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DEPARTMENT OF MATHEMATICS
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Modeling Complex Systems (1MA256)
Spring 2023

LAB 1

The deadline for this assignment is April 12th.

Please submit in studium or by email. All code should be included feel free to submit videos illustrating your results where appropriate, via studium or uploaded elsewhere such as vimeo or youtube. You may work in groups of size 1-7, and only one group member needs to submit the assignment. State clearly the members of the group.

The tasks in this Lab do not involve much coding, but rather getting acquainted with some existing python codes. If you prefer to work in a different language, you can do so, however you wold have to find equivalent files for that language yourself.

1. Getting started

Start by going through and running the code for the bifurcation diagram of the logistic map, which can be found at here.

2. Universality of the onset of chaos
Perturb the logistic map by adding another function (ex, a polynomial $ap(x)$, or a monomials ax^4), where a is small), or take the sine map

$$f_r(x) = r\sin(\pi x), \tag{1}$$

$r > 0$ and $x \in [0, 1]$.

Task 1: Modify the previous code to compute and draw the bifurcation diagram for this new map.

Task 2: Calculate the Feigenbaum constants α and β for this new map and compare with those for the logistic map.

2. Sensitive initial conditions in the Lorenz system

Study the python code for the 4th order Runge-Kutta method for a system of ordinary differential equations, and implement it for the Lorenz system with the classical parameters. Also, look here.

Task 3: Draw the Lorenz attractor using this code.

Task 4: Choose some initial condition (x_0, y_0, z_0) so that its orbit is in the basin of attraction of the Lorenz attractor. Write a code to compute the Lyapunov exponent along this orbi. What is it's value? Is it positive, or negative? What does it tell us?