Name: ____________________

CS523 **Sample** Midterm Exam.
This version of the exam is for students enrolled in *CS523: Complex Systems*. If you are enrolled only in *CS423: Introduction to Complex Systems* please ask for the corresponding exam. If are enrolled in both CS523 and CS423 take this exam.

The questions in each section refer specifically to the associated reading printed in **bold**. Mark the best answer by filling in the circle next to it. Explanatory comments will not be considered.

The **real** exam is worth 15% of your final grade for this course, and contains 25 questions each equally weighted (1 point each). The exam period is 50 minutes. This sample exam has fewer questions.

Holland, J., Complex Adaptive Systems

1. (1 point) Holland discussed two advances that allow us to better study complex systems. They are:
   - ○ Simulations and recognising that complex adaptive systems evolve.
   - ○ Feigenbaum's constant and the Lyapunov exponent.
   - ○ Computational models and better ways to measure turbulence.
   - ○ Advances in dynamical systems theory and quantum entanglement.
   - ○ The Lottke-Volterra equations and the Lorenz map.

Flake, G. The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation

2. (1 point) The value associated with the rate at which bifurcations occur in maps is known as:
   - ○ Hawking's constant.
   - ○ Feigenbaum's constant.
   - ○ Lord May's constant.
   - ○ The Mitchell constant.
   - ○ Chaos.

3. (1 point) Flake discusses the *shadowing lemma*. The shadowing lemma states that:
   - ○ Computer models are useless for simulating chaotic dynamical systems.
   - ○ The domain of a function can be used to determine when it goes chaotic.
   - ○ Computer models can capture the dynamics of chaotic systems.
   - ○ A positive Lyapunov exponent indicates chaos.
   - ○ A negative Lyapunov exponent indicates chaos.

May, R. Simple Mathematical Models with Very Complicated Dynamics

4. (1 point) The emphasis on studying linear systems in most university courses on physical systems...
   - ◯ Is a good basis for studying non-linear systems because all non-linear systems are ultimately linear.
   - ◯ Ill equips students to deal with the bizarre behaviour of the simplest non-linear system.
   - ◯ Arises from Aristotle's model of biological evolution.
   - ◯ Fails to account for the role of consciousness in non-linear systems.
   - ◯ Allows mathematical models that capture long term dynamical behaviour especially when they are chaotic.

5. (1 point) The system May studies in this paper is:
   - ◯ A model of atmospheric turbulence
   - ◯ Feigenbaum's pendulum.
   - ◯ A population growth model.
   - ◯ A model of how slime moulds solve a maze.
   - ◯ None of the above.

Lorenz, E., Computational Chaos

6. (1 point) The central question Lorenz studies in this paper is:
   - ◯ Weather forecasting in the continental US.
   - ◯ Modelling computation as a complex system in massively parallel environments.
   - ◯ The relationship between chaos and numerical instability.
   - ◯ Chaotic behaviour arising from the reduction of transistors to the quantum scale.
   - ◯ The Shadowing Lemma.

Gell-Mann, M. What is Complexity?

7. (1 point) Gell-Mann argues that most of the complexity we observe in the universe is due to:
   - ◯ "Hawking's constant"
   - ◯ "Lorenz turbulence"
   - ◯ "frozen accidents"
   - ◯ "period-doubling bifurcations"
   - ◯ "Quarks with positive Lyapanov exponents"

Crutchfield, J. Between Order and Chaos

8. (1 point) One of the main themes of this paper is:
   - ◯ Natural systems tend to self organise so they are between complete predictability and unpredictability.
   - ◯ Natural systems tend to become more ordered over time, which is why evolution is able to balance order and chaos.
   - ◯ Artificial systems and natural systems both exhibit the same phase transitions when subjected to random perturbations.
   - ◯ Order and chaos are really two sides of the same coin. Small changes in initial conditions lead to order or chaos depending on Cruchfield's "balance parameter".
   - ◯ None of the above.

Hughes, A. The Central Dogma and Basic Transcription

9. (1 point) Which of the following is described as being like programs executing in the cell:
   - ◯ DNA
   - ◯ RNA
   - ◯ Ribosomes
   - ◯ Proteins
   - ◯ Chromosomes

Losos, J. Evolutionary Biology for the 21st Century

10. (1 point) According to Losos et al., Evolutionary Theory
    - ◯ is fundamental to our understanding of many areas in biology.
    - ◯ is undermined by the rapid increase in available data.
    - ◯ underlies the Lorenz model of complexity.
    - ◯ is completely understood.
    - ◯ is unchanged since Darwin wrote the Origin of Species.

Forrest, S. Genetic Algorithms: Principles of Natural Selection Applied to Computation

11. (1 point) Genetic algorithms may not be appropriate when:
    - ◯ the problem is to minimise rather than maximise a function.
    - ◯ Feigenbaum's constant is less than zero.
    - ◯ there are two fitness peaks of different heights.
    - ◯ genetic algorithms are remarkably flexible and can solve all optimisation problems efficiently.
    - ◯ the problem is to find the exact global optimum.

Floreano, D. Evolution of Adaptive Behaviour in Robots by Means of Darwinian Selection

12. (1 point) Robots were able to evolve which of the following:
    - ◯ Chaotic behaviour.
    - ◯ Flight.
    - ◯ Cooperation.
    - ◯ A complex society.
    - ◯ None of the above.

Weimer, W. Automatically Finding Patches Using Genetic Programming

13. (1 point) This paper discusses:
    - ◯ Automatic program debugging.
    - ◯ Increasing program efficiency through evolution.
    - ◯ Adaptation to programmer style.
    - ◯ Foraging in a physical environment by robots for resource patches.
    - ◯ Foraging in a virtual environment by programs for resource patches.

Neumann, J, Theory of Self-Reproducing Automata

14. (1 point) A central theme of Neumann's paper is that:
    - ◯ artificial systems can cope with error much better than natural systems because they are orders of magnitude faster.
    - ◯ artificial systems can cope with error much better than natural systems because the materials used are much stronger.
    - ◯ artificial systems can cope with error much better than natural systems because they are Turing complete.
    - ◯ artificial systems can cope with error much better than natural systems because they have a designer that can anticipate problems.
    - ◯ none of the above.

Wolfram, S. Cellular Automata as Models of Complexity

15. (1 point) Class II can be classified as:
    - ◯ A strange attractor.
    - ◯ Feigenbaum's constant.
    - ◯ A regular language.
    - ◯ The Mitchell constant.
    - ◯ Chaotic.

Project 1: Dynamical Systems

16. (1 point) You were asked to use which value to determine whether a system was chaotic:
    - ◯ Hawking's constant.
    - ◯ Feigenbaum's constant.
    - ◯ Lord May's constant.
    - ◯ The fractal dimension.
    - ◯ The Lyapunov exponent.

Project 2: Genetic Algorithms

17. (1 point) Which of the following crossover methods were you required to implement:
    - ◯ No crossover, uniform crossover, and 1-point crossover.
    - ◯ No crossover, 1-point crossover, and 2-point crossover.
    - ◯ Tournament crossover, roulette crossover, and uniform crossover.
    - ◯ No crossover, tournament crossover, and roulette crossover.
    - ◯ No crossover, tournament crossover, uniform crossover, and 1 and 2-point crossover.