

Modélisation de solides déformables

Plan

I. Présentation et première approche

- A. Inspiration
- B. Etude d'un mouvement
- C. Première solution : les systèmes masse-ressort

II. Réalisation

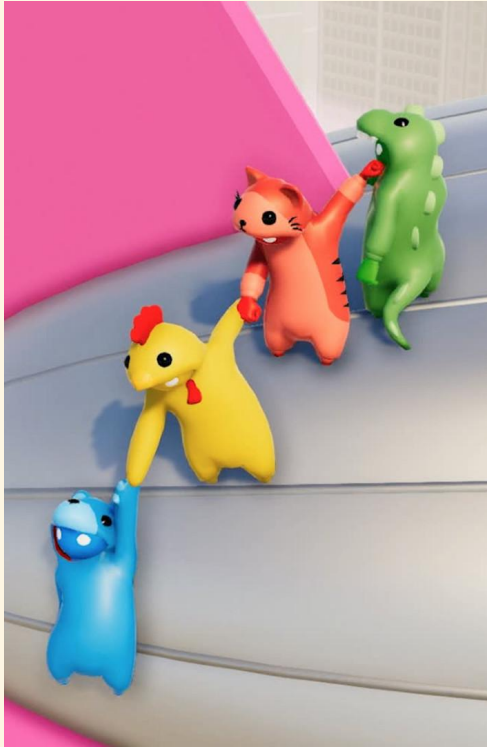
- A. Première méthode d'intégration : Euler
- B. Deuxième Méthode : Runge Kutta
- C. Problème de la réaction du support

III. Deuxième approche

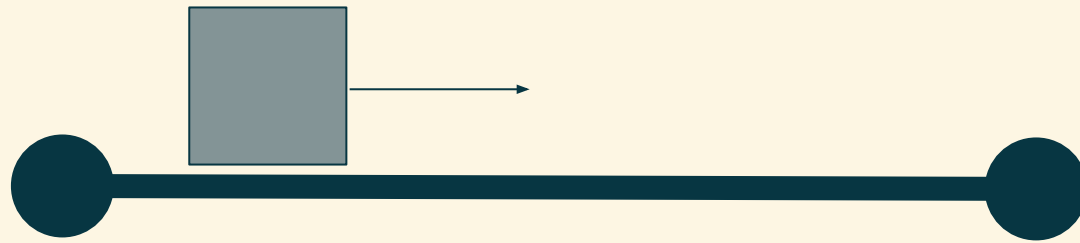
- A. Modèle du gaz parfait
- B. Confirmation avec expérimentation

Présentation du problème et première approche

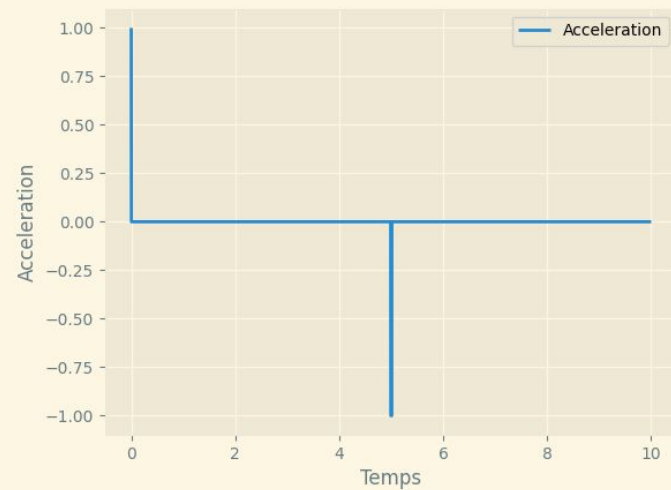
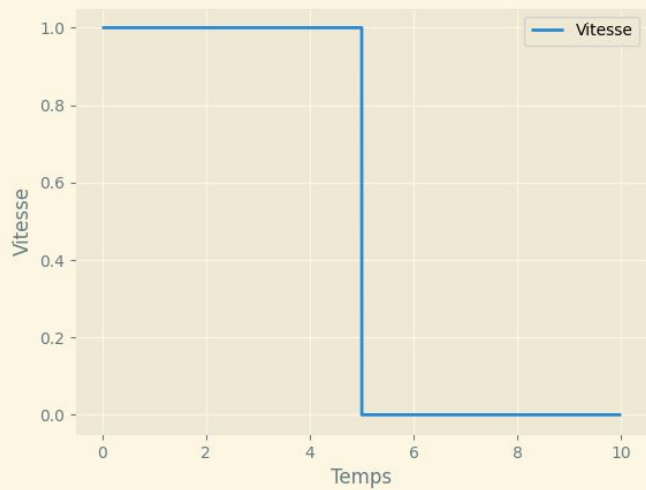
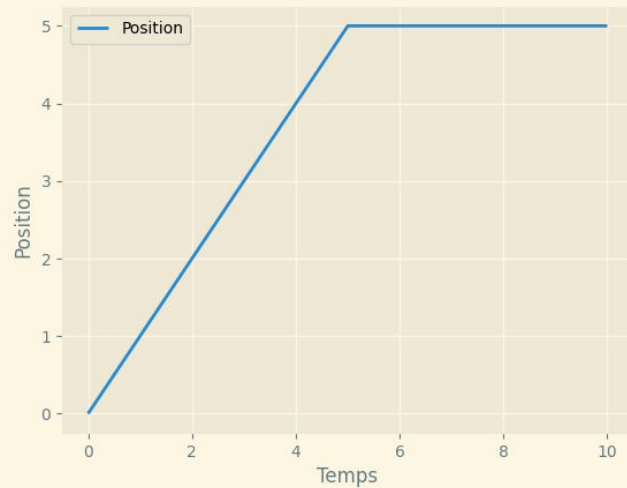
Inspiration



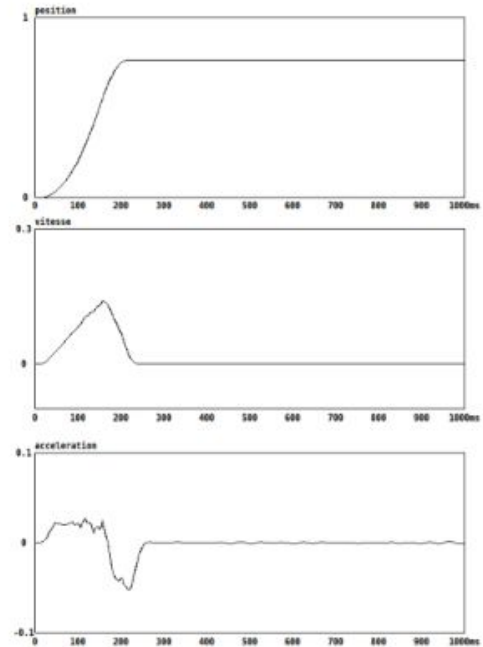
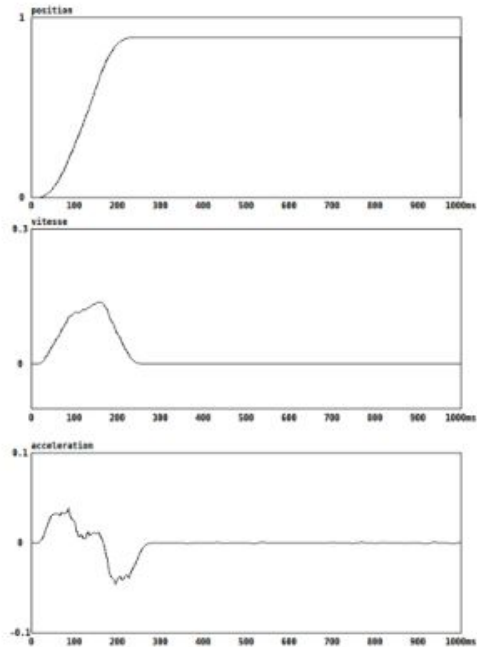
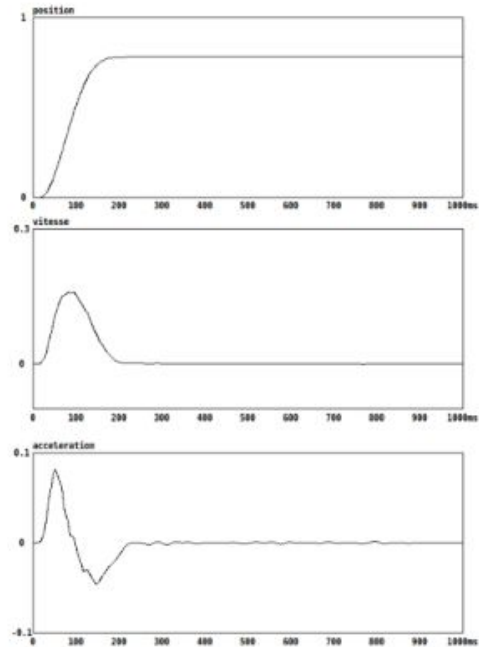
Modélisation réaliste du mouvement



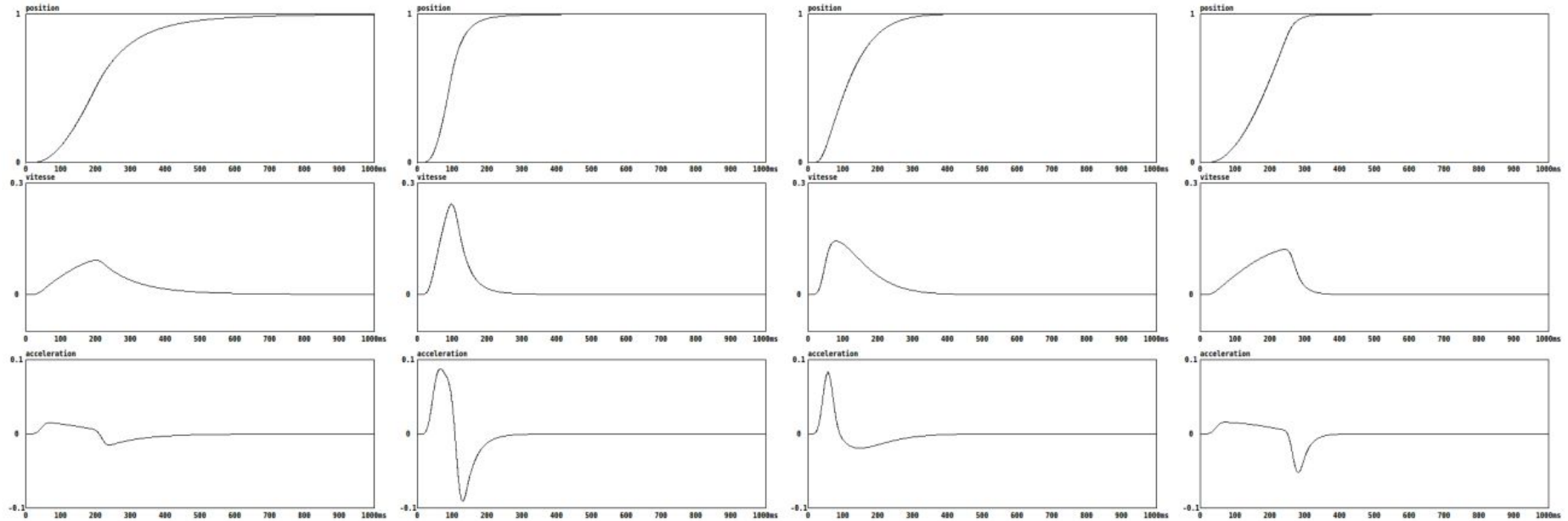
Modèle informatique simple



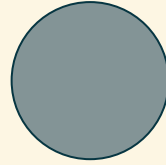
Mouvements naturels



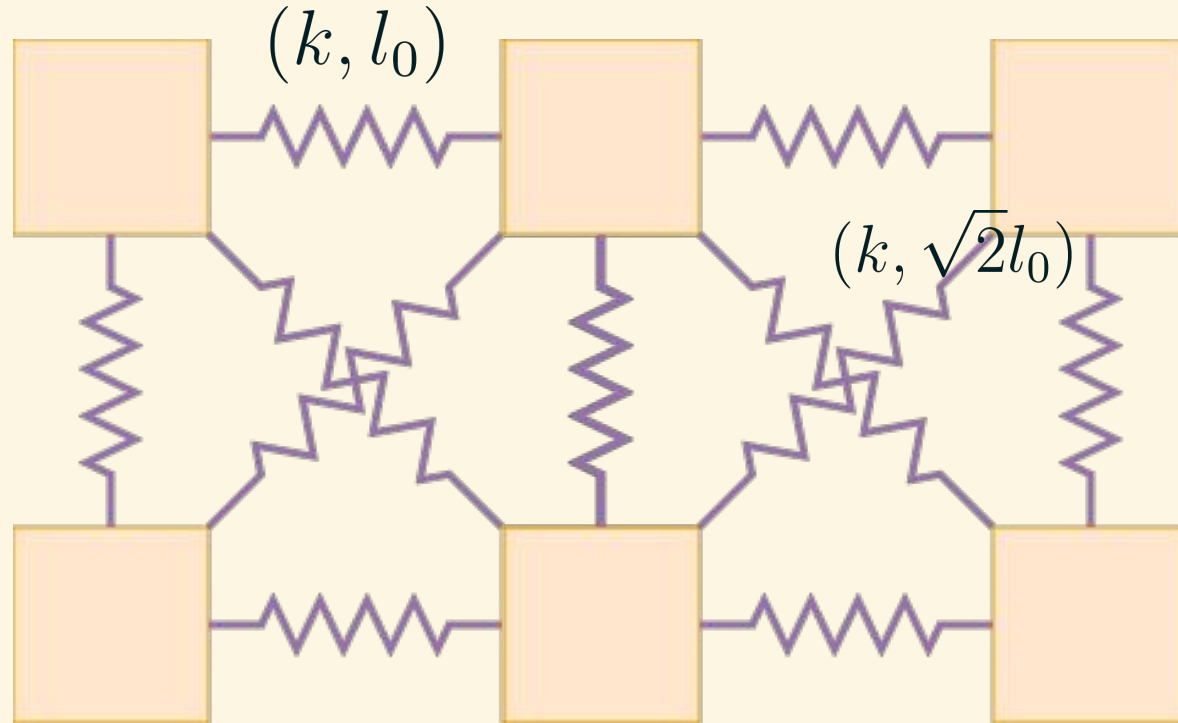
Mouvements type Système masse-ressort



Simplification

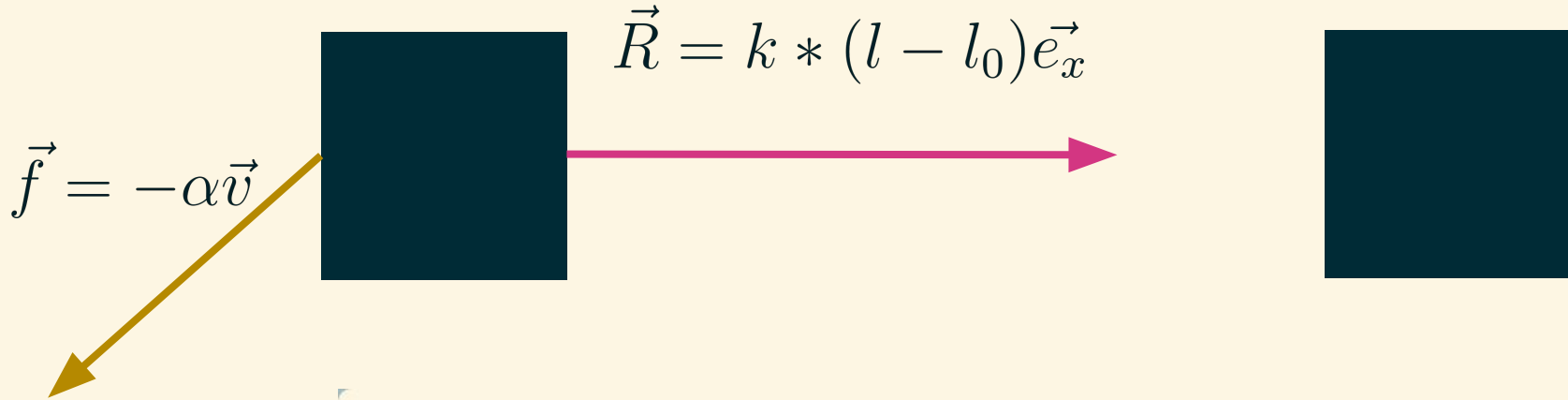


Structure du système



II. Réalisation

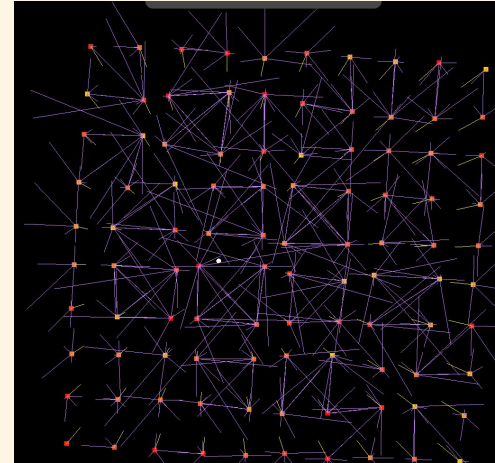
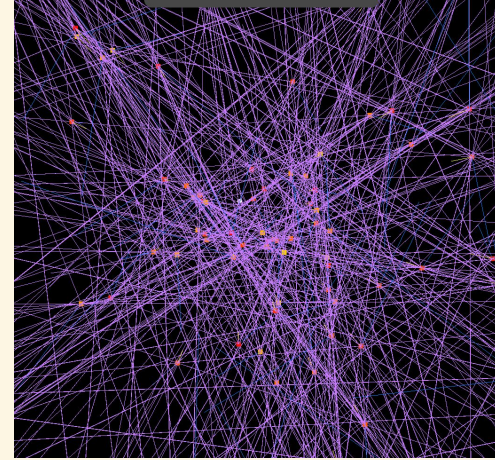
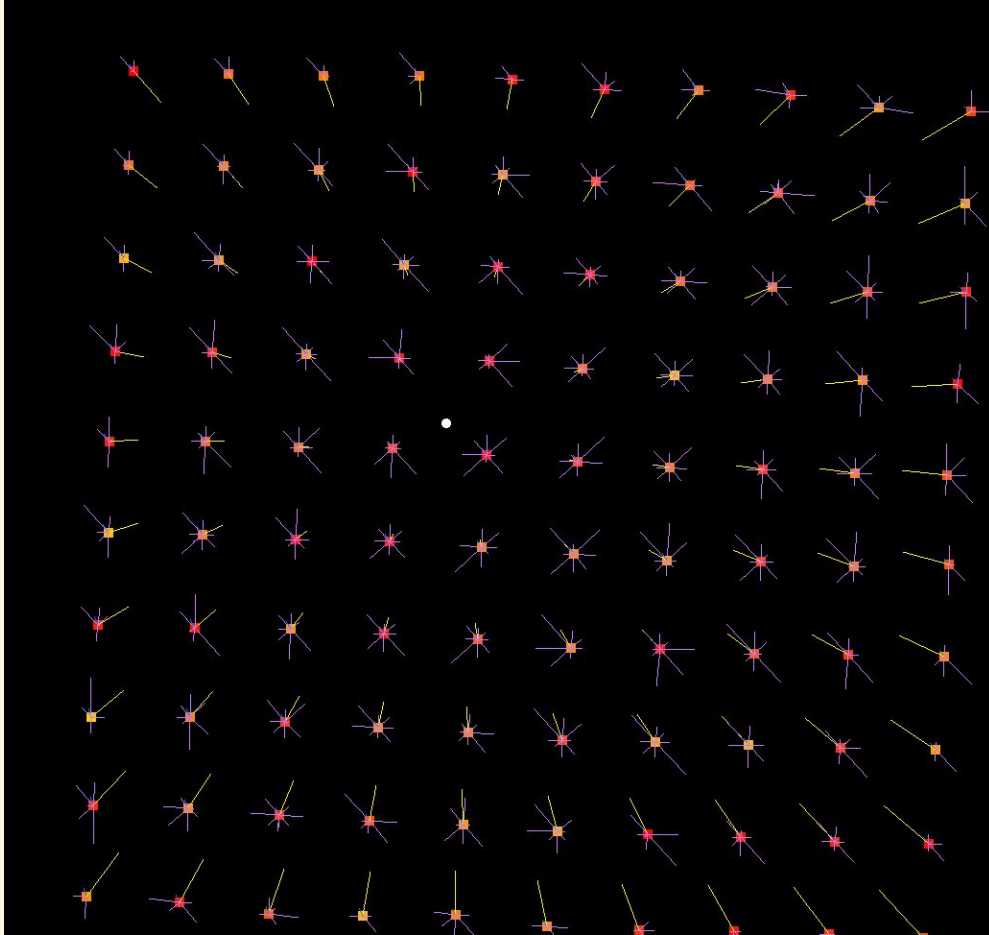
Méthode d'Euler



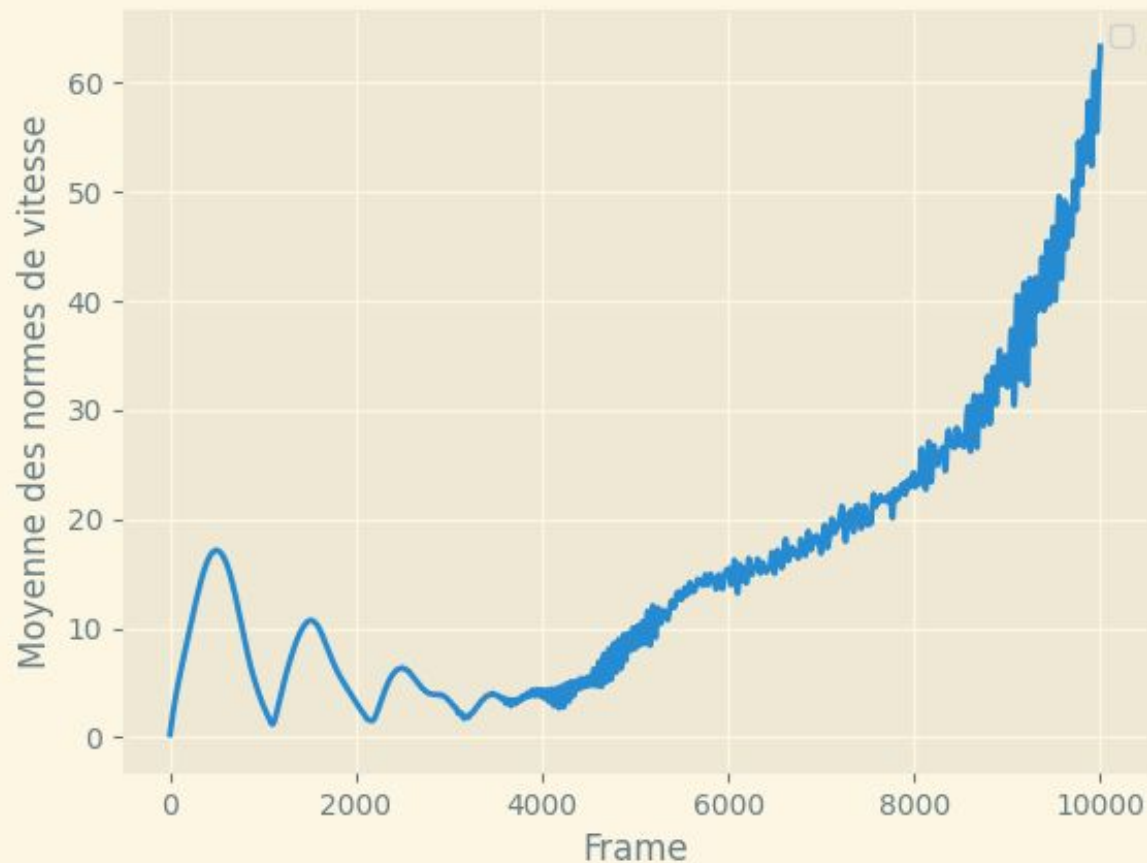
$$x[t + 1] = x[t] + v[t] * dt$$

$$v[t + 1] = v[t] + \text{acceleration}(t) * dt$$

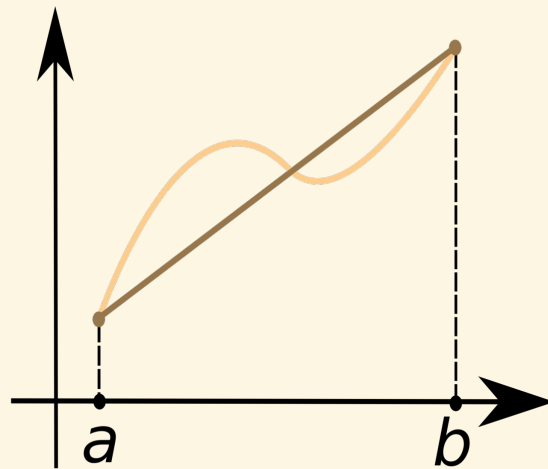
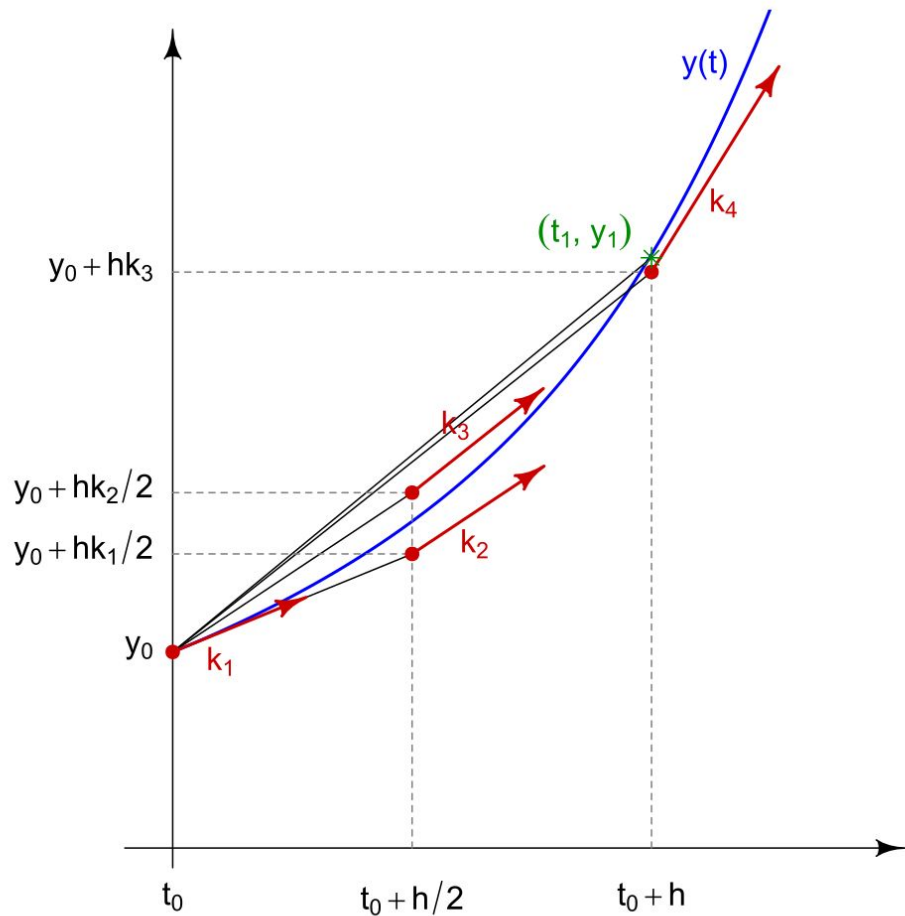
Première expérience



Première expérience

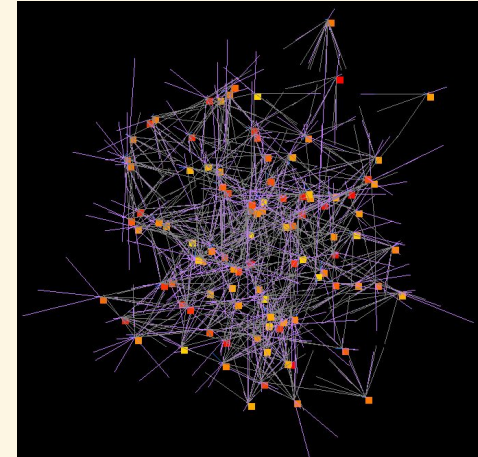
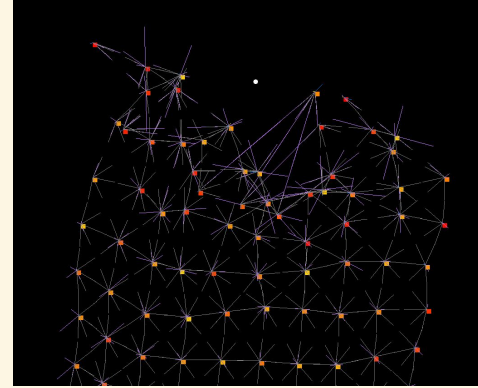
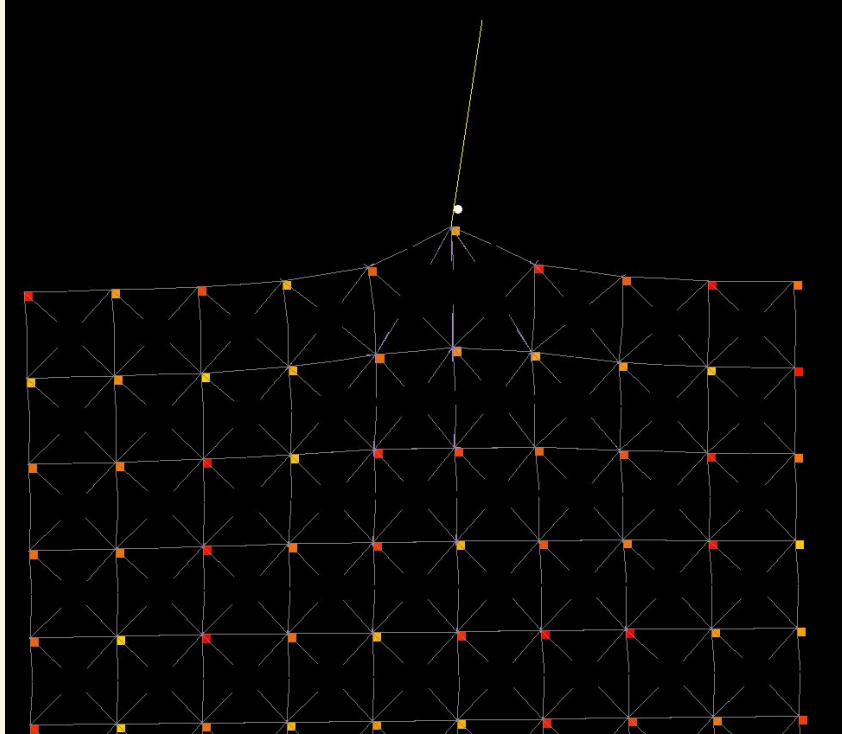


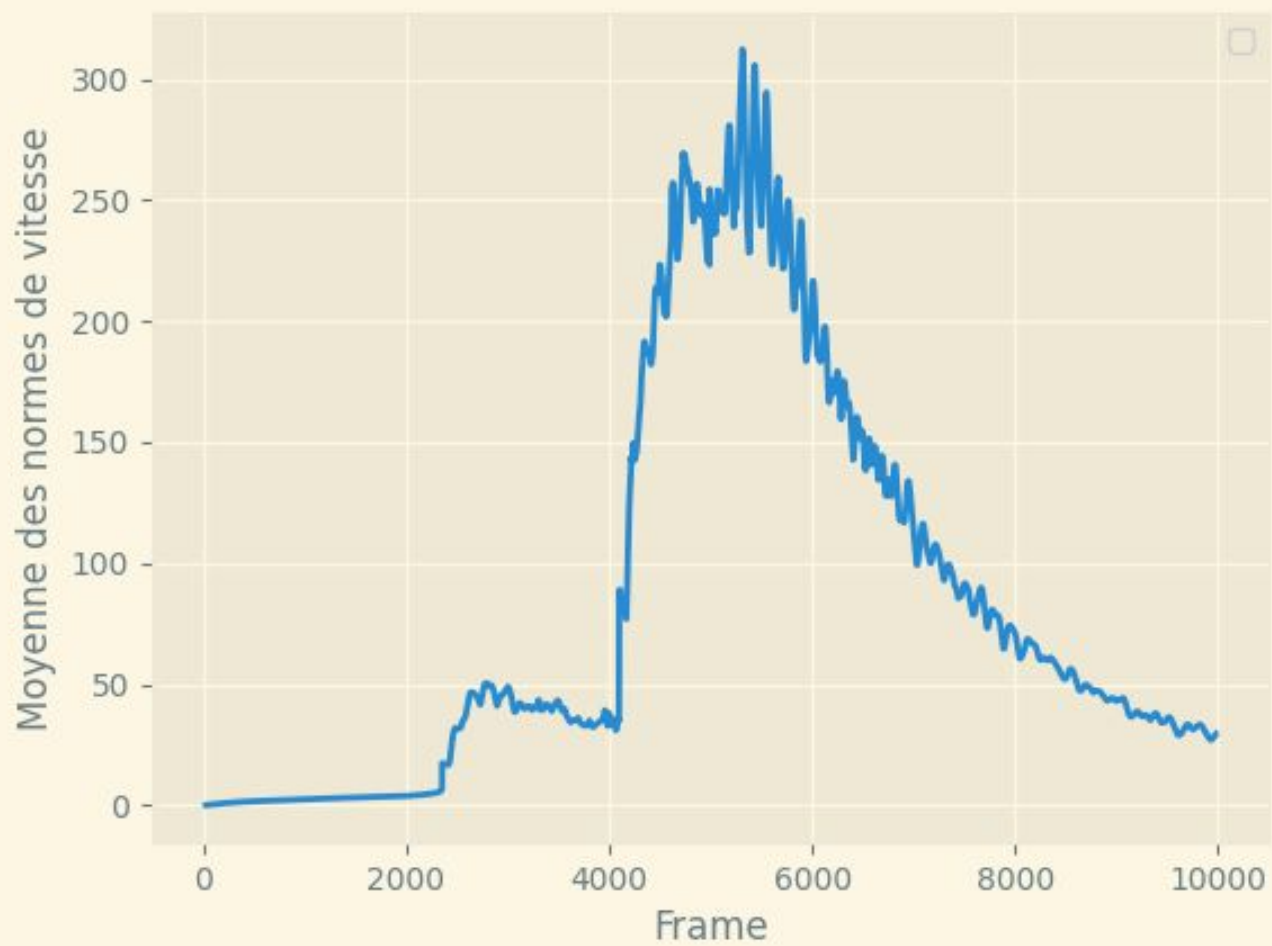
Méthode de Runge-Kutta



$$\int_t^{t+h} f(x) dx \approx h \frac{f(t) + f(t+h)}{2}$$

Expérimentatio n





Nouvelle description du système

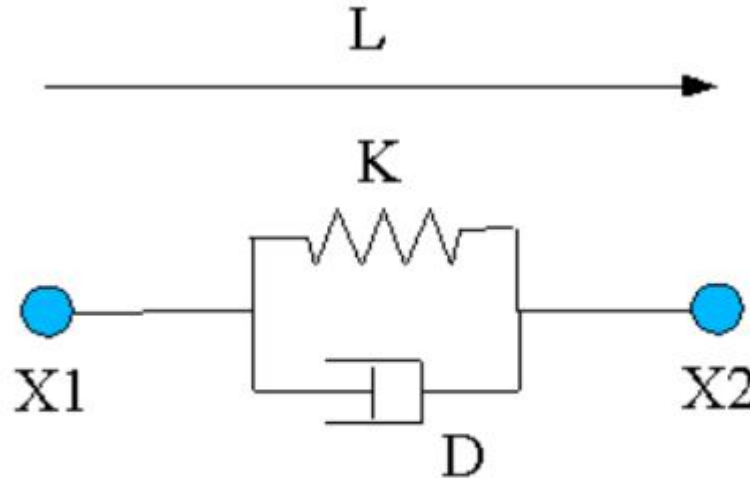
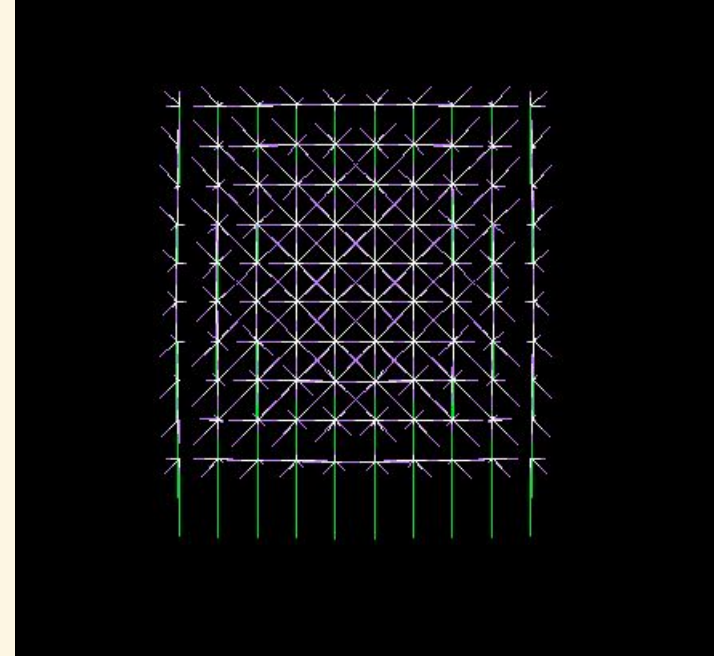
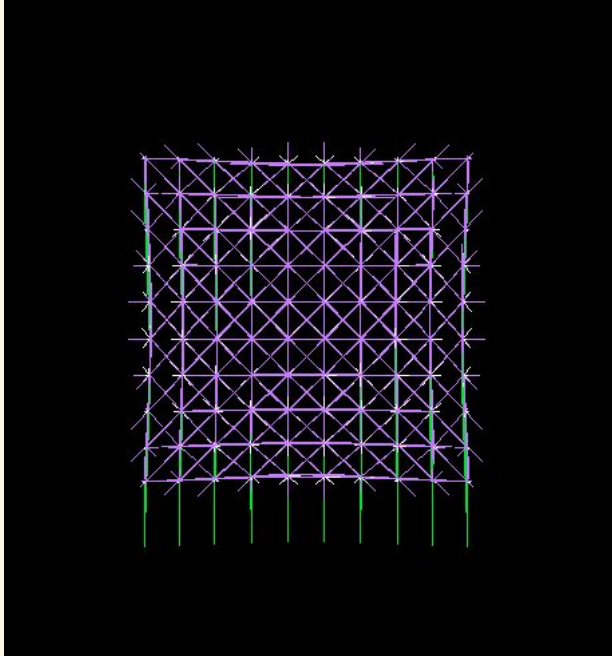


figure 4: representation of a spring and a damper connected as a single link

Effet de respiration



gravité

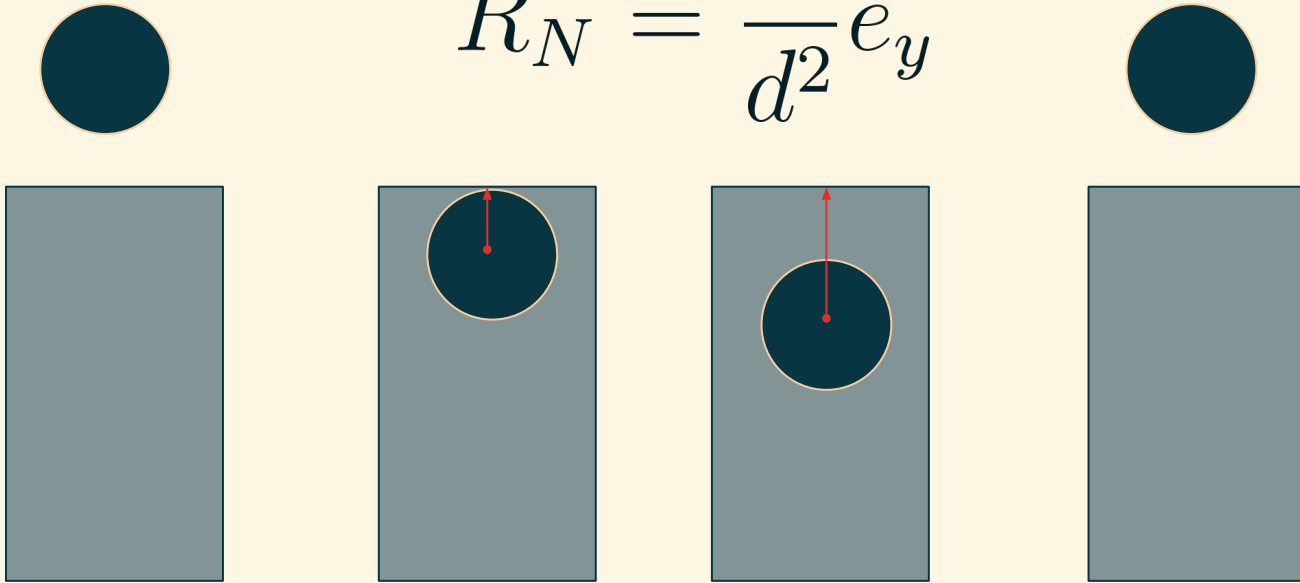
frottement du ressort

force de ressort élastique

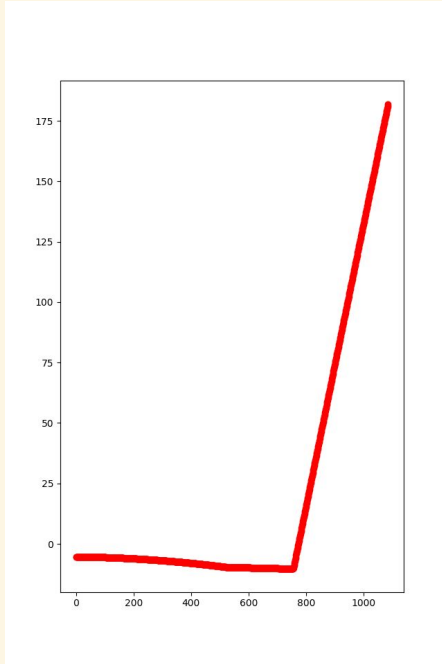
Collisions

Collision “magnétique”

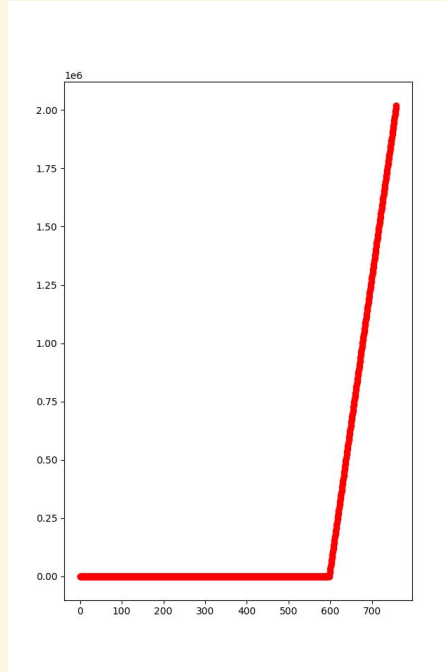
$$\vec{R}_N = \frac{K}{d^2} \vec{e}_y$$



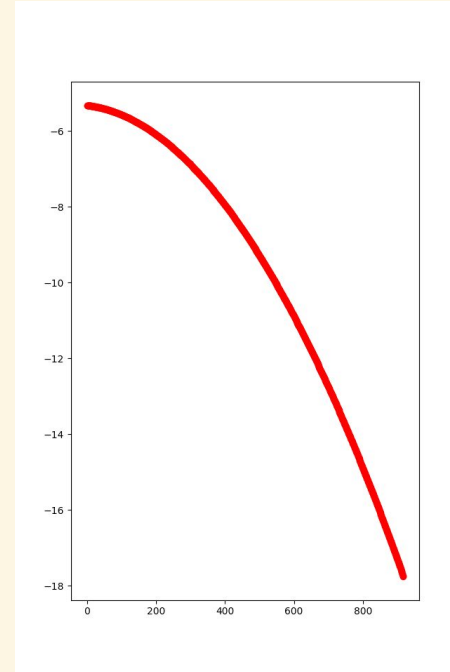
Résultats pour différentes valeurs de K



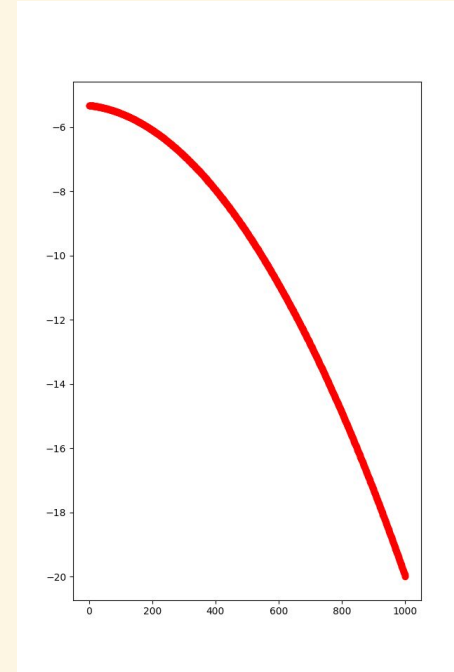
$$K = 1.0$$



$$K = 1.0e - 1$$



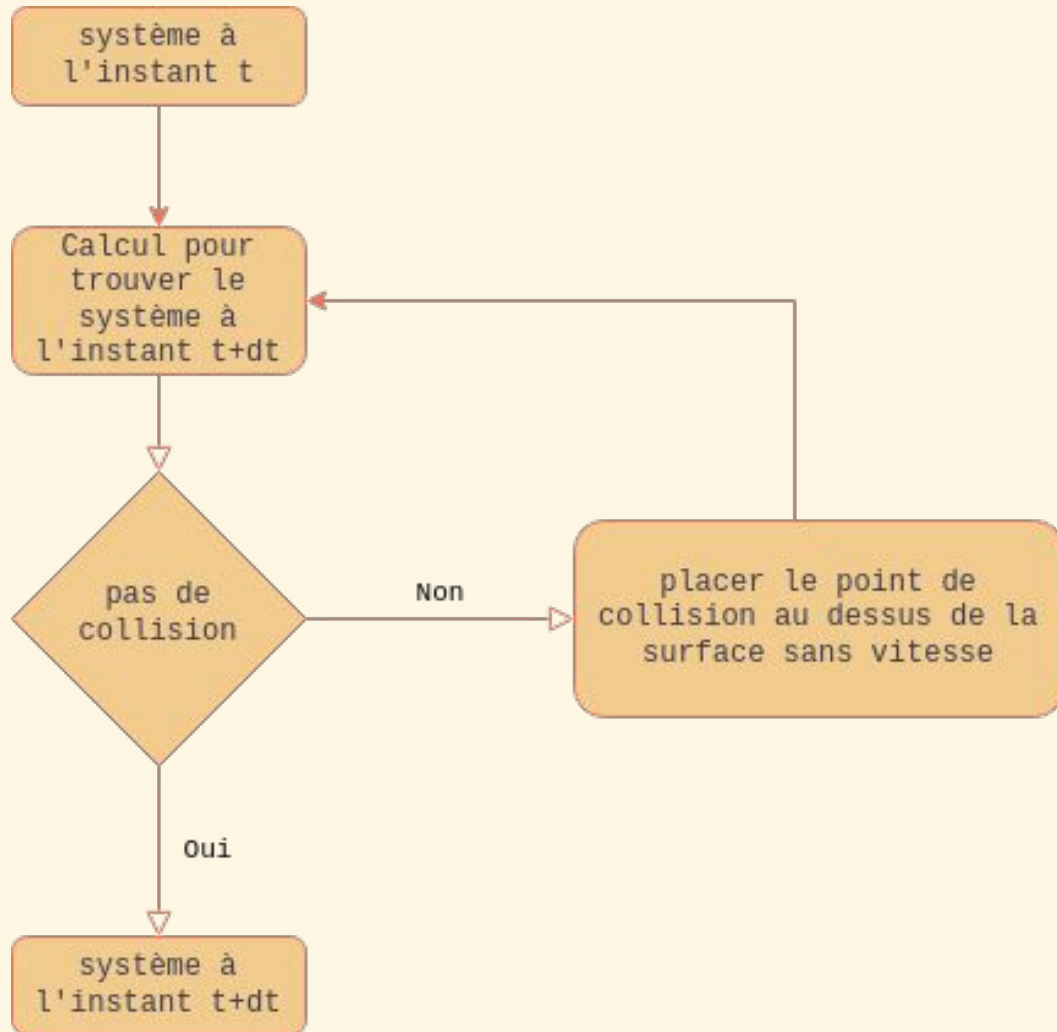
$$K = 1.0e - 2$$

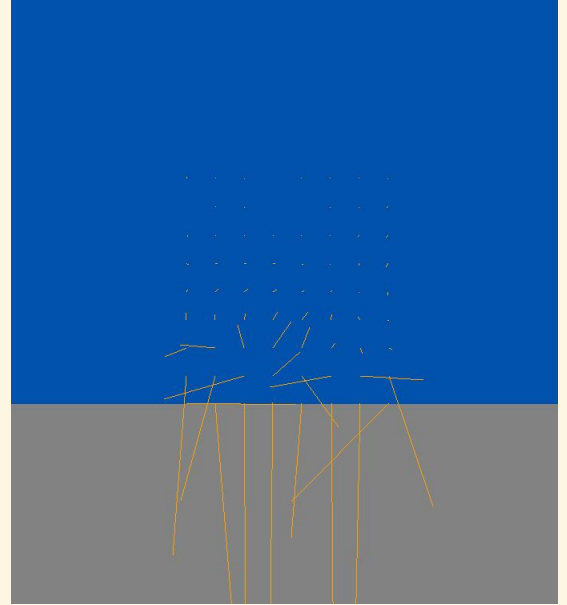
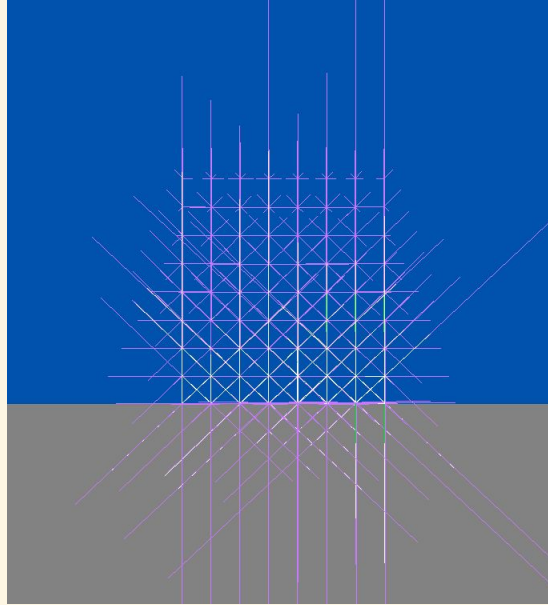
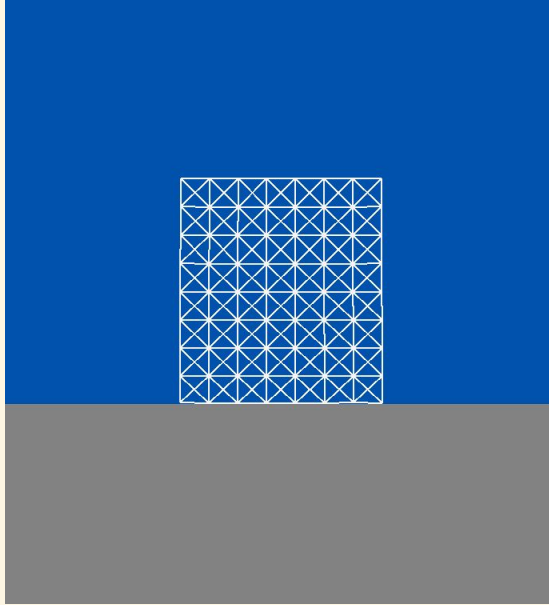


$$K = 1.0e - 4$$

Position moyenne verticale en fonction du temps

Backtracking



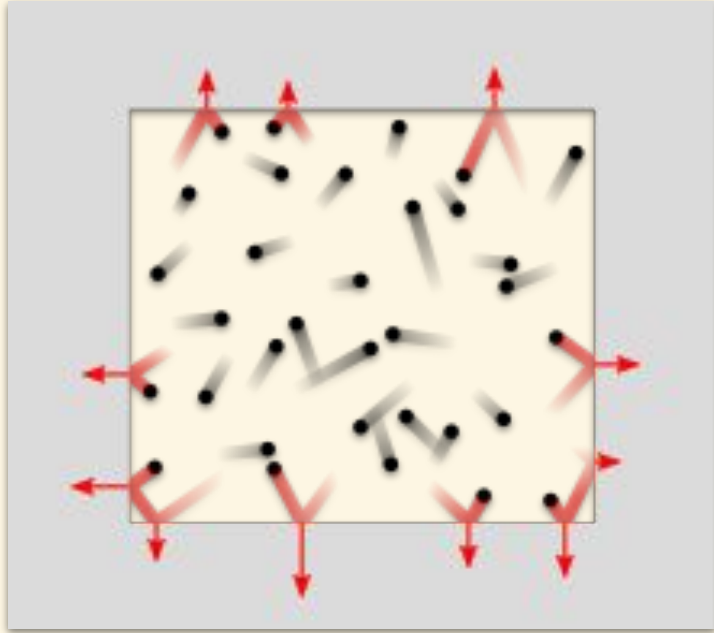


Problèmes :

- Nombreux calculs de remplacement
- Imprécision sur les points à la surface

III. Deuxième approche

Modèle du gaz parfait



$$\vec{F} = P d\vec{S}$$

$$P = \frac{nRT}{V}$$

$$\vec{F} = K_{nRT} \frac{1}{V} d\vec{S}$$

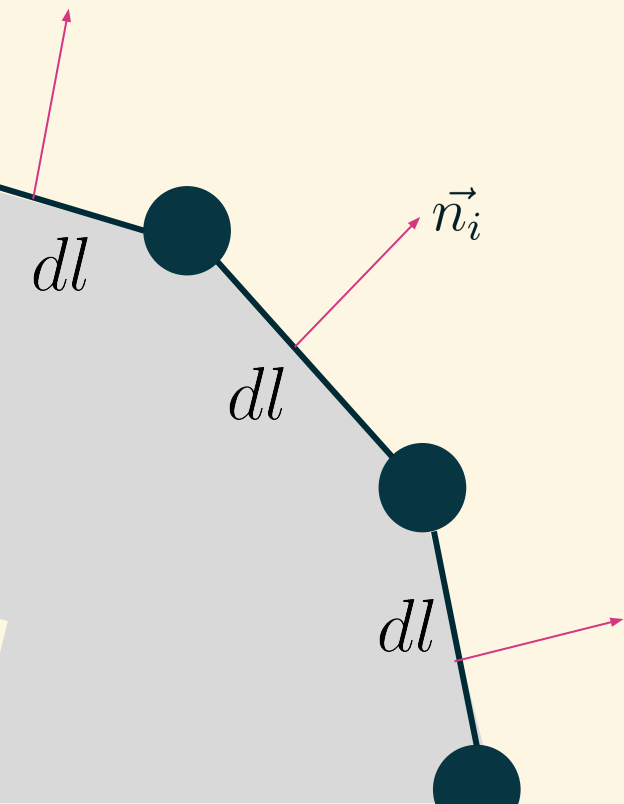
Calcul du volume

Théorème de Stokes :

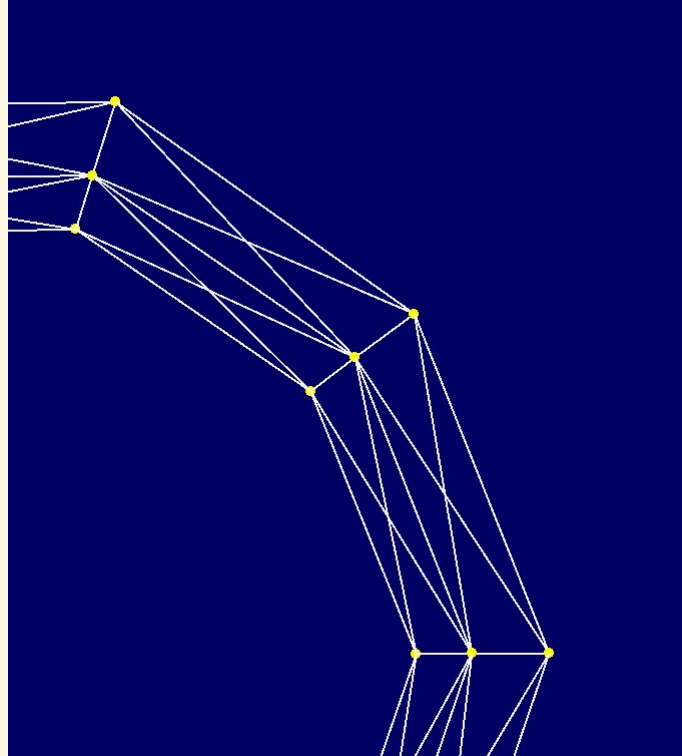
$$\boxed{\iint_S \operatorname{div} \vec{F} \cdot d\vec{S} = \oint_C \vec{F} \cdot d\vec{l}}$$

$\vec{F} = x\vec{e}_x$	$\vec{F} \cdot d\vec{l}$
$\operatorname{div} \vec{F} = 1$	$= \vec{F} \cdot \vec{n} dl$
	$= x \cdot n_x \cdot dl$

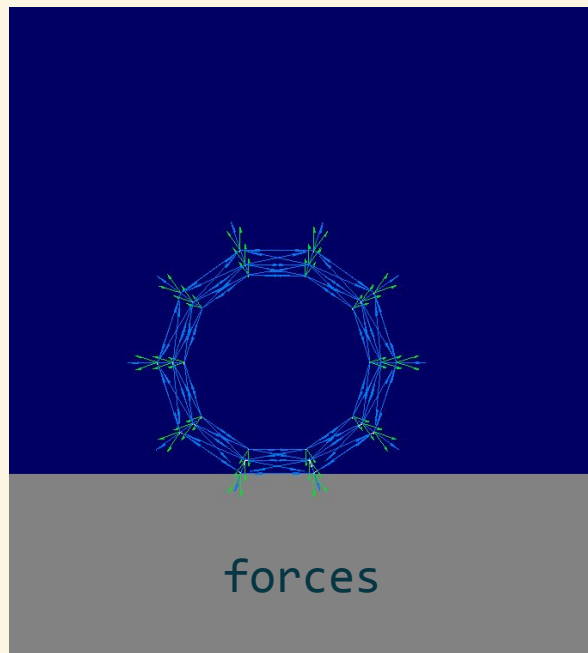
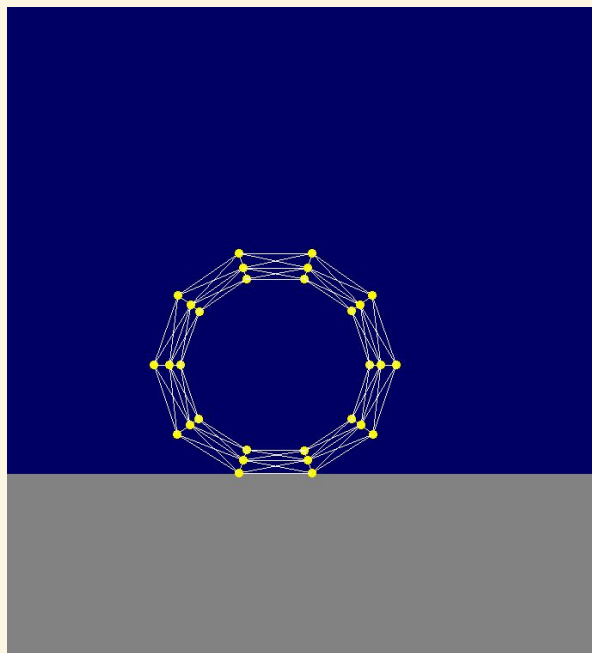
$$S \approx \sum x_i \cdot n_i \cdot dl$$



Compromis ressort/gaz



Résultat



gaz

gravité

force de ressort élastique

Améliorations possibles

- Programmation parallèle
- Simulation en 3 dimensions