Final Paper/Project Topic Suggestions

You will have two options for your Final Paper or Project, each described below. In either case, the goal is to explore a topic of interest to you, and through that topic demonstrate mastery of material covered in this seminar. This Paper/Project will constitute the final exam for the class.

Option 1. Final Paper

*For these suggestions, you would utilize library resources to critically examine a topic of your choosing in an approximately 8-10 page paper (2000 words). Here are some sample topics you might consider; feel free to adapt these to your interests, or create your own.*

- **[Biology]** The survival of bacteria depends on their ability to find resources. What techniques do they use, and what happens to bacteria in resource-limited situations?
- **[Biology]** How do embryos generate the spatial patterns which control their development?
- **[Biology/Ecology]** What kinds of chaos exist in predator/prey dynamics, both in the real world and in computer models? How are the models and real systems similar or different?
- **[Biology/Medicine]** How does the patterning of cells in the retina affect the mechanisms we use for sight?
- **[Chemistry]** Self-assembled monolayers are single layers of molecules deposited on a smooth surface which can form patterns during their deposition. Explore how these are being used for such applications as nanoelectronics and new substrates for cell cultures.
- **[Chemistry]** Which Turing-type reactions have found application in real systems?
- **[Earth Science]** Why is earthquake prediction so difficult and what contributions have the ideas from this class made in trying to improve predictions?
- **[Earth Science]** The field of geomorphology aims to describe how natural features come to have the particular shapes they do. Explore a particular aspect of geomorphology such as river shapes, sand ripples, alluvial fans, or fjords.
- **[Chemical Engineering/Oceanography]** How is chaos involved in ensuring good mixing during industrial processes or global ocean/atmospheric circulations?
- **[Mechanical/Civil Engineering]** How are bifurcations and chaos relevant to developing robust structures?
- **[Electrical Engineering]** How does our nation's electrical distribution system stay balanced with so many inter-connected sources and loads?
- **[Computer Science]** To what extent is the internet a fractal structure, and what problems/solutions are associated with the structure of connections?
- **[Physics/Electrical Engineering]** How can chaos be used for encrypted communication?
- **[Physics/Materials Science]** How does the microscopic order/disorder of a material effect its (electrical, mechanical, or magnetic) properties?
- **[Physics]** Rayleigh-Benard convection has played a large role in the development of the field of pattern formation. What is that role, and why is convection used as a model system?
- **[Physics]** The universe is not homogeneous: large open spaces exist on many length scales (between planets, between stars, between galaxies). Investigate how spatial symmetries were broken during the creation of the universe.
- **[Physics/Philosophy of Science]** What is self-organized-criticality, and why is it a controversial approach to understanding the failure of systems?
- **[Philosophy of Science]** Consider to what extent fractals are descriptive vs. predictive, and how this relates to their utility in science and engineering.
Financial markets are highly unpredictable, yet there is enormous money to be made if you can figure ways to make predictions just accurate enough to beat the odds. How are the ideas we discussed in this class being used to this end? (And how have they failed recently?)

Paul Krugman won the Nobel Prize this year, for which the citation read "for his analysis of trade patterns and location of economic activity." What aspects of feedback and pattern-formation are present in his research?

Mathematician Greg Chaitin found a number, which he called omega (Ω), which is so random that it can be defined, but not computed! Write an overview of what Ω is, what (if anything) it tells us about the universe, and why it’s a useful concept. (This is not the same Ω as the one we’ve been using to calculate entropy.)

What are desirable qualities in a computerized random number generator, how do they work, and why are good ones so hard to find?

What techniques exist for analytically finding the parameter value at which a system of equations bifurcates?

How does Tom Stoppard use the ideas from this class in his play Arcadia?

Fractals have been used to characterize Jackson Pollock's paintings, and the resulting identification of fraud has been controversial. Summarize the arguments in favor and against the use of such techniques.

How are fractals used to create artificial landscapes in movies?

Pick a topic we discussed in class (or skipped in Self-Made Tapestry) and explore it further, or push it in a different direction.

What contribution do the works of ______ make to understanding order and disorder in the universe? (Lots of good ideas in both Chaos and Self-Made Tapestry)

Find a professor at NC State whose research touches on the themes of this course. Email them with a request to obtain some relevant journal or popular science publications, read these papers (which may require some additional resources/research), and interview either them or a graduate student during a visit to their lab. Use what you find to write a paper.

What role has ______________ played in popular culture/art/literature/architecture? Critically assess the accuracy and relevance of the portrayal? (e.g. Butterfly Effect, Chaos Theory, Fractals)

Option 2. Final Project

For these suggestions, you would make a project and provide a brief (~3 page) description of the techniques and results. I will consider joint proposals (2 or 3 people) for these, if the scope of the proposed work is large enough and there is a suitable division of labor proposed. Each member of the team will write their own written report.

Consider an experiment or computer simulation we performed or discussed as part of class: can you use one of them to ask a scientific question and determine an answer via an experiment or computer simulation of your creation? (e.g. The chaotic pendulum in the Riddick Reading Room, one of the examples in the back of SMT, ...)

Make a video or other art form which exhibits chaos, fractals, or non-equilibrium order as an illustration of the themes explored in this class.
**Topic Preparation**

The first assignment is to prepare three ideas you might want to write about. You should have done some exploratory research of your ideas and have some sense of the feasibility, to help you determine which one you want to choose. Resources to consider for brainstorming topics:

- course texts (SMT and Chaos)
- books on physical reserve at Hill Library
- Scientific American or American Scientist website
- Media Blog entries by yourself or others

The first part of the assignment is to provide a numbered list (in order of your interest) of three paper topics, each written in a similar style to those presented above. You can use/adapt any of the ones I've provided.

If I approve your #1 choice, then you are set to start writing. If you have a favorite, but aren’t certain about its appropriateness/feasibility, mark it your #1 and I will give you some feedback. If somebody has already chosen a topic too close to your #1 choice, I will approve your #2 choice instead, etc. Topic proposals will be processed in the order in which they were submitted to Blackboard.

**Campus Resources**

Library Services: [http://www.lib.ncsu.edu/course/HON/292A/](http://www.lib.ncsu.edu/course/HON/292A/)
Writing Center: [http://www.ncsu.edu/tutorial_center/writespeak/](http://www.ncsu.edu/tutorial_center/writespeak/)

**Format**

Double-spaced in a 12-point, readable font, labeled with an appropriate title, your name, HON292A, and the date.

**Important Dates**

*Library resources session:* Tues, Nov 11, in computer lab (120 Dabney). Led by Reference Librarian Josh Wilson. Have at least three topic ideas already in mind, since time will be available during class to start finding sources.

*Topic preparation:* Due Tues, Nov 17 via Blackboard/Vista.

*Draft reference list:* Due Tues, Nov 25 via Blackboard/Vista. Class time available Tues, Nov 25 to work on reference list and outline. You will be free to add additional resources after this date, but this is an opportunity for me to provide feedback ahead of the writing process. If you are doing a project, a list of required supplies/resources (and whether or not you already have them available) will be a necessary part of this.

*Outline target date:* Due Tues, Dec 2. Appointment times available this week for feedback on outline.

*Final paper:* Due Tues, Dec 9 at 4pm in 258C Riddick (my office). This is the official final exam slot, since this paper/project constitutes the final exam. Either an emailed electronic copy (PDF preferred if you want to be certain I can read it) or a paper copy are acceptable. If you want to turn in the paper early and I am not there, you can slide the paper under my door.