Massa-Mola / Pêndulo

$$\frac{\partial^2 x}{\partial t^2} = -\omega^2 \operatorname{sen}(x) - \gamma v, \qquad v = \frac{\partial x}{\partial t}$$

1) Método de Verlet

$\Longrightarrow$ 2) Redução de ordem + RK4

$$\frac{\partial x}{\partial t} = v$$

$$\frac{\partial v}{\partial t} = -\omega^2 \operatorname{sen}(x) - \gamma v$$

→ Vetorizar: $\vec{y}(t) = \begin{pmatrix} x(t) \\ v(t) \end{pmatrix}$

Cond. inicial em $t = 0$

$y(0) = \begin{pmatrix} x(0) \\ v(0) \end{pmatrix}$

$y(0) = \begin{pmatrix} \alpha\pi \\ 0 \end{pmatrix}$

$$\frac{\partial \vec{y}}{\partial t} = \begin{pmatrix} y_1 \\ -\omega^2 \operatorname{sen}(y_0) - \gamma y_1 \end{pmatrix} = \vec{f}(\vec{y}, t)$$

$$\boxed{\frac{\partial \vec{y}}{\partial t} = \vec{f}(\vec{y}, t)}$$

Euler: $\vec{y}_{n+1} = \vec{y}_n + \vec{f}(\vec{y}_n, t_n)\,\Delta t$

Append!

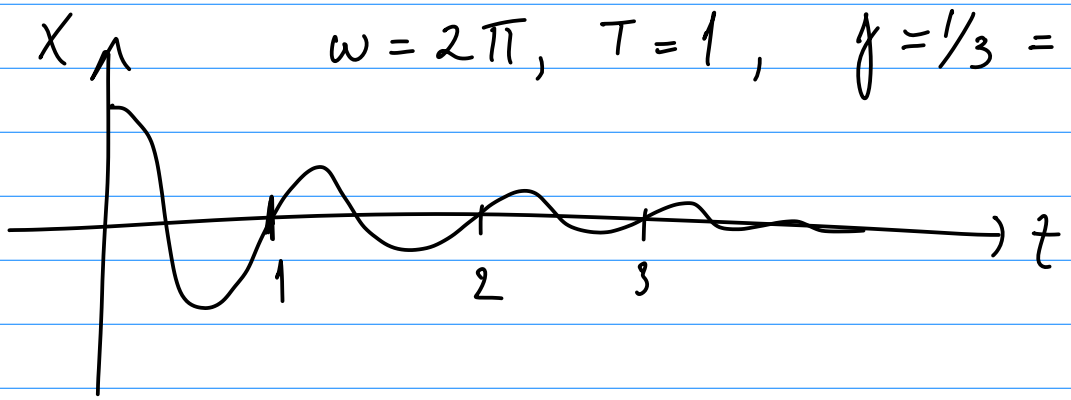
(1D) $(x, y, z) \longrightarrow (x, y, z, p)$

p

(2D) $\begin{pmatrix} x_1 & x_2 \\ y_1 & y_2 \\ z_1 & z_2 \end{pmatrix} \longrightarrow (p_1, p_2) \longrightarrow \begin{pmatrix} x_1 & x_2 \\ y_1 & y_2 \\ z_1 & z_2 \\ p_1 & p_2 \end{pmatrix}$

ERRADO: $(x_1 \; x_2 \; y_1 \; y_2 \; z_1 \; z_2 \; p_1 \; p_2)$

Resultado esperado



$\omega = 2\pi, \quad T = 1, \quad f = 1/3 = 1/6_d$