EE 5323 Homeworks
Fall 2021

Updated: Sunday, September 12, 2021

DO NOT DO HOMEWORK UNTIL IT IS ASSIGNED.
THE ASSIGNMENTS MAY CHANGE UNTIL ANNOUNCED.

- Some homework assignments refer to the textbook: Slotine and Li, etc.
- For full credit, show all work.
- Some problems require hand calculations. In those cases, do not use MATLAB except to check your answers.

It is OK to talk about the homework beforehand.

BUT, once you start writing the answers, MAKE SURE YOU WORK ALONE.

The purpose of the Homework is to evaluate you individually, not to evaluate a team.

Cheating on the homework will be severely punished.

The next page must be signed and turned in at the front of ALL homeworks submitted in this course.

EE 5323 Nonlinear Control Systems

Homework Pledge of Honor

On all homeworks in this class - YOU MUST WORK ALONE.

Any cheating or collusion will be severely punished.

It is very easy to compare your software code and determine if you worked together
It does not matter if you change the variable names.

Please sign this form and include it as the first page of all of your submitted homeworks.

....

Typed Name: ____

Pledge of honor:

"On my honor I have neither given nor received aid on this homework."

e-Signature: ____

EE 5323 Homework 1

State Variable Systems, Computer Simulation

1. Simulate the van der Pol oscillator $y''+\alpha(y^2-1)y'+y=0$ using MATLAB. Plot y(t) vs. t and also the phase plane plot y'(t) vs. y(t). Use y(0)=0.1, y'(0)= 0.2
   a. For α= 0.03.
   b. For α= 0.95.

2. Do MATLAB simulation of the Lorenz Attractor chaotic system. Run for 150 sec. with all initial states equal to 0.5. Plot states versus time, and also make 3-D plot of x_1, x_2, x_3 using PLOT3(x1,x2,x3).

$$\begin{aligned}\dot{x}_1 &= -\sigma(x_1 - x_2)\\ \dot{x}_2 &= rx_1 - x_2 - x_1x_3\\ \dot{x}_3 &= -bx_3 + x_1x_2\end{aligned}$$

use σ= 10, r= 28, b= 8/3.

3. Consider the Voltera predator-prey system

$$\begin{aligned}\dot{x}_1 &= -x_1 + x_1x_2\\ \dot{x}_2 &= x_2 - x_1x_2\end{aligned}.$$

Simulate the system using MATLAB for various initial conditions. Take ICs spaced in a uniform mesh in the box x1=[-2,2], x2=[-2,2]. Make one phase plane plot with all the trajectories on it. Plot phase plane on square [-5,5]x[-5,5].

EE 5323 Homework 2

Nonlinear Systems Simulation

1. Duffing's equation is interesting in that it exhibits bifurcation, or dependence of stability properties and number of equilibrium points on a parameter. The undamped Duffing equation is

   $$\ddot{x} + \alpha x + x^3 = 0$$

   a. Find the equilibrium points. Show that for $\alpha > 0$ there is only one e.p.
   b. Simulate the Duffing oscillator and make time plot and phase plane plot. Do for 3 cases:
      a. $\alpha = -1$
      b. $\alpha = -0.1$
      c. $\alpha = 1$

For each case, take ICs spaced in a uniform mesh in a suitable box to show the behavior. Pick the box size. Make one phase plane plot for each case showing all trajectories for that case.

2. Consider the system

   $$\dot{x} = y(1 + x - y^2)$$
   $$\dot{y} = x(1 + y - x^2)\,.$$

Simulate the system using MATLAB for various initial conditions for the two cases:

   a. Take ICs spaced in a uniform mesh in the box x1=[-10,10], x2=[-10,10]. Make one phase plane plot with all the trajectories on it. Plot phase plane on square [-15,15]x[-15,15].
   b. Take ICs spaced in a uniform mesh in the box x1=[-3,3], x2=[-3,3]. Make one phase plane plot with all the trajectories on it. Plot phase plane on square [-5,5]x[-5,5].

3. The system of equations

   $$\dot{x}_1 = ax_1 - bx_1x_2 - cx_1^2$$
   $$\dot{x}_2 = dx_2 - ex_1x_2 - fx_2^2$$

describes the growth of two competing species that prey on each other. The constants are positive parameters. Pick *a=c=d=f=2, b=e=3.*

Simulate the system using MATLAB for various initial conditions. Take ICs spaced in a uniform mesh in the box x1=[-2,2], x2=[-2,2]. Make one phase plane plot with all the trajectories on it. Plot phase plane on square [-5,5]x[-5,5].

EE 5323 Homework 3

Nonlinear Systems and Equilibrium Points

1. Consider the Voltera predator-prey system

$$\begin{aligned}\dot{x}_1 &= -x_1 + x_1 x_2 \\ \dot{x}_2 &= x_2 - x_1 x_2\end{aligned}.$$

Find the equilibrium points and their nature.

2. Equilibrium points and linearization

System is

$$\begin{aligned}\dot{x}_1 &= x_2(-x_1 + x_2 - 1) \\ \dot{x}_2 &= x_1(x_1 + x_2 + 1)\end{aligned}$$

   a. Find all equilibrium points
   b. Find Jacobian
   c. Find the nature of all e.p.s

3. Simulate the system

$$\begin{aligned}\dot{x}_1 &= x_2(-x_1 + x_2 - 1) \\ \dot{x}_2 &= x_1(x_1 + x_2 + 1)\end{aligned}$$

using MATLAB for various initial conditions for the two cases:

   a. Take ICs spaced in a uniform mesh in the box x1=[-10,10], x2=[-10,10]. Make one phase plane plot with all the trajectories on it. Plot phase plane on square [-15,15]x[-15,15].
   b. Take ICs spaced in a uniform mesh in the box x1=[-3,3], x2=[-3,3]. Make one phase plane plot with all the trajectories on it. Plot phase plane on square [-5,5]x[-5,5].