WINONA STATE UNIVERSITY

COLLEGE OF SCIENCE AND ENGINEERING

DEPARTMENT OF MATHEMATICS AND STATISTICS

**Course Outline – MATH 302**

**Title:** Chaos Theory

**Number of Credits:** 3

**Catalog Description:** An introduction to chaos theory and fractal geometry. Topics will include bifurcations, Julia sets, the Mandelbrot set, fractal geometry, iterated function systems, and a survey of the applications of this theory to a variety of disciplines. Prerequisite:  MATH 212 - Calculus I. Offered periodically spring semesters of odd numbered years (e.g. Spring 2013, Spring 2015, etc.).

**Possible Textbooks:**

* *A First Course in Chaotic Dynamical Systems: Theory and Experiment*, Robert L. Devaney, 1991
* *Encounters with Chaos*, Denny Gulick, McGraw Hill, 1992
* *Chaos: An Introduction to Dynamical Systems*, Alligood, Sauer, and Yorke, Springer-Verlag, 1997
* *Understanding Nonlinear Dynamics*, Kaplan and Glass, Springer-Verlag, 1995.

**Topics Covered:**

1. Randomness vs. Determinism as it relates to the Natural and Social Sciences.
2. Discrete vs. Continuous Dynamical Systems
3. 1-D Discrete Systems
   1. Linear and affine systems
   2. Attracting and repelling periodic points
   3. Cobweb diagrams
   4. Basins of attraction
4. Bifurcations and Chaos
   1. Period-doubling route to chaos
   2. Various definitions of chaos
   3. Topological conjugacy and Cantor sets
5. 2-D Discrete Systems
   1. Matrices and eigenvalue analysis
   2. Various attractors
   3. Mandelbrot & Julia Sets
   4. Fractal Geometry
   5. Iterated Function Systems
6. Chaos and Complexity
   1. 1/f-noise in music, earthquakes, etc.
   2. Self-Organize Criticality

**Listing of Sections to be Covered:** Not applicable to this course, since there is no standard textbook. Chosen sections of any text should correspond to the topics outlined above.

**Remarks:** A significant conceptual foundation and philosophical context must be laid at the beginning of this course so that the students’ understanding of the difference between true randomness, such as the type occurring in Quantum Mechanics, and determinism is clearly understood.

**Approximate Pace of Coverage:** Not Applicable.

**Method of Instruction:** Lecture-presentation, discussion, question-answer sessions,

use of calculators/computers, group work.

**Evaluation Procedure:** Homework, quizzes, projects, midterm exams, and a final exam.

**Minnesota Transfer Curriculum:** Not Applicable

**MnSCU Learning Outcomes:**

* Students will explain the key differences between deterministic and random system, giving examples of each.
* Students will analyze and describe the global asymptotic behavior of 1-D discrete dynamical systems using standard tools.
* Students will apply the definition of chaos to period-doubling maps using symbolic dynamics.
* Students will analyze the structure of the Mandelbrot set and identify its relationship to corresponding Julia Sets.
* Students will create fractals using IFS and identify their fractal (Hausdorff) dimension.
* Students will create and analyze the behavior of self-organized critical systems using appropriate software tools.

**Last Revised:** Spring 2013 by the Mathematics Subgroup (Double-checked Spring 2016)