# Physics 5413: Chaos and Dynamics – Final Project Suggestions

due: May 13, 2022

For the final project you have the choice between several topics that involve reading and exploring as well as performing calculations, computer simulations or experiments. Part of your task is to identify interesting questions and make a plan of what to work on.

You can form teams of students who work together and submit a joint report. In this case, each of the team members must be responsible for a specific part of the project, and the report must identify who worked on what.

The following is a list of possible topics, but you are free to suggest other topics based on your experiences in this class or elsewhere.

1. **Chaotic electric circuits**

   Build a nonlinear electric circuit and perform measurements. (for example the circuit from section 1.3 in Hilborns book or the circuit model of the Lorenz equations in section. 9.6 of Strogatz book)

2. **Chaotic billards:**

   H. J. Korsch and F. Zimmer: Chaotic Billiards in: "Computational Statistical Physics - From Billiards to Monte Carlo", K. H. Hoffmann, M. Schreiber., Eds., (Springer 2001), p. 15-36 (an electronic version of the paper is at http://kluedo.ub.uni-kl.de/volltexte/2000/1202/).

   This project explores Hamiltonian chaos on the example of "billiards". Write programs to simulate the billiards, measure chaotic properties Should be a good topic for students interested in doing computer simulations.

3. **Synchronized chaos and the sending of secret messages**

   Section 9.6 of Strogatz' book and references therein.

   Two chaotic systems can be synchronized in time. This can be used to transmit a message masked by a chaotic signal. Project involves reading about synchronized chaos and performing computer simulations and/or building an electric circuit model of two coupled Lorenz systems.

4. **Self-organized criticality, sand piles and forrest fires**

   Section 11.7 of the textbook and references therein,
   Siegfried Clar, Barbara Drossel and Franz Schwabl, *Forest fires and other examples of self-organized criticality*, J. Phys. 8, 6803 (1996).

   Self-organized criticality is mechanism which explains how fractal, scale-invariant structures can arise in nature without fine-tuning of parameters. Project involves reading and computer simulations.

5. **Fractal growths - Diffusion limited aggregation (DLA)**

   Section 11.6 of the textbook, Chapter 4 of Feder's book

   DLA describes a process in which a substance diffuses rather slowly through a medium until it hits an object to which it can stick. Then other particles can stick to it and in this way a cluster or "crystal" grows. The resulting structure has beautiful fractal properties which you can explore. Mostly a computational project. (Or do the actual experiment!)

6. **Chaos and quantum mechanics**

Section 12.2 of the textbook,

Quantum Chaos: An Introduction, H.-J. Stockmann, Cambridge University Press, Cambridge (2000),

Chaos in Classical and Quantum Mechanics, M. C. Gutzwiller, Springer-Verlag, New York (1990),

"Quantum chaos", R. V. Jensen, Nature 23 January 1992, p. 311. This is a great place to start and it is written by one of the leading researchers in the field.

"Quantum Chaos", M. C. Gutzwiller, Scientific American January 1992, p. 78. Another good introduction.

Depending on your taste, this could be a more theoretical or a more computational project. Talk to instructor.

7. **HTML5 applets for course use**

Write HTML5 applets that could be used in later iterations of the class to replace the old Java apps Talk to instructor!