

# Introduction to Complexity (Fall 2016)

## 2.10 Take Unit 2 Test » Unit 2 Test

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### Instructions 1

You may use any course materials, websites, Netlogo models, calculators, etc. for this test. Just don't ask another person for the answer and don't share your answers with other people.

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### Question 2

**Aristotle and Newton differed in their beliefs in the following way:**

- A. Aristotle believed that the earth revolved around the sun, whereas Newton believed that the sun revolved around the earth.
  - B. Aristotle believed that objects set in motion will stay in motion, whereas Newton believed that objects set in motion would slow down and eventually stop.
  - C. Aristotle believed that there were two separate sets of laws, one for behavior in the "heavens" and one for behavior on earth. Newton believed that the same laws applied to both.
  - D. Aristotle believed that the planets move in perfect circles about a non-moving sun, whereas Newton showed that they move in ellipses.
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### Question 3

**Pierre Simon Laplace believed that:**

- A. The existence of sensitive dependence on initial conditions makes perfect prediction impossible.
  - B. If we had perfect knowledge of the positions of all elements of the universe and all forces acting on them, perfect prediction would be possible in principle.
  - C. Newton's laws are imperfect, which makes perfect prediction impossible.
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### Question 4

**According to Henri Poincaré:**

- A. Perfect prediction is impossible for any phenomenon in nature.
  - B. If we had perfect knowledge of the positions of all elements of the universe and all forces acting on them, perfect prediction would be possible in principle.
  - C. In some systems, sensitive dependence on initial conditions might make perfect prediction impossible in practice, due to errors or imprecision in measurement conditions.
  - D. Newton's laws are imperfect, which makes perfect prediction impossible.
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### Question 5

**Suppose a population grows without limit, according to the formula**

$$n_{t+1} = \text{birthrate} * n_t$$

**If  $\text{birthrate} = 4$  and the initial (year 0) population  $n_0 = 1$ , which is the correct formula for the population at year  $t$  (i.e.,  $n_t$ )?**

- A.  $n_t = 4t$
- B.  $n_t = 4t^2$
- C.  $n_t = t^4$
- D.  $n_t = 4^t$
- E.  $n_t = 4 * 2^t$

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Question 6

Recall that the logistic model is:

$$n_{t+1} = (\text{birthrate} - \text{death-rate}) * [n_t - (n_t^2 / k)]$$

where  $k$  is the maximum population (or carrying-capacity).

Suppose that  $\text{birthrate} = 4$ ,  $\text{death-rate} = 0$ ,  $k = 20$ , and the initial population  $n_0 = 20$ .

Using this model, what is  $n_{12}$  ?

- A. 20
  - B. 21
  - C. 1
  - D. 0
  - E. 4
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Question 7

For the logistic model (given in the question above), let  $\text{birthrate} = 5$ ,  $\text{death-rate} = 0$ ,  $k = 100$  and  $n_0 = 20$ . What is the fixed-point of the these values?

- A. 50
  - B. 80
  - C. 20
  - D. 100
  - E. 0
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Question 8

Recall that the logistic map is:

$$x_{t+1} = R (x_t - x_t^2)$$

where  $x$  = current-population / carrying-capacity and  $R$  = birthrate – deathrate.

Let  $R = 1.6$ . What is the fixed-point attractor for this value of  $R$ , starting from any  $x_0$  (assuming  $x_0$  is greater than 0 and less than 1) ?

- A. 0.375
- B. 0.450
- C. 0.2
- D. 0.355
- E. 0.575

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**Question 9**

**For the logistic map, let  $R = 3.2$ . What kind of attractor does this yield?**

- A. Fixed point attractor
  - B. Period 2 attractor
  - C. Period 4 attractor
  - D. Period 8 attractor
  - E. Chaotic attractor
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**Question 10**

**Which of the following can you conclude from the logistic map bifurcation diagram?**

- A. When  $R$  is between 2.4 and 3.0, the logistic map has a fixed point that increases as  $R$  increases.
  - B. When  $R$  is between 3.0 and 3.4, the logistic map has a period-2 attractor in which, as  $R$  increases, the two values in the attractor get closer together.
  - C. The onset of chaos for the logistic map is between 3.4 and 3.5.
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**Question 11**

**A system exhibits *deterministic chaos* if:**

- A. Chaos occurs for only some values of  $x_0$
  - B. If two initial conditions are very close, their trajectories under the system will also be close.
  - C. The system is deterministic, but its behavior can be impossible to predict with perfect accuracy.
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**Question 12**

**Which of these best describes what Feigenbaum's constant measures?**

- A. The distance between bifurcations in the logistic map as  $R$  increases
- B. The rate at which the distance between bifurcations in the logistic map decreases as  $R$  increases
- C. The increase in the periods of attractors in the logistic map increases as  $R$  increases