

# Introduction to Complexity (Spring 2013)

## 9.7 Submit Unit 9 Homework » Unit 9 Homework

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### Instructions 1

A PDF version of this homework is on the Course Materials page. (Please re-download it if you downloaded it before May 9.)

This homework has no ungraded part.

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### Question 2

Consider the log-log plot of earthquake magnitudes recorded worldwide, given in the PDF version of Unit 9 Homework (<http://s3.amazonaws.com/complexityexplorer/Unit9Homework.pdf>).

Which of the following is true, given the data in the plot?

- There are about 2 times as many magnitude 4 earthquakes as magnitude 5 earthquakes.
  - There are about 10 times as many magnitude 4 earthquakes as magnitude 5 earthquakes.
  - There are about 100 times as many magnitude 4 earthquakes as magnitude 5 earthquakes.
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### Question 3

Zipf's law predicts that in a given text (in any natural language), that the frequency of a word in the text is proportional to the inverse word's rank (where the most frequent word has rank 1, the second most frequent word has rank 2, etc.):

Frequency of word is proportional to  $1 / \text{rank}$ .

Thus, Zipf's law predicts which of the following:

- The most frequent word will appear 10 times more often than the second most frequent word.
  - The most frequent word will appear twice as often as the second most frequent word.
  - The most frequent word will appear five times as often as the second most frequent word.
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### Question 4

The surface hypothesis states that that metabolic rate is proportional to  $\text{mass}^{2/3}$  (i.e., mass to the 2/3 power).

For this question, assume that

*metabolic rate (in calories per day) = 90 \* mass<sup>2/3</sup> (in kilograms).*

Using a calculator or PowerLawCalculator.nlogo (from the Course Materials page), use this formula to find the predicted metabolic rate for a 70 kg human.

[Hint: In the PowerLawCalculator, set C to 90, X to 70, and alpha to 0.667]

- About 1531 calories per day
- About 2040 calories per day
- About 900 calories per day

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**Question 5**

Kleiber's law states that metabolic rate is proportional to  $\text{mass}^{3/4}$ . For this question, assume that

$$\text{metabolic rate (in calories per day)} = 90 * \text{mass}^{3/4} \text{ (in kilograms)}.$$

Using a calculator or PowerLawCalculator.nlogo (from the Course Materials page), use this formula to find the predicted metabolic rate of a 70 kg human.

[Hint: In the PowerLawCalculator, set C to 90, X to 70, and alpha to 0.75]

- About 2178 calories per day
  - About 3025 calories per day
  - About 1974 calories per day
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**Question 6**

Which of the following is implied if Kleiber's law is true?

- A mouse and a human will have the same metabolic rate.
  - A 70 kg human has a higher metabolic rate than the surface hypothesis would predict.
  - None of the above.
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**Question 7**

Another observed scaling law mentioned in the lectures is that heart rate is proportional to mass raised to the  $-1/4$  power. For this question, assume that

$$\text{heart rate (beats per minute)} = C * \text{mass}^{-1/4} \text{ (in kilograms)}.$$

where  $C$  is a constant.

Using a calculator or PowerLawCalculator.nlogo, find the constant  $C$  such that a 70 kg human will have heart rate approximately 70 beats per minute.

[Hint: You can do this either via trial and error, or by solving an equation. In PowerLawCalculator.nlogo, set X to 70, alpha to  $-0.25$ , and experiment with different values of  $C$ ]

Which of these is correct?

- $C$  is about 100
  - $C$  is about 200
  - $C$  is about 300
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**Question 8**

Using the same value of  $C$  that you found for question 7, find the predicted heart rate in beats per minute of a 7 kg dog.

- About 123 beats per minute
- About 155 beats per minute
- About 203 beats per minute