$\ddot{x} + \dot{x} - x + x^3 = 0$

Oscilador de Duffing

$\rightarrow x_1 = x$

$x_2 = \dot{x}$

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = x_1(1 - x_1^2) - x_2 \end{cases}$$

EE.

$\dot{x}_1 = 0 \rightarrow x_2^* = 0$

$\dot{x}_2 = 0 \rightarrow x_1^*(1 - x_1^{*2}) = 0 \rightarrow x_1^* = 0$

$x_1^* = \pm 1$

$\rightarrow (0,0);\ (1,0)$ e $(-1,0)$

LINEARIZAR

$$\begin{cases} f_1 = x_2 \\ f_2 = x_1 - x_1^3 - x_2 \end{cases}$$

$$\underline{\underline{A}} = \begin{bmatrix} 0 & 1 \\ 1 - 3x_1^{*2} & -1 \end{bmatrix} \qquad \underline{\underline{B}} = \underline{\underline{0}}$$

$$\begin{cases} y_1 = x_1 \\ y_2 = x_2 \end{cases}$$

$$\underline{\underline{C}} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \qquad \underline{\underline{D}} = \underline{\underline{0}}$$

$$\begin{cases} \dfrac{d\underline{x}}{dt} = \begin{bmatrix} 0 & 1 \\ 1 - 3x_1^{*2} & -1 \end{bmatrix} \underline{x} \\ \underline{y} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \underline{x} \end{cases} ; \quad \underline{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}, \ \underline{y} = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix}$$

ESTABILIDADE

EE1: $(0,0) \rightarrow J^* = \begin{bmatrix} 0 & 1 \\ 1 & -1 \end{bmatrix} \rightarrow$ INSTÁVEL

EE2: $(1,0) \rightarrow J^* = \begin{bmatrix} 0 & 1 \\ -2 & -1 \end{bmatrix} \rightarrow$ ESTÁVEL

EE3: $(-1,0) \rightarrow J^* = \begin{bmatrix} 0 & 1 \\ -2 & -1 \end{bmatrix} \rightarrow$ ESTÁVEL