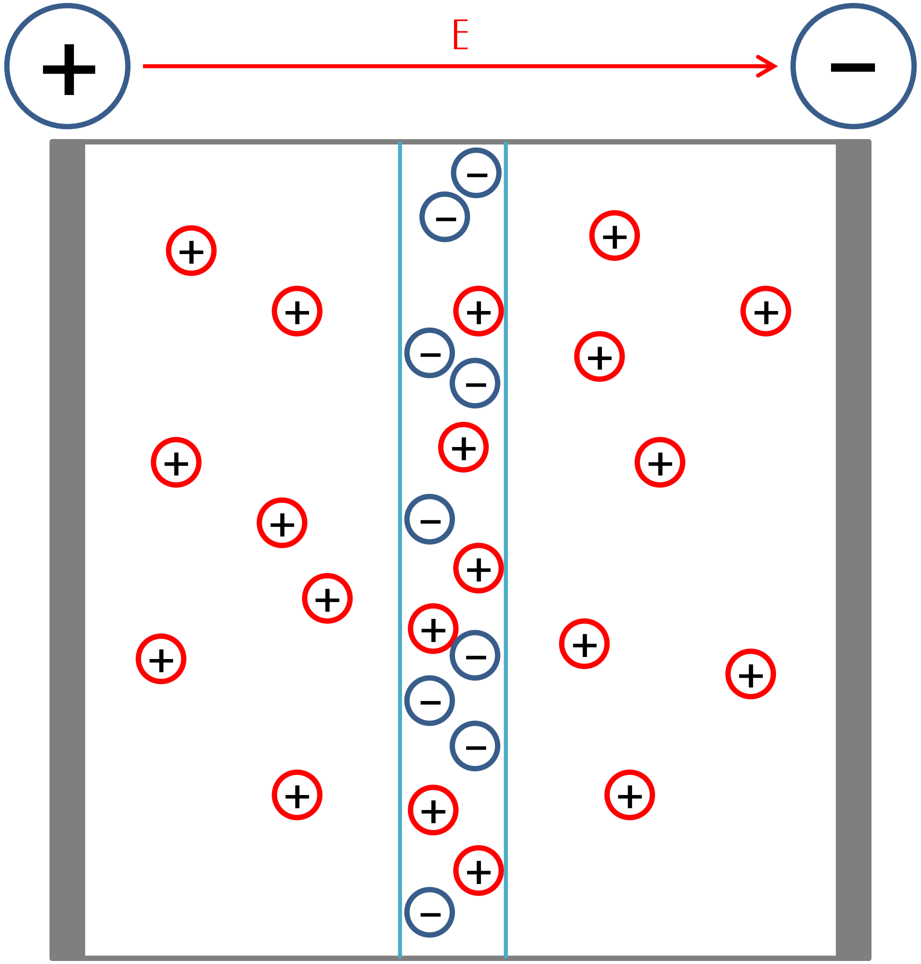

2 cm
3,5 cm
7 cm

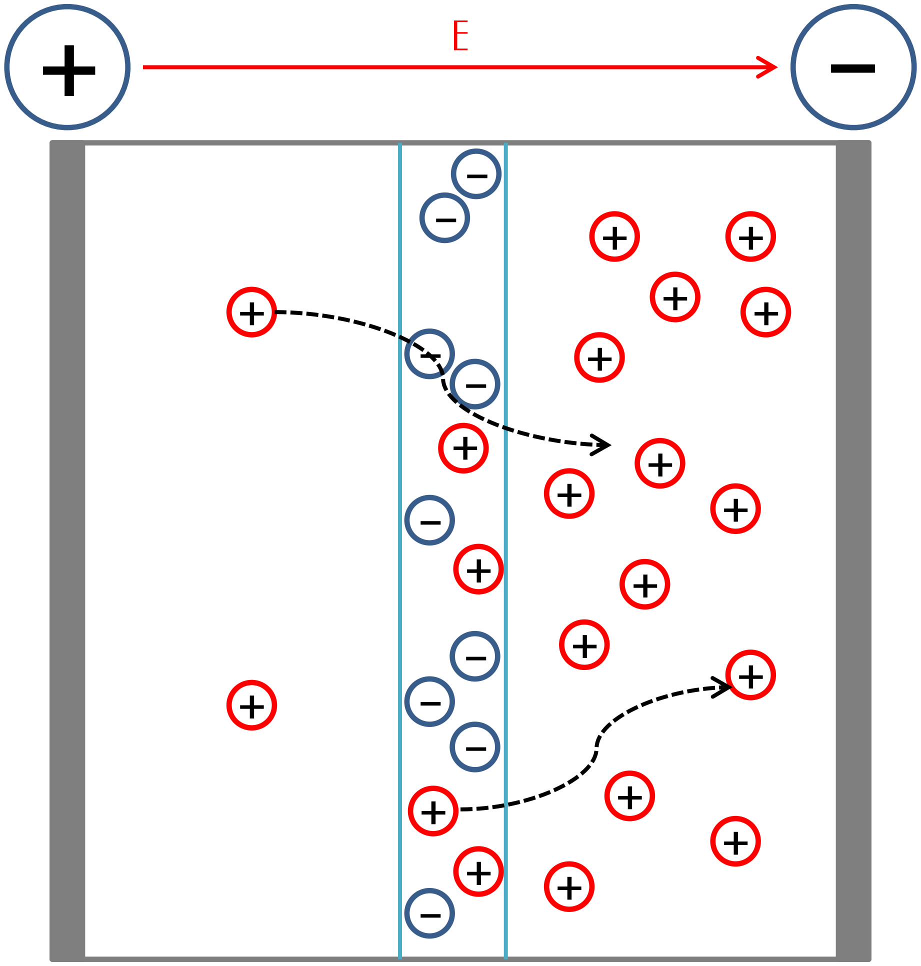

Vee=6V
Vee
L1
Vdd
R2
R1
C1
C2
U
Électrodes
U
+
-
R3
Vdd
C3
Hacheur
Relais
Oscillateur

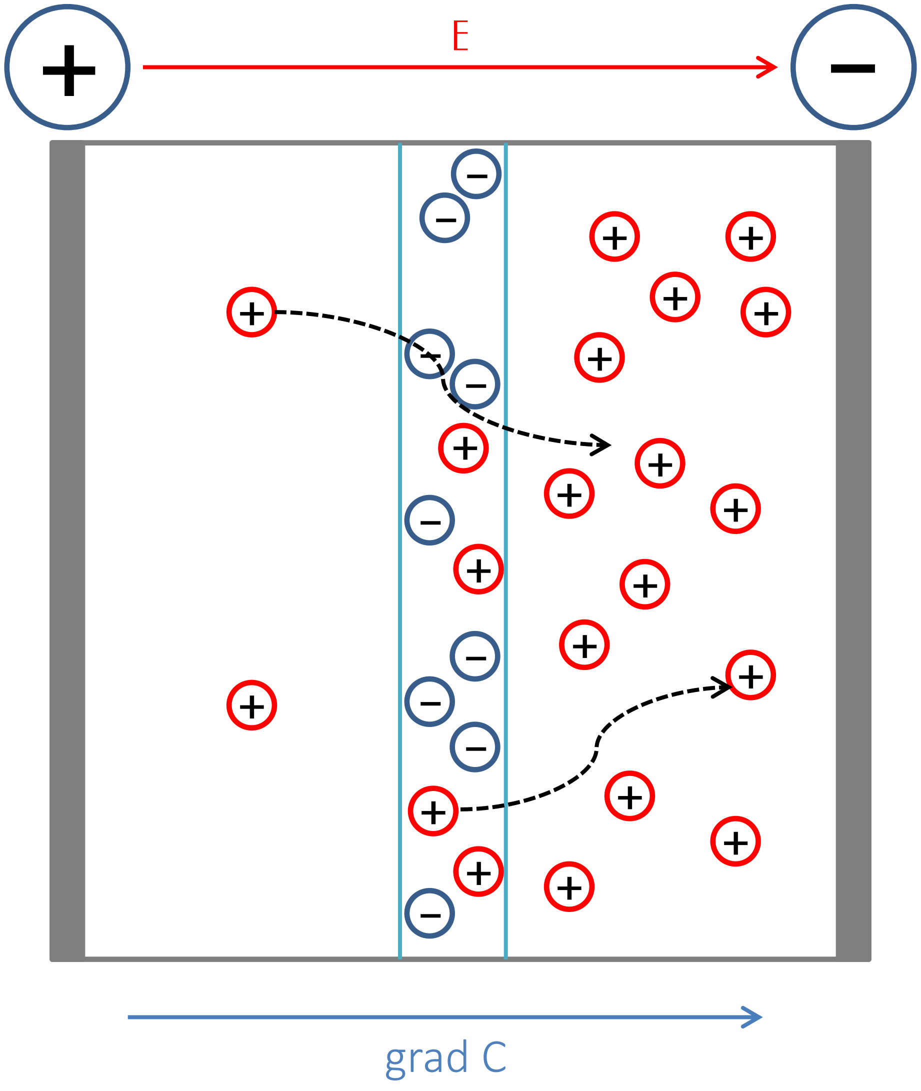

U (V)
60
6
0
-60
t

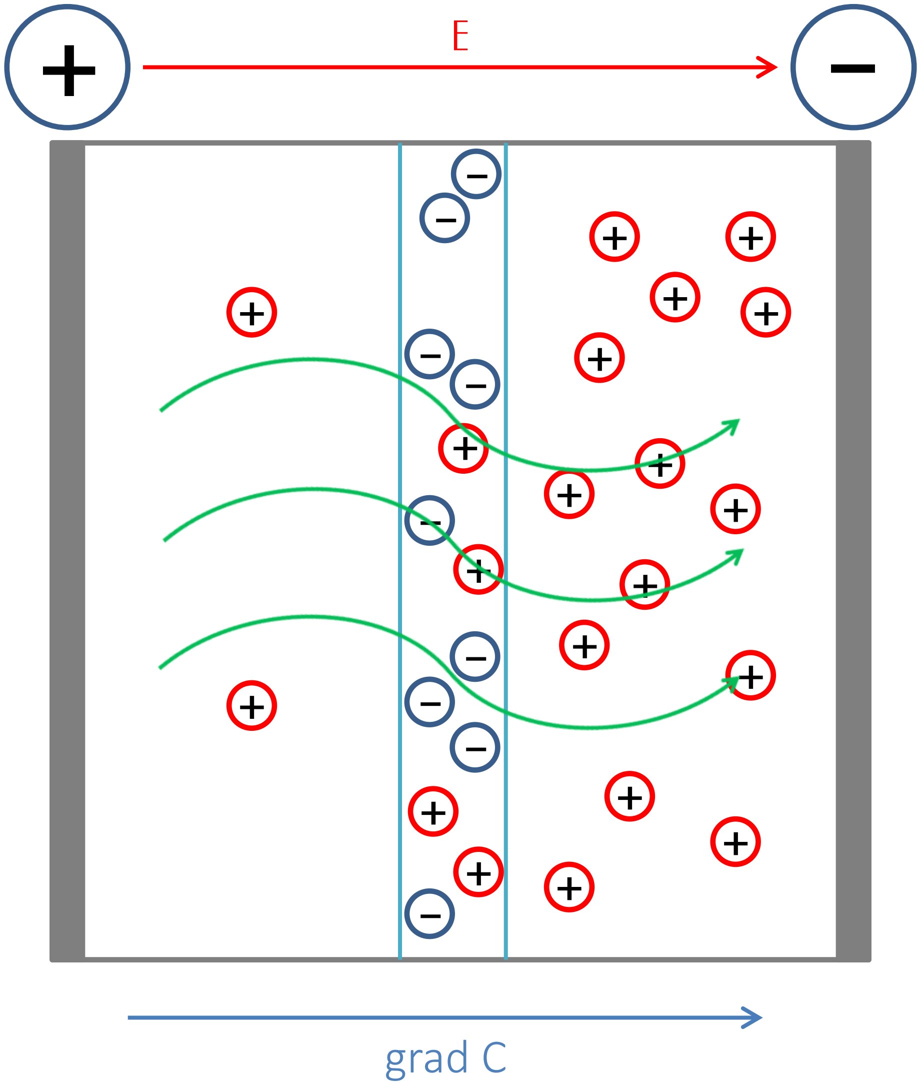
Pas d’interaction charges fixes-électrode



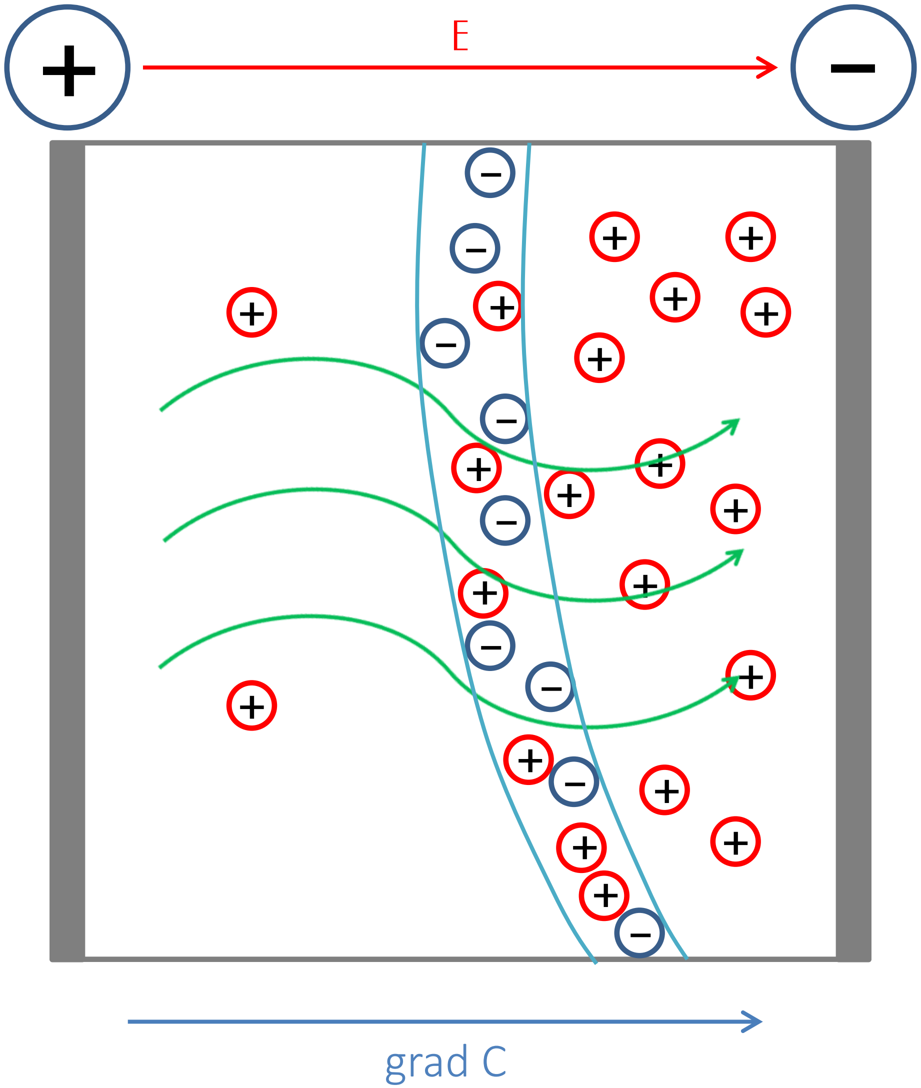

E

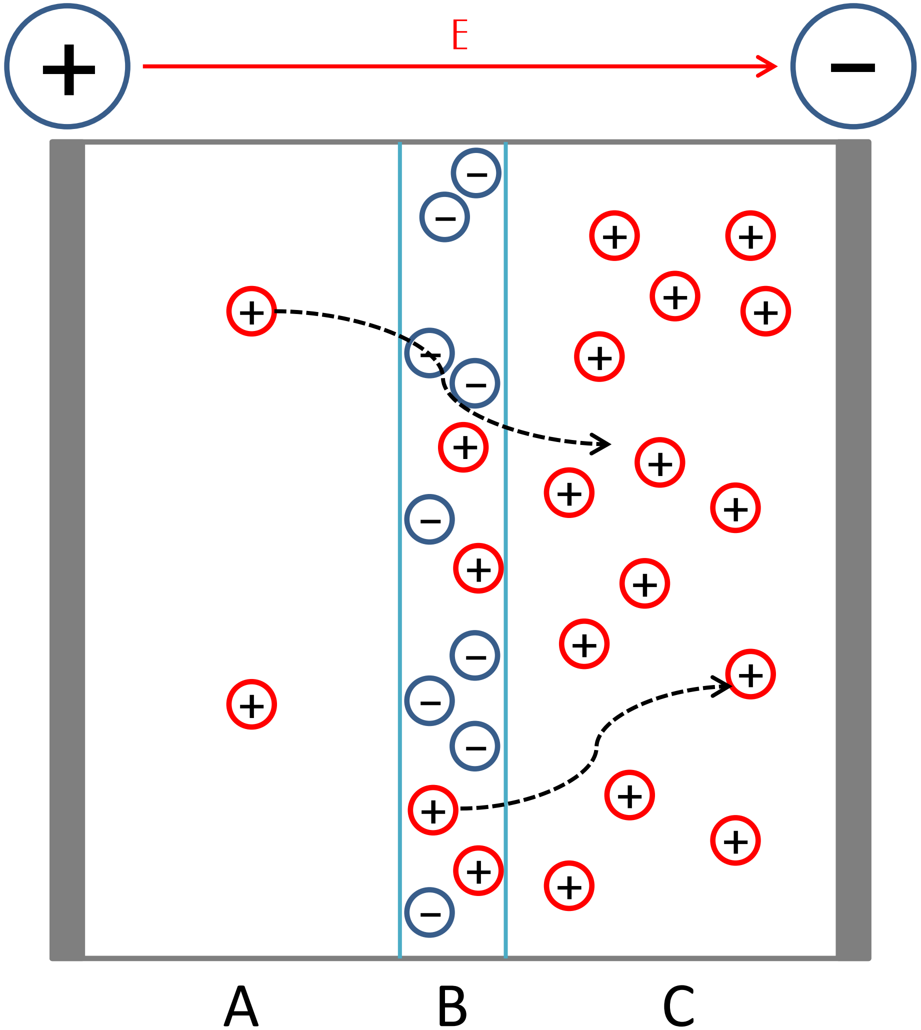

E


E
grad C



E
grad C


E
grad C



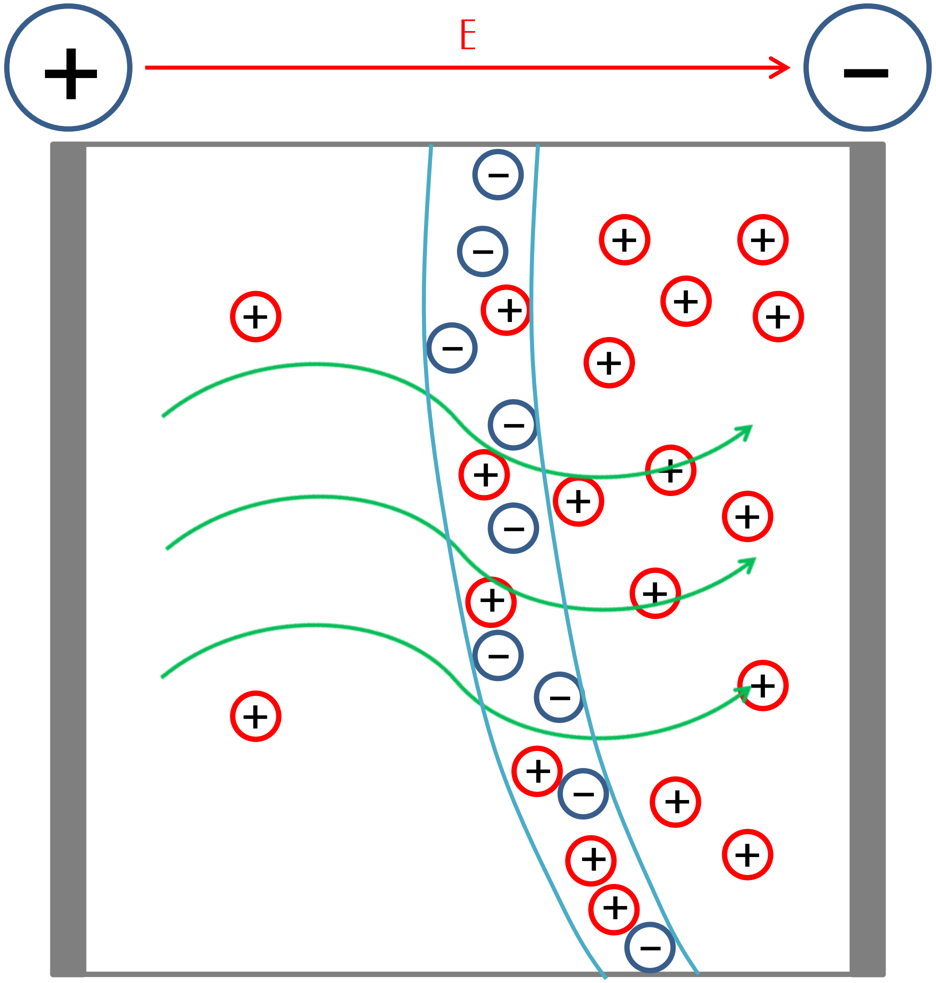
Pression osmotique

$$C_A(t) = C_A(1 - Dt)$$

$$C_B(t) = C_B(1 - Dt) + C_A\frac{V_A}{V_B}Dt(1 - Dt)$$

$$C_C(t) = C_C + C_B\frac{V_B}{V_C}Dt + C_A\frac{V_A}{V_C}h^2t^2$$

Loi de Van't Hoff $\Delta\pi = RT\left[C_C(t) - C_A(t)\right]$



Pression osmotique

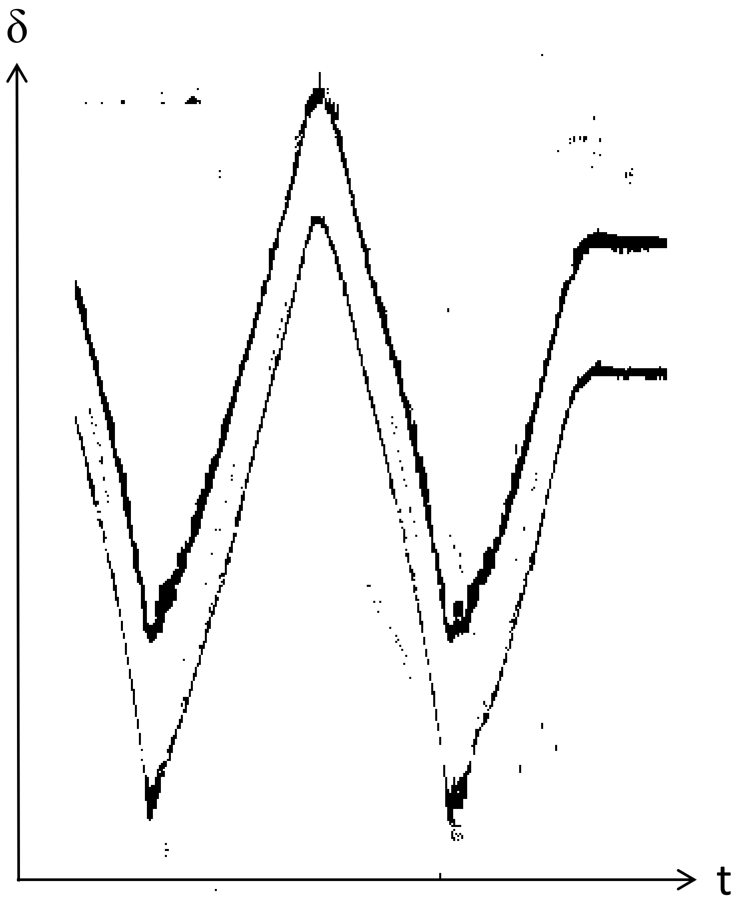
$$\Delta\pi \simeq 2RTC_{O-,B}\frac{V_B}{V_C}D_{Na^+}t$$

Contrainte de flexion faible

$$\Delta\pi = \sigma = \frac{Eh\delta}{L^2}$$

$$\boxed{\delta = \frac{2RTC_{O-,B}V_B D_{Na^+}L^2 t}{hEV_C} \propto n_{O-,B}\frac{L^2}{h}t}$$

Reslice sur Image J

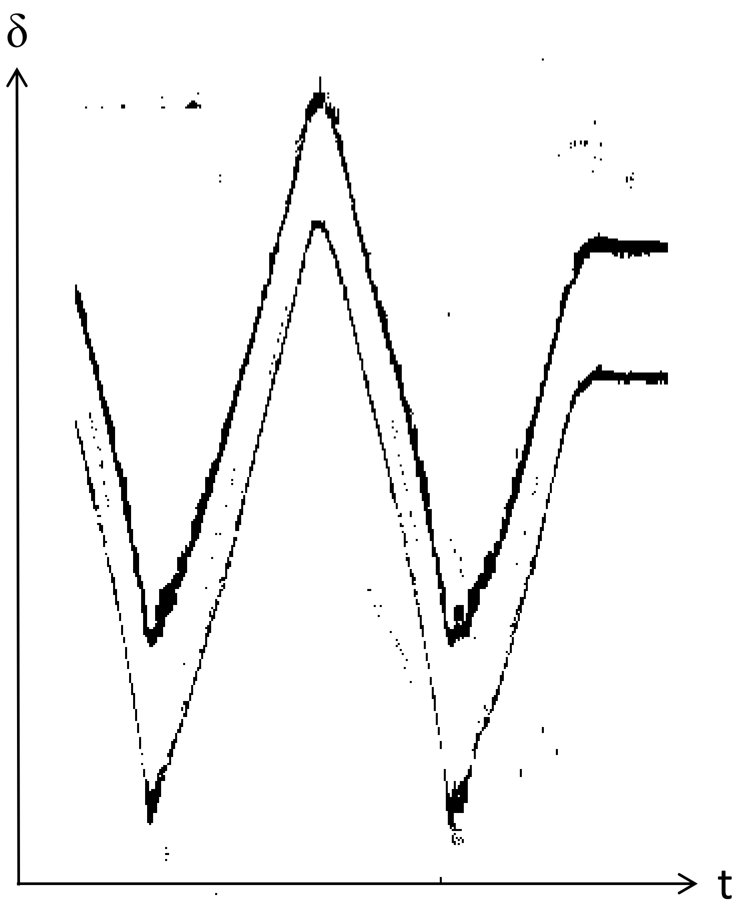


f = 100mHz
U = 106 V

$$\delta = \frac{2RTn_{O^-,B}D_{Na^+}L^2}{hEV_C}t$$

Profil linéaire
v = 8,4 mm/s

Reslice sur Image J



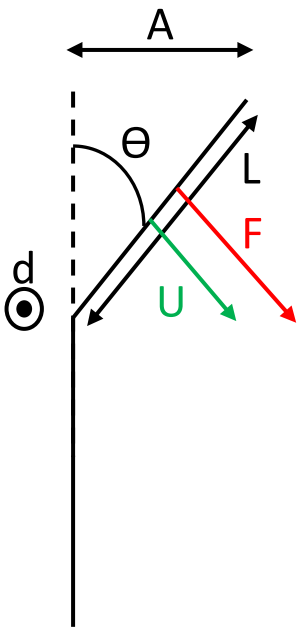
f = 100mHz
U = 106 V

Profil linéaire
v = 8,4 mm/s

$$v = \frac{2RTn_{O^-,B}D_{Na^+}L^2}{hEV_C}$$

$$\boxed{E \sim \frac{RT(n_{O^-,B})^2\mu_{Na^+}UL}{d_{elec}h^4v} \sim 1,2MPa}$$

Caoutchouc : E ~ 100 MPa
Collagène : E ~ 6 MPa
Silicone : E ~ 1 MPa

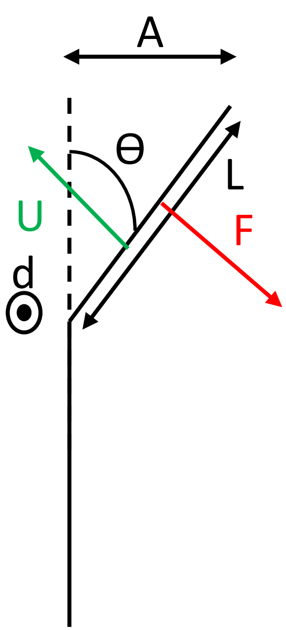


$$\frac{\mathrm{d}U}{\mathrm{d}t} < 0$$

$$\boxed{Re = \frac{\rho A v}{\eta} \sim 100}$$

Force de masse ajoutée

$$\overrightarrow{F} = -M_f \frac{\mathrm{d}U}{\mathrm{d}t} \frac{\overrightarrow{U}}{|\overrightarrow{U}|}$$



$$\frac{\mathrm{d}U}{\mathrm{d}t} > 0$$

$$\left.\begin{aligned} M_f &\sim \rho A L d \\ \frac{dU}{dt} &\sim A\ddot{\theta} \sim \frac{A^2}{L} f^2 \end{aligned}\right\} \quad \boxed{F_{prop} \sim \rho A^3 f^2 d}$$

Merci à tous pour votre attention !