

# AP<sup>®</sup> STATISTICS 2010 SCORING GUIDELINES

## Question 1

### Intent of Question

The primary goals of this question were to assess students' ability to (1) apply terminology related to designing experiments; (2) construct an appropriate plot that could be used to investigate the fit of a linear model; (3) decide, from a graphical display, whether a linear regression model is appropriate for a set of data.

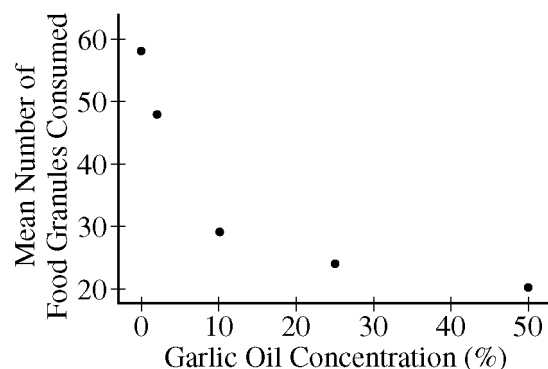
### Solution

#### **Part (a):**

- The treatments are the different concentrations of garlic in the food granules. Specifically, there are five treatments: 0 percent, 2 percent, 10 percent, 25 percent and 50 percent.
- The experimental units are the birds (starlings), each placed in an individual cage.
- The response is the number of food granules consumed by the bird.

#### **Part (b):**

- The following scatterplot results from these data.



- The curved pattern in this scatterplot reveals that a linear regression model would not be appropriate for modeling the relationship between these variables.

### Scoring

Parts (a) and (b) are scored as essentially correct (E), partially correct (P) or incorrect (I).

**Part (a)** is scored as follows:

Essentially correct (E) if the student correctly identifies all three subparts—the treatments, the experimental units and the response that will be measured.

Partially correct (P) if the student identifies two subparts correctly.

Incorrect (I) otherwise.

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## 2010 SCORING GUIDELINES

### Question 1 (continued)

#### Notes

- In subpart ii, it is acceptable to identify the experimental units as the cages.
- In subpart iii, it is not correct to identify the response as the *mean* number of granules consumed.

**Part (b)** is scored as follows:

Essentially correct (E) if the student produces a correct graph (a reasonable scatterplot or residual plot with correct labels and scales) and then concludes, based on one or more features of the graph, that the pattern of the relationship does not appear to be linear.

Partially correct (P) if the student produces a correctly shaped graph but concludes that the data are linear *OR* if the student produces an incorrectly shaped graph but makes a reasonable conclusion based on one or more features of the graph.

Incorrect (I) if the student does not include a graph *OR* if the student produces an incorrect graph and does not make a reasonable conclusion based on one or more features of the graph.

*Note:* Any of the following will result in an incorrect graph.

- Incorrect scale
- Reversed axes
- Missing label(s)
- Other types of graph (histogram, bar graph, etc.)

#### **4 Complete Response**

Both parts essentially correct

#### **3 Substantial Response**

One part essentially correct and one part partially correct

#### **2 Developing Response**

One part essentially correct and one part incorrect

*OR*

Both parts partially correct

#### **1 Minimal Response**

One part partially correct and one part incorrect

STATISTICS

SECTION II

Part A

Questions 1-5

Spend about 65 minutes on this part of the exam.

Percent of Section II score—75

1A1

**Directions:** Show all your work. Indicate clearly the methods you use, because you will be scored on the correctness of your methods as well as on the accuracy and completeness of your results and explanations.

1. Agricultural experts are trying to develop a bird deterrent to reduce costly damage to crops in the United States. An experiment is to be conducted using garlic oil to study its effectiveness as a nontoxic, environmentally safe bird repellent. The experiment will use European starlings, a bird species that causes considerable damage annually to the corn crop in the United States. Food granules made from corn are to be infused with garlic oil in each of five concentrations of garlic—0 percent, 2 percent, 10 percent, 25 percent, and 50 percent. The researchers will determine the adverse reaction of the birds to the repellent by measuring the number of food granules consumed during a two-hour period following overnight food deprivation. There are forty birds available for the experiment, and the researchers will use eight birds for each concentration of garlic. Each bird will be kept in a separate cage and provided with the same number of food granules.

(a) For the experiment, identify

i. the treatments

5 Treatments (amount of garlic infused in corn)  
 0% garlic    50% garlic  
 2% garlic  
 10% garlic  
 25% garlic

ii. the experimental units

The 40 birds serve as the experimental units.

iii. the response that will be measured

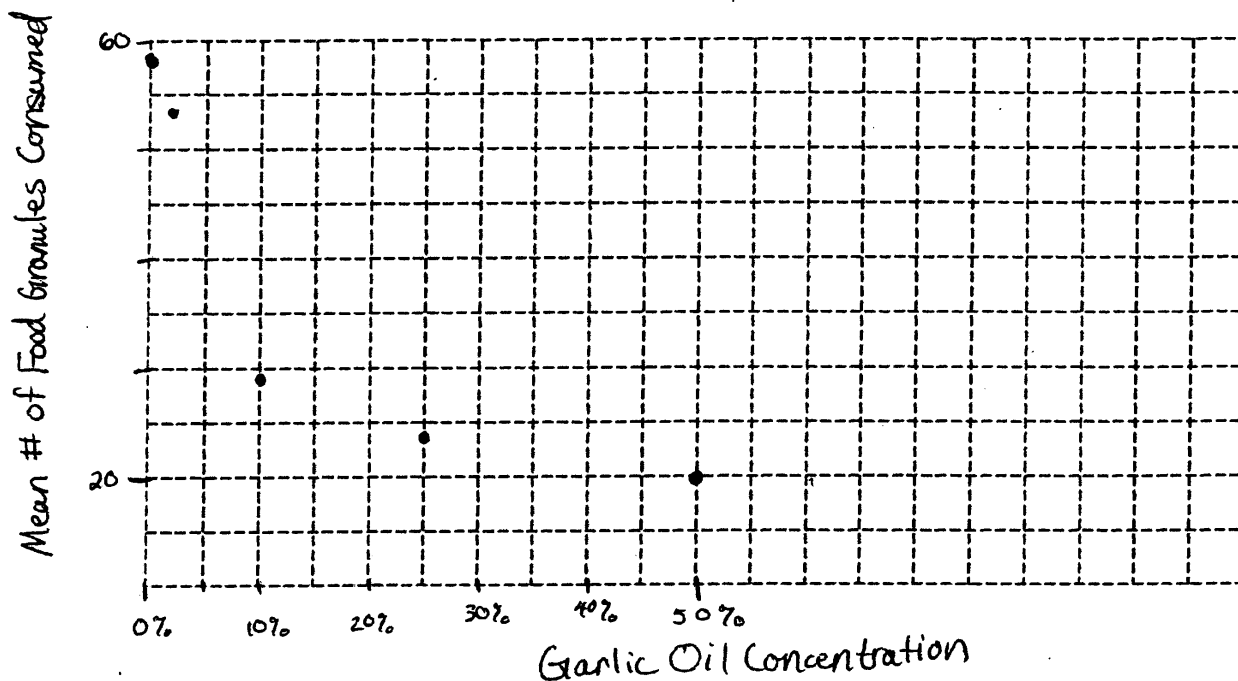
The birds' adverse reaction is the response, measured by the amount of corn eaten by the birds after overnight starvation.

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(b) After performing the experiment, the researchers recorded the data shown in the table below.

Garlic oil concentration	0%	2%	10%	25%	50%
Mean number of food granules consumed	58	48	29	24	20
Number of birds	8	8	8	8	8

i. Construct a graph of the data that could be used to investigate the appropriateness of a linear regression model for analyzing the results of the experiment.



ii. Based on your graph, do you think a linear regression model is appropriate? Explain.

A linear regression appears inappropriate, as the data exhibits a more exponential pattern. The rate at which the granules consumed is decreasing seems to slow with increased concentrations of garlic oil.

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## STATISTICS

## SECTION II

## Part A

## Questions 1-5

Spend about 65 minutes on this part of the exam.

Percent of Section II score—75

**Directions:** Show all your work. Indicate clearly the methods you use, because you will be scored on the correctness of your methods as well as on the accuracy and completeness of your results and explanations.

1. Agricultural experts are trying to develop a bird deterrent to reduce costly damage to crops in the United States. An experiment is to be conducted using garlic oil to study its effectiveness as a nontoxic, environmentally safe bird repellent. The experiment will use European starlings, a bird species that causes considerable damage annually to the corn crop in the United States. Food granules made from corn are to be infused with garlic oil in each of five concentrations of garlic—0 percent, 2 percent, 10 percent, 25 percent, and 50 percent. The researchers will determine the adverse reaction of the birds to the repellent by measuring the number of food granules consumed during a two-hour period following overnight food deprivation. There are forty birds available for the experiment, and the researchers will use eight birds for each concentration of garlic. Each bird will be kept in a separate cage and provided with the same number of food granules.

(a) For the experiment, identify

i. the treatments

The treatments in this experiment are the five concentrations of garlic oil to be infused in the food granules.

ii. the experimental units

The experimental units in this experiment are the forty birds, divided into 5 groups of 8, that will eat the food granules.

iii. the response that will be measured

The response that will be measured for this experiment is the number of food granules that each bird eats ~~after~~ in a 2-hour period after a night of food deprivation.

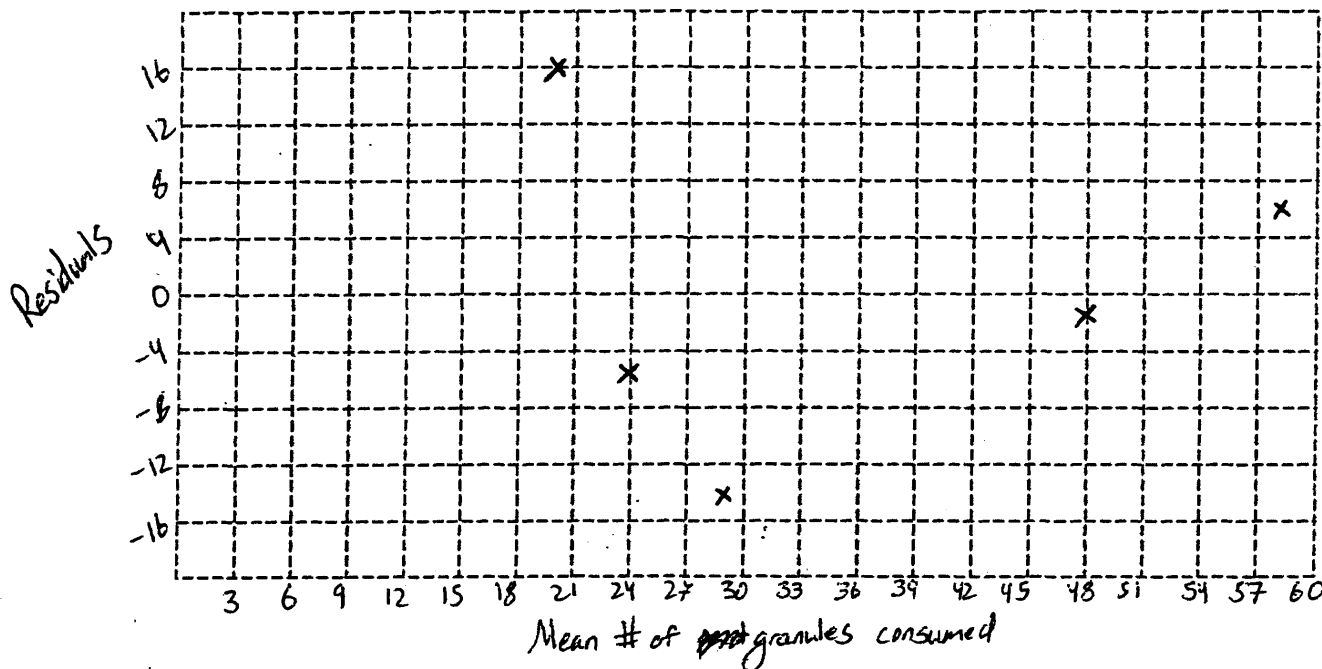
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(b) After performing the experiment, the researchers recorded the data shown in the table below.

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Garlic oil concentration	0%	2%	10%	25%	50%
Mean number of food granules consumed	58	48	29	24	20
Number of birds	8	8	8	8	8

i. Construct a graph of the data that could be used to investigate the appropriateness of a linear regression model for analyzing the results of the experiment.



ii. Based on your graph, do you think a linear regression model is appropriate? Explain.

Because the residuals plot has a curved shape to it, it appears that a linear regression is not appropriate.

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STATISTICS  
SECTION II

Part A

Questions 1-5

Spend about 65 minutes on this part of the exam.

Percent of Section II score—75

101

**Directions:** Show all your work. Indicate clearly the methods you use, because you will be scored on the correctness of your methods as well as on the accuracy and completeness of your results and explanations.

1. Agricultural experts are trying to develop a bird deterrent to reduce costly damage to crops in the United States. An experiment is to be conducted using garlic oil to study its effectiveness as a nontoxic, environmentally safe bird repellent. The experiment will use European starlings, a bird species that causes considerable damage annually to the corn crop in the United States. Food granules made from corn are to be infused with garlic oil in each of five concentrations of garlic—0 percent, 2 percent, 10 percent, 25 percent, and 50 percent. The researchers will determine the adverse reaction of the birds to the repellent by measuring the number of food granules consumed during a two-hour period following overnight food deprivation. There are forty birds available for the experiment, and the researchers will use eight birds for each concentration of garlic. Each bird will be kept in a separate cage and provided with the same number of food granules.

(a) For the experiment, identify

i. the treatments

There are five treatments in this experiment. They are bird food granules containing 0%, 2%, 10%, 25%, and 50% garlic oil concentrations, each ~~per~~ level of concentration being a different treatment.

ii. the experimental units

The units are <sup>number of</sup> food granules and garlic oil concentration, garlic oil concentration being the explanatory variable and the number of food granules eaten being the response variable.

iii. the response that will be measured

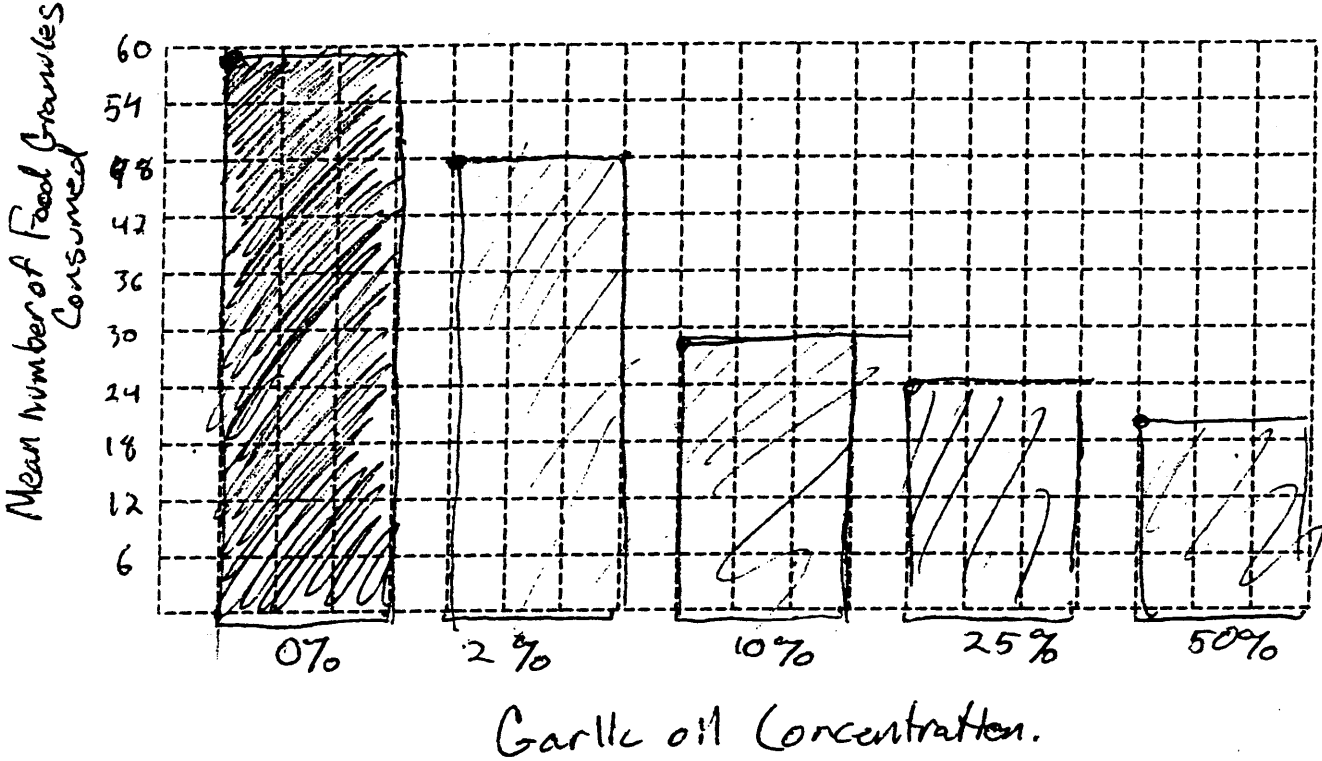
The response will be number of food granules eaten. The null hypothesis is that this will be the same for all treatment groups. The alternative hypothesis is that greater garlic oil concentration will lead to ~~greater~~ less granule consumption, thereby proving garlic oil to be an effective bird repellent. GO ON TO THE NEXT PAGE.

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(b) After performing the experiment, the researchers recorded the data shown in the table below.

Garlic oil concentration	0%	2%	10%	25%	50%
Mean number of food granules consumed	58	48	29	24	20
Number of birds	8	8	8	8	8

i. Construct a graph of the data that could be used to investigate the appropriateness of a linear regression model for analyzing the results of the experiment.



ii. Based on your graph, do you think a linear regression model is appropriate? Explain.

A linear regression model is not appropriate for these data, because they follow a roughly negative exponential model. Looking at the top left (or right) corners of the bars makes this clearer. Also, the concentrations are not evenly spaced: if they were, the exponential decay would be clearer.

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# AP<sup>®</sup> STATISTICS

## 2010 SCORING COMMENTARY

### Question 1

#### Overview

The primary goals of this question were to assess students' ability to (1) apply terminology related to designing experiments; (2) construct an appropriate plot that could be used to investigate the fit of a linear model; (3) decide, from a graphical display, whether a linear regression model is appropriate for a set of data.

#### Sample: 1A

**Score: 4**

In part (a), subpart i, the student correctly lists the five treatments. It should be noted that the parenthetical statement “(amount of galic [*sic*] infused in corn)” could be viewed as the factor (or variable) involved in the experiment and, if given alone, would not be a correct response for this component. In part (a), subpart ii, the answer is clear and correct. In part (a), subpart iii, although the student identifies the response that will be measured as the “birds’ adverse reaction” rather than the amount eaten, it is acceptable to say that the adverse reaction is measured by the amount eaten. As all three subparts are correct, part (a) was scored as essentially correct. In part (b), subpart i, the student draws a well-labeled and correct scatterplot. In part (b), subpart ii, the response correctly states that the linear model is inappropriate because “the data exhibits a more exponential pattern.” This first sentence is sufficient to answer this subpart correctly. The second sentence presents a nice argument based on a change in the rate of consumption; this also would have been sufficient to correctly answer this subpart. So there are two parallel solutions to this subpart, and both are correct. As both components of part (b) are correct, it was scored as essentially correct. Both parts (a) and (b) were scored as essentially correct, so the response earned a score of 4.

#### Sample: 1B

**Score: 3**

In part (a), subpart i, “the five concentrations of garlic oil” is sufficient to correctly answer this component. In part (a), subpart ii, the response identifies the 40 birds as the experimental units, so it is correct. The statement dividing the birds into groups is extraneous. In part (a), subpart iii, the response is clear and correct. As all three subparts are correct, part (a) was scored as essentially correct. In part (b), subpart i, the student draws a residual plot but places the wrong variable along the horizontal axis, so this component was scored as incorrect. In part (b), subpart ii, the response identifies the “curved shape” of the residual plot and therefore correctly concludes that linear regression is not appropriate. With one of the two subparts correct, part (b) was scored as partially correct. Because part (a) was scored as essentially correct and part (b) was scored as partially correct, the response earned a score of 3.

#### Sample: 1C

**Score: 2**

In part (a), subpart i, the student gives a clear and detailed correct response. In part (a), subpart ii, the student identifies two experimental units, the “number of food granules” and “garlic oil concentration.” Neither of these is correct. The statement about the explanatory and response variable was considered extraneous and certainly does not improve the answer. This subpart was scored as incorrect. In part (a), subpart iii, the student correctly identifies the response that will be measured in the first sentence. The statements concerning the hypotheses were considered extraneous. As two of the three subparts are correct, part (a) was scored as partially correct. In part (b), subpart i, the student draws a bar chart,

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**2010 SCORING COMMENTARY**

**Question 1 (continued)**

making this subpart incorrect. In part (b), subpart ii, the response identifies the curved (“roughly negative exponential”) shape of the data by looking at the top left corner of the bars, essentially treating these positions as points on a scatterplot. This interpretation is reasonable for the given graph, so this response was scored as correct. With one of the two subparts correct, part (b) was scored as partially correct. Because both parts (a) and (b) were scored as partially correct, the response earned a score of 2.