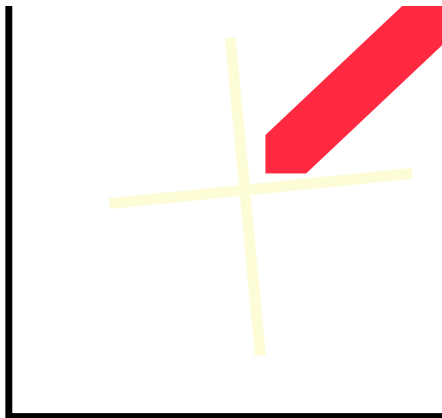


Filets

2 directions de fils

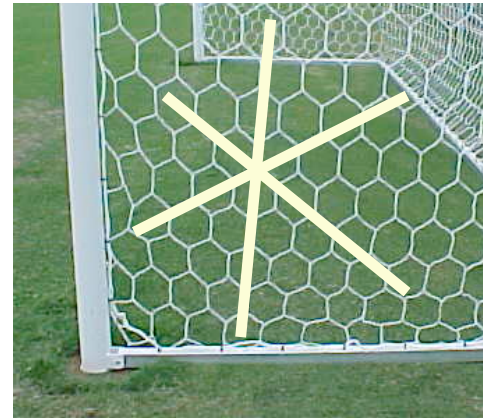


Maille losange



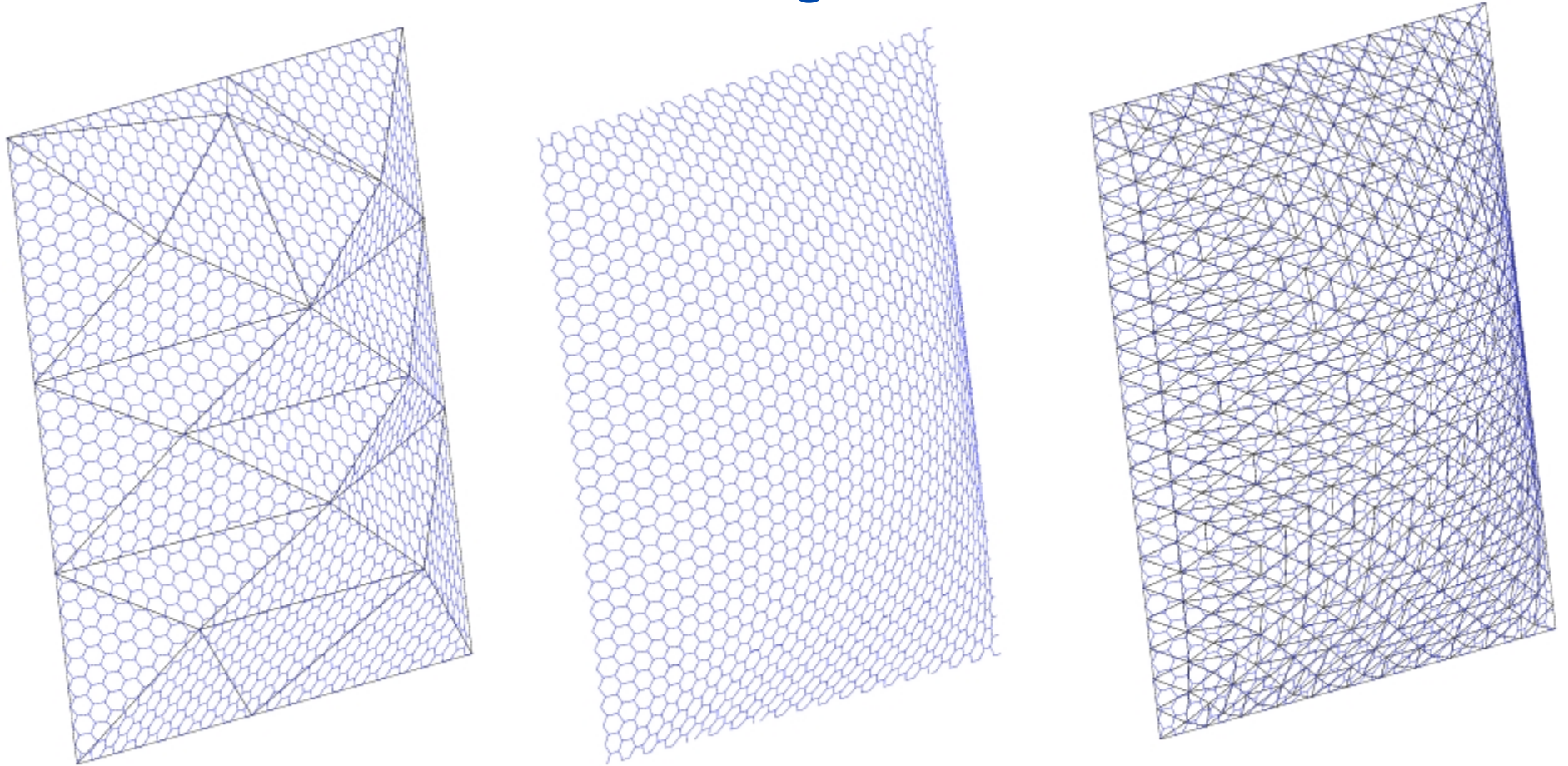
Carrée

3 directions



Hexagonale

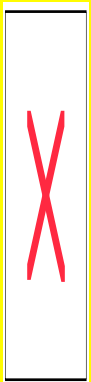
Méthode aux éléments finis: élément triangulaire



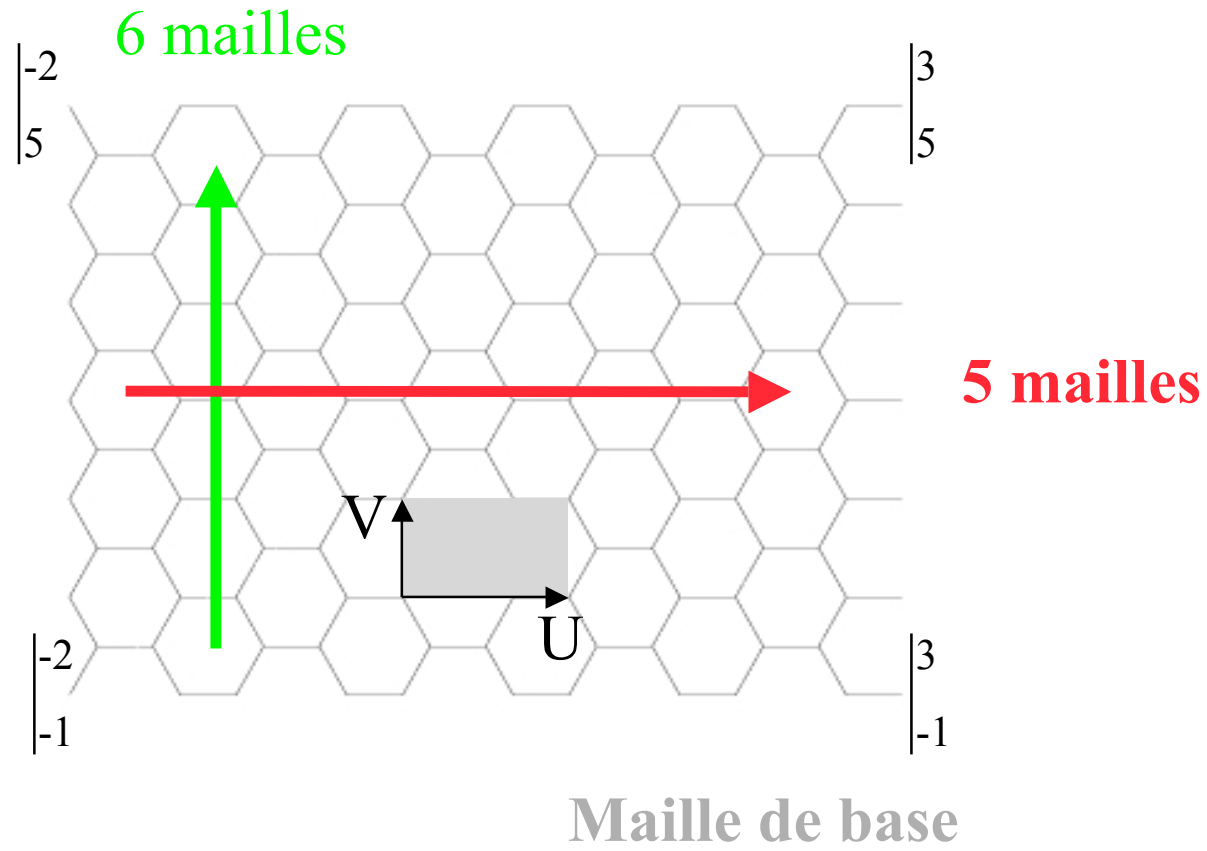
Approximation:

Déformation constante par élément triangulaire

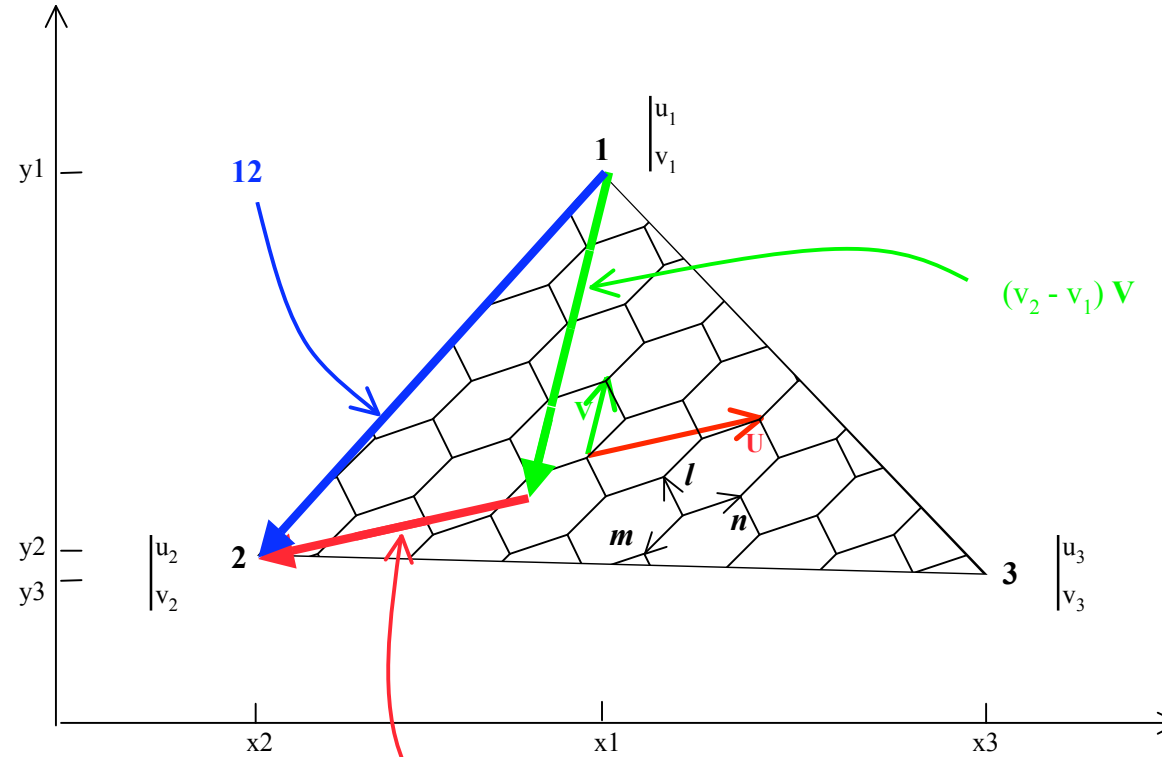




Filet à mailles hexagonales: comptage des mailles



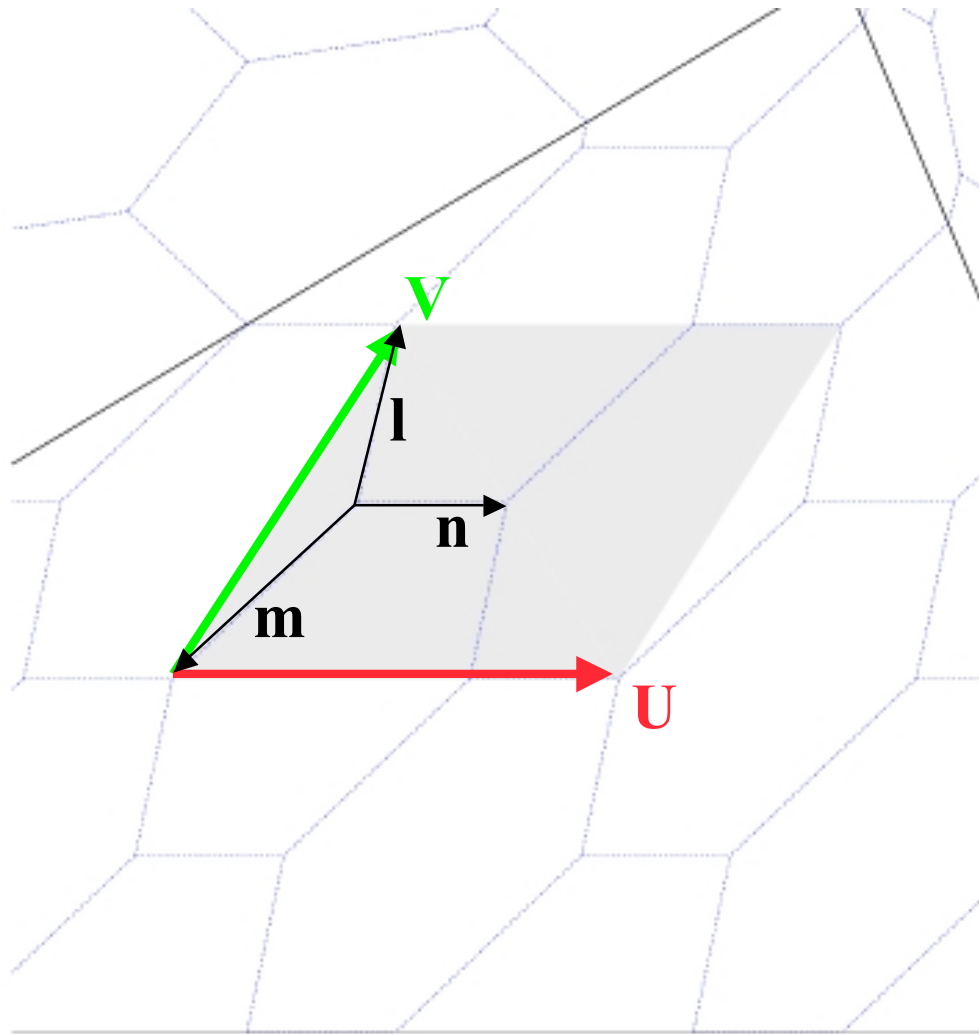
Élément triangulaire: U & V



$$\mathbf{12} = (u_2 - u_1) \mathbf{U} + (v_2 - v_1) \mathbf{V}$$

$$\mathbf{13} = (u_3 - u_1) \mathbf{U} + (v_3 - v_1) \mathbf{V}$$



Longueurs et tensions dans les fils l , m et n 

$$\mathbf{U} = -\mathbf{m} + 2\mathbf{n} - \mathbf{l}$$

$$\mathbf{V} = -\mathbf{m} + \mathbf{l}$$

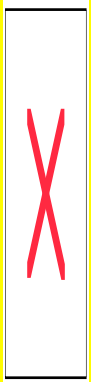
$$|\mathbf{T}_l| = EA \frac{|\mathbf{l}| - l_0}{l_0}$$

$$|\mathbf{T}_m| = EA \frac{|\mathbf{m}| - m_0}{m_0}$$

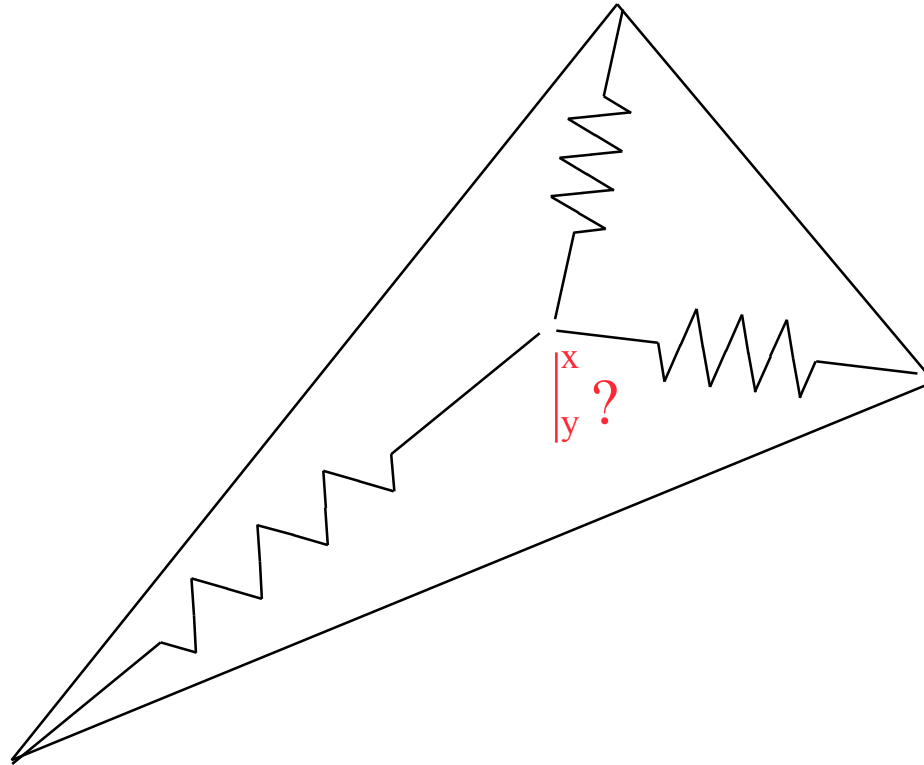
$$|\mathbf{T}_n| = EA \frac{|\mathbf{n}| - n_0}{n_0}$$

$$\mathbf{T}_l + \mathbf{T}_m + \mathbf{T}_n = \mathbf{0}$$





Équilibre de 3 fils élastiques



Réduction à 2 équations à 2 inconnues

$$T_{lx} + T_{mx} + T_{nx} = 0$$

$$T_{ly} + T_{my} + T_{ny} = 0$$

$$\frac{l_x}{|l|} \frac{|l| - l_0}{l_0} + \frac{m_x}{|m|} \frac{|m| - m_0}{m_0} + \frac{n_x}{|n|} \frac{|n| - n_0}{n_0} = 0$$

Pas de solution
analytique

$$\frac{l_y}{|l|} \frac{|l| - l_0}{l_0} + \frac{m_y}{|m|} \frac{|m| - m_0}{m_0} + \frac{n_y}{|n|} \frac{|n| - n_0}{n_0} = 0$$

Approximation:

$$\frac{l_x}{|l|} \approx \frac{l_x}{l_0}$$



2 équations simplifiées à 2 Inconnues: m_x et m_y

$$l_x \frac{|l| - l_0}{l_0^2} + m_x \frac{|m| - m_0}{m_0^2} + n_x \frac{|n| - n_0}{n_0^2} = 0$$

$$l_y \frac{|l| - l_0}{l_0^2} + m_y \frac{|m| - m_0}{m_0^2} + n_y \frac{|n| - n_0}{n_0^2} = 0$$

Pas de solution
analytique



Newton-Raphson

Dérivée de F

$$F' = \lim_{h \rightarrow 0} \frac{F(x+h) - F(x)}{h}$$

Si $F(x+h) = 0$ alors $h = \frac{F(x)}{-F'(x)}$

ici

$$F = \begin{cases} l_x \frac{|l| - l_0}{l_0^2} + m_x \frac{|m| - m_0}{m_0^2} + n_x \frac{|n| - n_0}{n_0^2} = F_1 \\ l_y \frac{|l| - l_0}{l_0^2} + m_y \frac{|m| - m_0}{m_0^2} + n_y \frac{|n| - n_0}{n_0^2} = F_2 \end{cases}$$

$$x = \begin{cases} m_x \\ m_y \end{cases}$$



Newton-Raphson

$$F' = \begin{vmatrix} D_{11} & D_{12} \\ D_{21} & D_{22} \end{vmatrix}$$

$$D_{11} = -\frac{l^2 - l l_0 + l_x^2}{l_0^2 l} - \frac{m^2 - m m_0 + m_x^2}{m_0^2 m} - \frac{n^2 - n n_0 + n_x^2}{n_0^2 n}$$

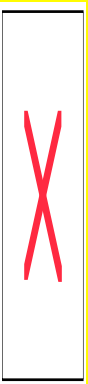
$$D_{12} = D_{21} = -\frac{l_x l_y}{l_0^2 l} - \frac{m_x m_y}{m_0^2 m} - \frac{n_x n_y}{n_0^2 n}$$

$$D_{22} = -\frac{l^2 - l l_0 + l_y^2}{l_0^2 l} - \frac{m^2 - m m_0 + m_y^2}{m_0^2 m} - \frac{n^2 - n n_0 + n_y^2}{n_0^2 n}$$

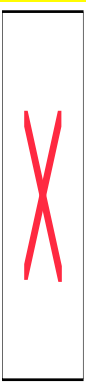
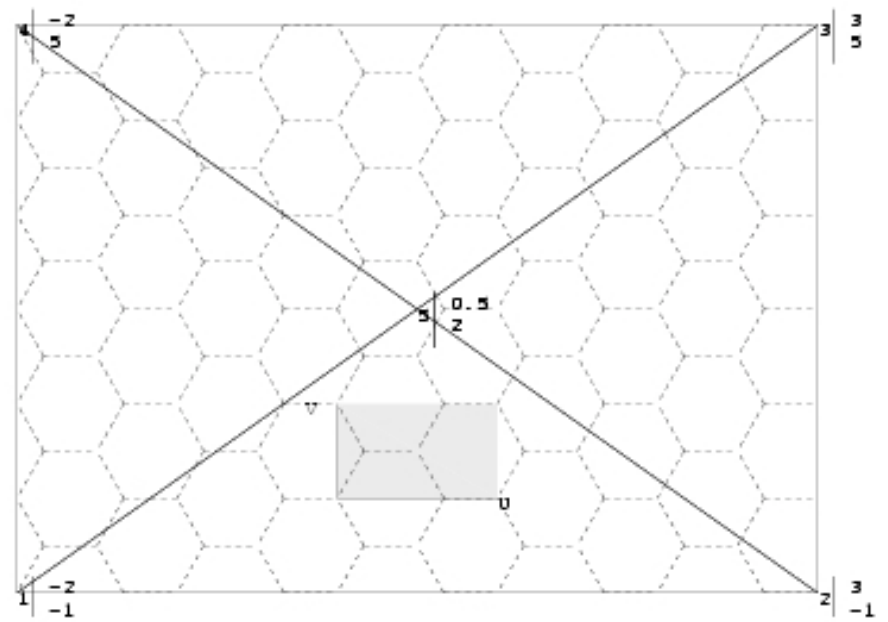
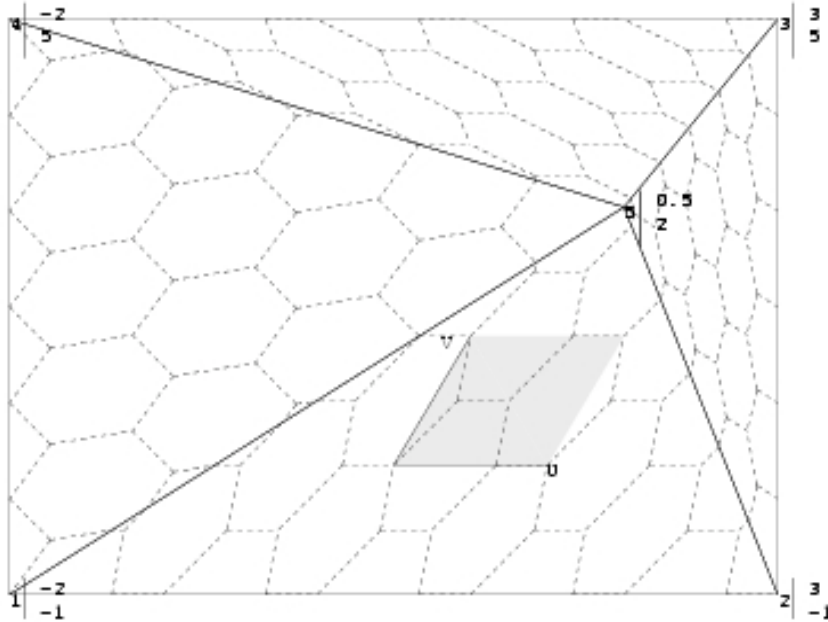
$$h = \begin{cases} \frac{D_{22} F_1 - D_{12} F_2}{D_{22} D_{11} - D_{12} D_{21}} \\ \frac{D_{22} F_2 - D_{21} F_1}{D_{22} D_{11} - D_{12} D_{21}} \end{cases}$$

$$m_x = m_x + \frac{D_{22} F_1 - D_{12} F_2}{D_{22} D_{11} - D_{12} D_{21}}$$

$$m_y = m_y + \frac{D_{22} F_2 - D_{21} F_1}{D_{22} D_{11} - D_{12} D_{21}}$$

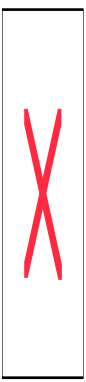
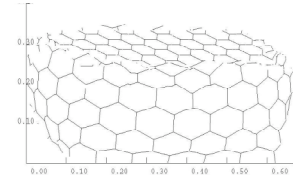
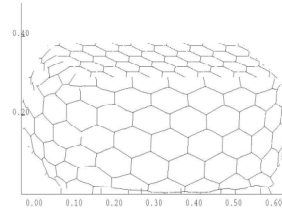
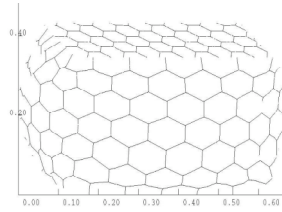
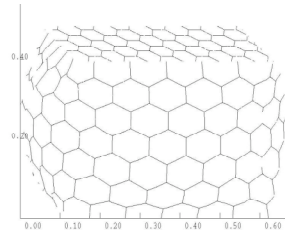
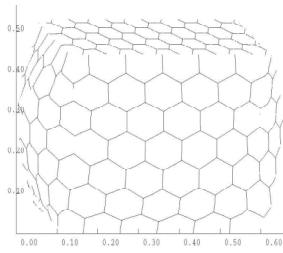


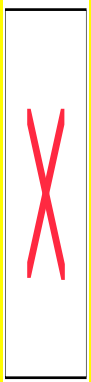
Méthode aux éléments finis: élément triangulaire



Application

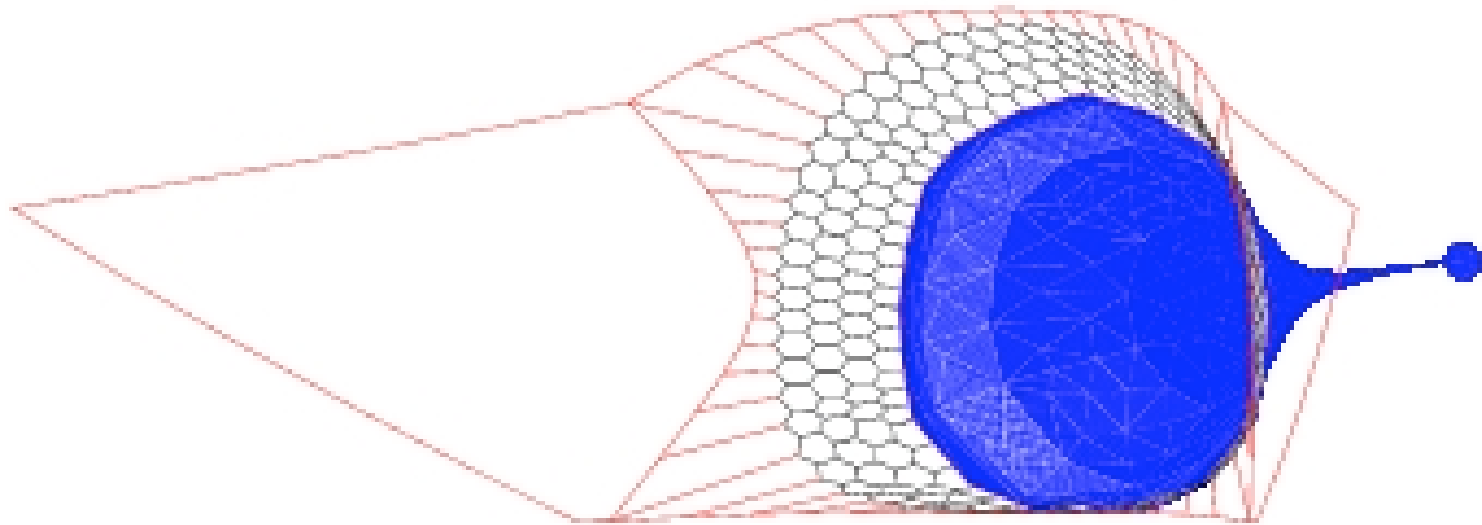
Gabion

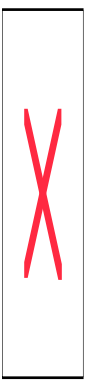




Application

Chalut

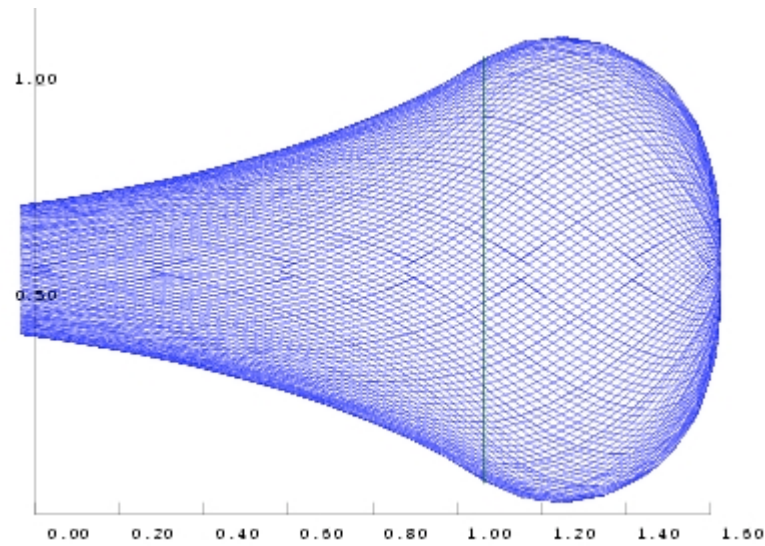




Application

Culs de chalut

Maille losange



Maille hexagonale

