Guidelines for final projects.
Dynamical Systems MATH 490

This document summarizes the format of your dynamical systems project. This project will contribute 60% toward your final grade. It should be considered as one of the most serious short term projects in your mathematical education at SFSU (falling short of a thesis, and a Final Math Project.)

1 Main objectives.

While the topics covered in the project should be related to dynamical systems, students are flexible to propose a variety of topics tailored to their interest. Projects will be divided into two categories, (a) theoretical, (b) experimental. The goal of such a project is to stimulate and further students interest in contemporary topics in dynamical systems, gain a better understanding of mathematical tools used in the process of discovery, enhance the students’ abilities to convey topics to general audiences, and finally to learn modern means of research delivery (professional typesetting, class presentation techniques, and multimedia enhancements).

2 Structure.

Each project can be undertaken by one, two, or in some case three people. It is expected that each member of a group devote at least 25-50 hours on the project. Each member of the group will receive the same final grade. Your product will consist of

- an abstract of the project delivered in writing at least three weeks before the project presentation.

- An oral polished presentation in class (4-7 minutes per person). If two or three people present the outcome of the project, a preferable method of delivery would be a carefully prepared dialog among the project members. However, a sequential presentation would be equally excepted. This presentation will be recorded and used as an advertisement for other students and researchers to read your written part. Unless you clearly object, a video recording of this presentation will be available to current and future generation of students. (In some special cases when a student is extremely uncomfortable delivering such a presentation, an alternative solution maybe negotiated.) Slides supported the presentation should be available of a web page. In order to prepare the slides, students may use, a simple html syntax. However, Powerpoint, Pdf formats are preferred. In an ideal setting, latex syntax would be great. (Latex is installed on all machines in TH404). When you prepare slides, keep in mind that more than 10-13 lines of text per slide is inappropriate. Also, please target not more than 2 slides per minute. I do recommend that you ask your colleague to rehearse yourself before you are ready to
make a class presentation. This will help you time it correctly and avoid some simple mistake that are harder to spot when preparing your presentation.

If you choose a more experimental approach to the project, you will be expected to the graphical (and possible audio) outcomes of your coding. This maybe done from within Mathematica or it maybe done using other means such as creating a multimedia file that contains animations.

• Written document. Such a professionally typeset (in Mathematica, equation editor, or in LaTeX) document should include the following:

  – **Abstract.** A very concise summary of your article. About 2-10 sentences should be enough.

  – **Introduction.** Usually on page 1 of your project, this text should be accessible to undergraduate students who have just completed a calculus sequence. Please do not assume that your audience understands and values your dynamical system. Try to convince the reader that it is worthwhile to read more beyond introduction. Possible questions to address include: What is this project about? Why is it interesting? Why is it not trivial? Does it have potential applications? What are the tools and means of your discovery? What are the implications of the main results? What are the innovative elements of your project. Is this a survey of what is known in the literature?

  – **Statement of results.** A short chapter, (maybe up to 1 page) stating precisely what you did what results you obtained. (A result maybe a theorem, or it maybe a movie illustrating an interesting bifurcation, or a movie illustrating the basins of attractions.

  – **Proofs or description of methods used.** For example, if you created a movie, describe in detail how you did this. Did you use C, Matheamtica, attach the code, examples, etc.

  – **Conclusion.** This is somewhat open. You may write down what would be possible future directions this project may take? Also, please include the summary of the main new skills that you learned while pursuing this project.

  – **Bibliography** Finally, the last part of the written presentation should include a list of books and articles that you used while working on the project.

3 Possible ideas for projects

While I expect that some of you have already chosen a general theme of interest here are some additional ideas that you might use.

Pure Mathematics projects.

• Entropy of a dynamical system. Read articles, books and explain this notion to undergraduate audiences.
- Notions of dimensions. Explore the literature pertaining to fractal, Hausdorff, box dimension.
- Fixed Point Theorem. Show your understanding of this result and explain it to an undergraduate student.
- Number theory and bulbs in the Mandelbrot set. Farey Tree
- Cantor Sets
- Measure zero. Students who took a Real Analysis class should not use this topic.
- Homoclinic Points
- Ergodic Theorems A good choice for a person with some background in Real Analysis.
- Uniform distribution of orbits
- Continued fractions and rotations on the unit circle Excellent choice for a person interested in number theory.
- Famous No wondering Domain Theorem by Sullivan.
- Billiards.

Mainly experimental and multimedia projects.

- Basins of attraction. This is a great topic with lots of room for exploration. Take a function \( f(x) : C \to C \) and determine experimentally what the possible attractors are. Then color the plan according to where the orbits are eventually attracted. Perturb the function a bit and see how the basin of attraction changes.
- Behavior of periodic structures under perturbation.
- Java applet illustrating first 10000 iterates of a function.