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

The exam is worth 15% of your final grade for this course. There are 25 questions each equally weighted (1 point each). The exam is 50 minutes long. 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.

1. **Chapter 1: What is Complexity?**

   (a) (1 point) Which of the following does Mitchell describe as a property of complex adaptive systems:

   ○ Complex collective behaviour only

   ○ Signalling only

   ○ Information processing only

   ○ Adaptation only

   √ **All of the above**

   (b) (1 point) According to Mitchell, which of the following is included in the *universally agreed upon* definition of a complex adaptive system:

   ○ Signalling only

   ○ Information processing only

   ○ Adaptation only

   ○ All of the above

   √ **There is no such definition**

   (c) (1 point) Which of the following is not a complex adaptive system:

   ○ Ant colonies

   ○ The brain

   ○ Economies

   ○ The World Wide Web

   √ **A hurricane**

2. **Chapter 2: Dynamics, Complexity, and Prediction?**

   (a) (1 point) $x_{t+1} = rx_t(1 - x_t)$ is called the:

      ○ Propulsion map

      ○ Complex map

      ○ Von Neumann map

      ○ Adaptive map

      √ **Logistic map**

   (b) (1 point) The map referred to in the previous question is a model of what?

      ○ Turbulence

      ○ Capitalism

      √ **Population growth**

      ○ Adaptation

      ○ Frozen accidents

   (c) (1 point) Which property causes the magnification of small changes in the initial conditions in chaotic systems over time:

      ○ Linearity

      √ **Non-linearity**

      ○ Randomness

      ○ Outside influences

      ○ Adaptation

   (d) (1 point) Which of the following is not a type of attractor:

      ○ Fixed-point

      √ **Adaptive**

      ○ Limit cycle or periodic

      ○ Chaotic

      ○ They are all attractors

   (e) (1 point) Which two discoveries undermined the hope of predictability in physics:

$\sqrt{}$ **Heisenberg's uncertainty principle and chaos.**

◯ Heisenberg's uncertainty principle and the holographic principle.

◯ Turings' uncertainty principle and chaos.

◯ Turings" uncertainty principle and the holographic principle.

◯ Hawkins' uncertainty principle and chaos.

(f) (1 point) What invention allowed complex and chaotic systems to be studied in detail:

◯ The telescope

◯ The microscope

◯ The centrifuge

$\sqrt{}$ **The electronic computer**

◯ Lorenzian analysis

3. **Chapter 3: Information**

   (a) (1 point) Shannon's definition of information is sometimes characterised as:

   $\sqrt{}$ **The average amount of surprise in a message.**

   ◯ The maximum length of the message.

   ◯ The symbol diversity.

   ◯ Not having an agreed upon definition.

   ◯ A convolution.

4. **Chapter 4: Computation**

   (a) (1 point) Who formulated a solution to the Entscheidungs problem:

   ◯ Leibniz.

   $\sqrt{}$ **Turing.**

   ◯ Gödel.

   ◯ Mitchell.

   ◯ Korek.

5. **Chapter 5: Evolution**

   (a) (1 point) Which of the following is not in Darwin's Theory of Natural Selection:

   ○ Species descend from a common ancestor.

   ○ Requires competition.

   ○ Traits are inherited with variation.

   √ **DNA.**

   ○ Evolutionary change is constant and gradual.

6. **Chapter 6: Genetics, Simplified**

   (a) (1 point) Which of the following is a DNA molecule:

   ○ Iron

   ○ Polysaccharide

   ○ Brontosine

   √ **Cytosine**

   ○ Plutonium

7. **Chapter 7: Defining and Measuring Complexity**

   (a) (1 point) Which of the following is discussed by Mitchell as a measure of complexity:

   ○ Data Supposition Complexity (DSC)

   √ **Algorithmic Information Content (AIC)**

   ○ Component Transparency Analysis (CTA)

   ○ Lorenz Complexity Analysis (LCA)

   ○ The Machine Order Method (MOM)

   (b) (1 point) Which describes the Koch curve?

   √ **A fractal**

   ○ An adaptive model

   ○ An example of a strange attractor

   ○ Where a system falls on the Koch curve tells you its complexity

   ○ Complicated but not complex systems are divided by the Koch curve

8. **Chapter 8: Self Reproducing Computer Programs**

    (a) (1 point) Who first proved that self-reproducing automata could exist:

    ○ Alan Turing

    √ **John von Neumann**

    ○ Edward Lorenz

    ○ Charles Darwin

    ○ Stephen Wolfram

9. **Chapter 9: Genetic Algorithms**

    (a) (1 point) What is Robby the Robot:

    √ **A can collecting robot**

    ○ A paradox

    ○ A self-reproducing robot built by Jon von Neumann

    ○ A robot example of chaos

    ○ None of the above

    (b) (1 point) Genetic algorithms...

    ○ Are inspired by biological evolution but includes a crossover operator which is not biological

    ○ Can always find the global optimum

    ○ Are unrelated to biological evolution

    ○ Are more complex than biological evolution

    √ **Are simpler than biological evolution**

10. **Chapter 10: Cellular Automata, Life, and the Universe**

    (a) (1 point) Which Wolfram CA class does Mitchell describe as being most interesting:

    ○ 1

    ○ 2

    ○ 3

    √ **4**

    ○ 5

(b) (1 point) How many CA rules are there for a 1D cellular automata with 3 binary inputs that map to 1 binary output:

$\sqrt{}$ **There are $2^3 = 8$ possible input values with 2 possible output values so there are 2^8 rules.**

$\bigcirc$ There are $3^2 = 9$ possible input values with 2 possible output values so there are 2^9 rules.

$\bigcirc$ There are $2^2 = 4$ possible input values with 3 possible output values so there are 3^4 rules.

$\bigcirc$ There are $3^3 = 27$ possible input values with 2 possible output values so there are 2^{27} rules.

$\bigcirc$ There are $3^2 = 9$ possible input values with 3 possible output values so there are 3^9 rules.

11. **Chapter 11: Computing with Particles**

(a) (1 point) What is majority classification:

$\bigcirc$ A task in which the majority is classified based on a Turing machine.

$\sqrt{}$ **Computation performed by a CA in which it must decide whether its initial input was mostly 1s or 0s.**

$\bigcirc$ A voting system suggested by Wolfram's CA classifications.

$\bigcirc$ An evolved CA which can always decide which of two populations is the majority.

$\bigcirc$ A computation performed by a GA in which is must decide whether the output is true.

12. **Project 1: Dynamical Systems**

(a) (1 point) You were asked study which two types of dynamical system:

$\sqrt{}$ **A map and a flow.**

$\bigcirc$ A system of differential equations and a flow

$\bigcirc$ A system of difference equations and a map

$\bigcirc$ Two systems of difference equations

$\bigcirc$ Two flows

(b) (1 point) You were asked to determine whether the dynamical systems were:

$\bigcirc$ Bound by the Feigenbaum exponent

$\bigcirc$ Bound by the Feigenbaum constant

$\sqrt{}$ **Dissipative or conserving**

$\bigcirc$ Expanding or dissipative

$\bigcirc$ Always less than the Lorenz exponent

13. **Project 2: Genetic Algorithms**

(a) (1 point) You were asked to implement which of the following as a way to preserve diversity and prevent premature convergence:

○ Island selection

○ Island mutation

○ Island crossover

√ **An island GA.**

○ None of the above.

(b) (1 point) The Mann-Whitney test produces which of the following:

○ Hawking's constant

○ Feigenbaum's constant

○ Lord May's constant

√ **A p-value**

○ None of the above