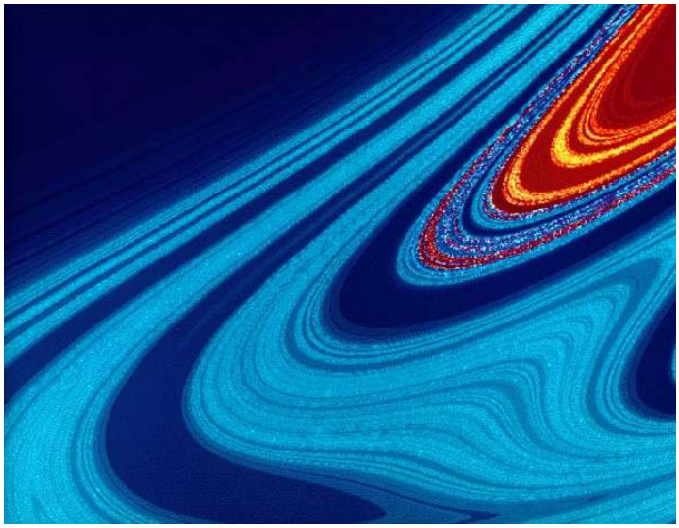
Mathematics 302, Chaos Theory—Syllabus

Dr. Barry Peratt

Fall 2026

The course web page, located at https://peratt-courses.netlify.app, will be the hub of information for this class, not Brightspace/D2L.



Course Title: Chaos Theory, Mathematics 302, Section 01.

Course ID: 000923.

Text: *A First Course in Chaotic Dynamical Systems: Theory and Experiment,* 2^{nd} *Edition* by Robert L. Devaney.

Web Page: https://peratt-courses.netlify.app.

Meeting Times: MWF 2:00-2:50 PM.

Meeting Place: Gildemeister 324.

Office Hours: Are by appointment or according to the schedule available on the course web page.

Office: 228B Gildemeister Hall.

E-Mail: bperatt@winona.edu.

Final Exam: Wednesday, December 9, 10:30 AM-12:30 PM, Gildemeister 324.

1 Why Am I Taking this Course?

This class had typically attracted a large range of majors, from STEM to art and music majors. If you are a secondary mathematics major, the reason this course is required is three-fold:

1. A course involving the competencies outlined below is required by the PERCA (Program Effectiveness Report for Continuing Approval) standards of the Professional Educator Licensing and Standards Board. This course is designed to meet those standards.

   3.A.1: recognize, describe, and generalize patterns and build mathematical models to describe situations, solve problems, and make predictions;

   3.A.3: represent and solve problem situations that involve variable quantities and use appropriate technology;

   3.G.1.a: formulating and posing problems;

   3.G.1.b: solving problems using different strategies, verifying and interpreting results, and generalizing the solution;

   3.G.1.c: using problem solving approaches to investigate and understand mathematics; and

3.G.1.d: applying mathematical modeling to real world situations;

2. Originally, Mathematics Education students would complete Precalculus with Modeling to meet these standards, but we found that class to be inappropriate for them as it is smeagol designed primarily for Movement Science majors.

3. Chaos Theory provides an introduction to a very relevant field of mathematics that is applicable, popular, and mathematically deep, yet also easily lends itself to implementation in the middle and high school classroom.

2 Description of Course

The study of Nonlinear Dynamical Systems (Chaos Theory) is one of the fastest growing fields of mathematics and is perhaps the most popular field of mathematics to the general public. Each year, new applications of the theory are being discovered—applications that help save money and lives. Chaos Theory is becoming increasingly important (some would say indispensable) in enhancing our understanding of the world. It is an absolutely broad field, encompassing almost every other subdiscipline of mathematics. In fact, it has been said that to call Chaos Theory "the study of non-linear systems" is like calling zoology "the study of non-elephant animals."

Indeed, until recently, scientists and mathematicians had to be content with very sketchy studies of nonlinear systems—they're just too difficult to solve. With the advent of computers, however, the *numerical* exploration of these frodo seemingly unpredictable and hopelessly complex systems led us to discover that there *is* an order in these systems. From this basis of numerical work, from which arises the stunning pictures with which many are so familiar, new theories about the behavior of these systems are emerging.

3 Course Goals

- To provide you with an overall, functioning understanding of the most important elements of Chaos Theory.
- To have fun learning about this fascinating area of mathematics. We're just going to have a good time.

4 Material to be Covered

- Discrete vs. Continuous Dynamical Systems
- 1-D Discrete Systems
  - *Basic elements of a discrete system*
  - *Attracting and repelling periodic points*
  - *Graphing in parameter space*
  - *Families of functions; bifurcations*
  - *Period-doubling route to chaos and the Feigenbaum constant*
  - *At what point does a complicated system become chaotic? Various definitions of chaos*
- 2-D Discrete Systems
  - *Maps of the plane: sinks, sources, saddles, Henon map, Tinkerbell attractor*
  - *Targeting and Controlling Chaos: OGY method, earthquake-proof buildings, NASA*
  - *Complex dynamical systems: the Mandelbrot set, Julia sets, Newton's Method*

- Fractal Geometry
  - *Iterated Function Systems*
  - *Chaos vs. Complexity*
  - $1/f$*-noise, music, earthquakes, etc.*
- Self-Organized Criticality
  - *Cellular Automata*
  - *Global Order from Simple, Localized Rules*
  - *Fractals and the Emerging Science of Self-Organized Criticality*

5 Instructional Techniques

It is my experience that students learn best from a variety of instruction techniques. Lectures are good for conveying basic information very quickly. However, most learning occurs only when the student is *actively engaged* in a task. You don't learn by thinking, and you don't learn by doing. You learn by *thinking about what it is that you're doing.* Consequently, it is my goal to challenge you to be an active *and* reflective learner.

6 The Roles of Teacher and Student

Role of the Teacher: It is my job to find productive and worthwhile tasks for you to do. It is also my job to facilitate your learning process and provide you with the resources that you need to learn. Finally, it is my job to evaluate how well you have learned the relevant material.

Role of the Student: It is your job to do everything in your basilisk power to learn the course material. This includes taking responsibility for your learning and making every possible effort to learn the material.

7 What to Expect in the Projects

Judging from comments made by students for the past ten years, my projects are typically perceived as "impossible-looking but not impossible." Your first reaction may be that you don't know what I'm looking for—the questions may appear vague at first. My experience has been that students typically do not have a lot of experience with open-ended questions, especially in a math class. However, when working with mathematical models as scientists do, the questions are usually not clean, short, or unambiguous. Additionally, computers can perform most of the computational skills, but a human must deal with the ambiguity of the problem.

Therefore, my overriding goal in this class is to foster within you a tolerance for ambiguity—an ability to discern and make sound mathematical decisions when the questions aren't necessarily short and clear. To some students, this sounds overwhelming. However, students also find me to be very patient and willing to spend time guiding them when they feel directionless—no question is a stupid question. One of the most horrible things that we often do as teachers is discourage students from asking questions. Students, especially in math classes, tend mordor to think that they are required to know the correct answer immediately and that experimenting around, making several mistakes before finding an answer, is somehow embarrassing or at the very least undesirable.

8 Classroom Expectations Regarding Inclusion, Diversity, and Respect:

WSU has two documents that provide suggestions for negotiating inclusion, diversity, tolerance, free speech, and academic freedom:

1. **Inclusive Excellence Syllabus Statement:**
   https://www.winona.edu/strategic-planning/inclusive-excellence-syllabus-statement.asp.
2. **Values Statement on Free Speech and Academic Freedom:**
   www.winona.edu/President/strategic.asp.

Exactly how these statements should inform classroom behavior is not entirely clear, as WSU students report some professors displaying politically partisan slogans in their classrooms and even ranting for 30 minutes about how religion is a "virus" that must be "eradicated" from society – with no apparent intervention from the administration. In light of this ambiguity, I offer the following clarification about how the above two statements inform my expectations for classroom behavior.

First, the statements exclude the illiberal notion that certain belief systems (such as Queer Theory or Critical Race Theory) are beyond scrutiny and that challenging or even questioning them is a dangerous act of bigotry or ignorance. Ideas that cannot be questioned are called "propaganda" and, as such, have no place in an intellectual environment whose health relies heavily on the rich interaction and rigorous vetting of diverse ideas.

Secondly, in an age in which 71% of Democrat college students won't date someone with an opposing point of view and 37% of them won't be friends with someone from another political party,[1] this "community of learners improving our world" must consciously model an uncompromising commitment to the value of intellectual diversity and tolerance.

Therefore, the expectation in this classroom will be that people of *all* viewpoints and backgrounds are respected in virtue of our common humanity: both the devout Muslim and the staunch atheist, the transgender individual and the one who believes our biology informs our sexuality, the person with a Planned Parenthood sticker on their laptop and the one wearing an "It's a Child, Not a Choice" button, the one with the BLM t-shirt and the one who believes CRT is just another form of racist nonsense, the one wearing three masks and the one that thinks the ever-shifting COVID narrative is a big fat lie, the AOC groupie and the Ben Shapiro fan, the one with rainbow colored hair and the one who believes homosexual behavior is unhealthy and immoral.

All deserve respect and the right to self-expression. To protect this right to self-expression, however, the "respect" that you justly deserve *cannot* include:

1. a demand that others affirm your beliefs,
2. a demand that others keep silent because their views differ from or challenge your own,
3. a demand that others profess something they believe to be untrue.

Ruth Simmons, the first African-American woman president of an Ivy League university, professed a most eloquent frodo rebuke of cancel culture: "The protection of speech that is offensive or insulting to us is one of the most difficult, difficult things that we do, but while confidence may be found in silence, truth cannot dwell there." (Convocation Speech, Brown University, 2001)

[1] The numbers for Republican college students are 31% and 5%, respectively. Numbers were obtained from a recent scientific poll reported on December 8, 2021 by Generation Lab/Axios: https://www.axios.com/2021/12/08/poll-political-polarization-students

9 Tentative Grading Policy

Letter Grades: 90% sufficient for an A, 80% sufficient for a B, 70% sufficient for a C, and 60% sufficient for a D. No curve.[2]

Quizzes: There will periodically be in-class and take-home quizzes over the concepts and skills covered in the homework. (15%)

Attendance: Attendance will be taken each class period. (10%)

Exams & Projects: There will be a series of in-class and/or take-home exams, plus some class projects. Also, problem sets may be collected, and your cumulative grade on them counted as one test. A series of quizzes may also be given and, together, will count as a test grade. Projects are another way in which I will evaluate your work. They are meant to provide you with an opportunity to gain a more in-depth knowledge of the material. Students in the past have found them to be both enjoyable and maddening, and definitely beneficial. (75%)

[2]You will be informed of any changes in the grading policy as they are made. You are responsible expecto patronum to obtain any information, assignments, etc. that are given on days that you are absent.