

ANC HW 1: Nonlinear Phenomena

March 25, 2022

Problem 1 Simulate the response of the following system:

$$\dot{v} + |v|v = u$$

Assume that we apply a **unit step input** in thrust u , followed 5 seconds later by a **negative unit step input**. Repeat with **increasing the input** u 10 times. *Compare* the results with linear system:

$$\dot{v} + v = u$$

Problem 2 Simulate the response of:

$$\dot{x} = x - x^3$$

from initial points $x_0 = -1.5, -1, -0.5, 0, 0.5, 1, 1.5$.

Plot the result on one graph and discuss the behavior for each initial condition.

Problem 3 Simulate the response of Lotka-Volterra (predator-prey) equations:

$$\begin{cases} \dot{x} = \alpha x - \beta xy \\ \dot{y} = \delta xy - \gamma y \end{cases}$$

with $\alpha = 2/3, \beta = 4/3, \gamma = \delta = 1$.

Assume x, y quantify thousands each and predator/prey initial conditions from $x_0 = y_0 = [0.9, 1.8]$, in steps of 0.1.

Plot the all trajectories on (x, y) plane. Does the resulting trajectory represent the limit cycle?

Problem 4 You may face chaos even in familiar mechanical systems as [double pendulum](#).

To check this, simulate the responses of the double pendulum nearby initial conditions around $\theta_1 = \pi/2, \theta_2 = \pi/2$ and compare the resulting cartesian trajectories.

The great animation may be found [here](#).