Physics 5413: Chaos, fractals, and nonlinear dynamics – Project 3

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due date Friday Friday, Feb 25, 2022; talks will be given in the week of Feb 28, 2022

State space analysis in two dimensions

In this project you will form small working groups consisting of about 4 students. Each team will explore the state space dynamics of one (real world) system using both analytical techniques (analysis of fixed points and limit cycles as well as their stability) and computational methods (numerical integration of the equation of motion to produce state state plots of the trajectories).

Each group picks one of the 4 topics below (and each topic can be picked only once):

The four topics are:

1. **Van-der-Pol oscillator:** $\ddot{Q} - (R - Q^2)\dot{Q} + Q = 0$
   Reading: appendix I of Hilborn's book and van der Pol's original paper (cited in the book, should be available in the library)

2. **Pendulum with constant torque:** $\ddot{\Theta} + \alpha\dot{\Theta} + \sin(\Theta) = \beta$
   Reading: Chapter VIII of Andronow/Chaikin: Theory of Oscillations, Princeton University Press (available in library)

3. **Simple Laser dynamics model**
   Reading: Appendix J of Hilborn's book

4. **Oscillating chemical reactions**
   Reading: Chapter 8.3 of Strogatz' book

5. **Infectious diseases**
   Reading: Chapter 11.1 of Hirsch/Smale/Devaney: Differential equations, dynamical systems & an introduction to chaos (available in library)

The "products" of this project will be in-class talks of about 20 minutes per group. Each talk should comprise an introduction to the physics behind the equations, an analytical analysis of state space behavior, and some characteristic numerical results from a simulation. Please prepare a suitable Powerpoint (or equivalent) presentation. Each group member should participate in both analyzing the problem and giving the talk.