

## Instructions

You may use any course materials, websites, books, computer programs, calculators, etc. for this test. Just don't ask another person for the answers or share your answers with other people. Be aware that simply typing the question text into google is unlikely to get you directly to the right answer; you're going to have to read what you find there in order to extract that answer, and the course videos are probably a faster way to do that.

"Experts" notes clarify situations that haven't been covered in this course, but that may introduce subtleties into the exam answers. Do not worry about them unless you understand the terms and issues in those notes.

If you have questions about this test, please email us at [nonlinear@complexityexplorer.org](mailto:nonlinear@complexityexplorer.org) rather than posting on the forum.

### Question 1

Maps describe continuous-time dynamics.

- True
- False

### Question 2

Difference equations are used to model discrete-time dynamics.

- True
- False

### Question 3

How many state variables does this map have?

$$x_{n+1} = \cos x_n$$

- 1
- 2
- 3
- Not enough information to answer
- Not defined

### Question 4

How many state variables does this map have?

$$x_{n+1} = ay_n$$

$$y_{n+1} = y_n \cos x_n$$

- 1
- 2
- 3
- Not enough information to answer
- Not defined

### Question 5

Dynamical systems must have lots and lots of state variables to be chaotic.

- True
- False

### Question 6

Consider the following map:  $x_{n+1} = rx_n + 3$

If  $r = 3$  and  $x_0 = 0.2$ , what is  $x_2$ ?

- 3.6
- 13.8
- 44.4
- None of the above

### Question 7

A fixed point is always stable.

- True
- False

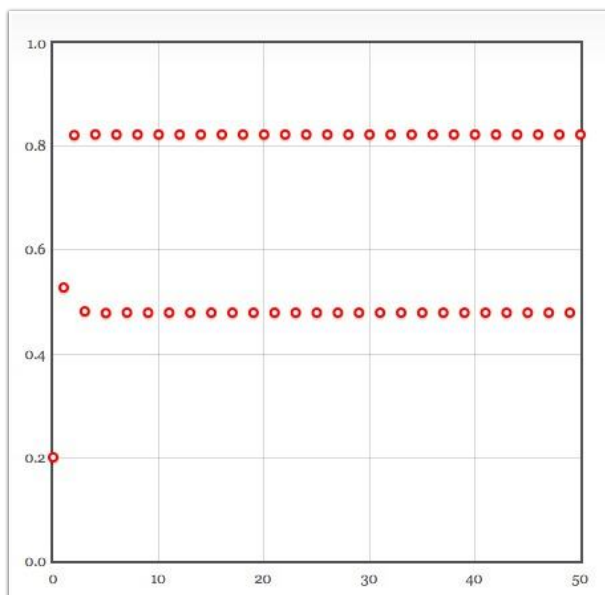
### Question 8

A fixed point of a map  $f$  is a state  $x^*$  such that

$$x^* = f(x^*)$$

- True
- False

### Question 9



Consider the above plot, which shows 50 iterates of the orbit of the logistic map from  $x_0 = 0.2$ .

To what kind of attractor is this orbit converging?

- Fixed point
- Periodic orbit
- Chaotic
- None

#### Question 10

Consider the plot in the previous question. How long is the transient, roughly?

- One iterate.
- Two or three iterates.
- There is no transient.
- The orbit hasn't converged, so everything that you see in the plot is technically a transient

#### Question 11

If two initial conditions of a given dynamical system—with the same parameter value(s)—converged to two different fixed points, both of those fixed points will always be unstable.

- True
- False

#### Question 12

If two initial conditions of a given dynamical system—with the same parameter value(s)—converged to two different fixed points, the transient lengths will always be different.

- True
- False

#### Question 13

If two initial conditions of a given dynamical system—with the same parameter value(s)—converged to two different fixed points, those initial conditions must be in different basins of attraction.

- True
- False

#### Question 14

Use the [logistic map app](#) to generate trajectories from a variety of different initial conditions in the range  $0.2 \leftarrow x \leftarrow 0.8$  with  $r=3.5$ . What kind of attractor (if any) does the system have?

- Fixed point
- Two cycle
- Four cycle
- Chaotic
- No attractor

### Question 15

All nonlinear systems are chaotic.

- True
- False

### Question 16

All chaotic systems are nonlinear.

(Note: this course is not about infinite-dimensional or function spaces.)

- True
- False

### Question 17

There are two variables in the logistic-map equation:  $x_n$  and  $r$ . Which of these is the *parameter*?

- $x_n$
- $r$

### Question 18

Can a change in the logistic map's *parameter* cause a change in the topology of the attractor, *i.e.*, a bifurcation in the dynamics?

- Yes
- No