4. An automobile company wants to learn about customer satisfaction among the owners of five specific car models. Large sales volumes have been recorded for three of the models, but the other two models were recently introduced so their sales volumes are smaller. The number of new cars sold in the last six months for each of the models is shown in the table below.

Car Model	A	B	C	D	E	Total
Number of new cars sold in the last six months	112,338	96,174	83,241	3,278	2,323	297,354

The company can obtain a list of all individuals who purchased new cars in the last six months for each of the five models shown in the table. The company wants to sample 2,000 of these owners.

(a) For simple random samples of 2,000 new car owners, what is the expected number of owners of model E and the standard deviation of the number of owners of model E?

(b) When selecting a simple random sample of 2,000 new car owners, how likely is it that fewer than 12 owners of model E would be included in the sample? Justify your answer.

(c) The company is concerned that a simple random sample of 2,000 owners would include fewer than 12 owners of model D or fewer than 12 owners of model E. Briefly describe a sampling method for randomly selecting 2,000 owners that will ensure at least 12 owners will be selected for each of the 5 car models.

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5. A large pet store buys the identical species of adult tropical fish from two different suppliers—Buy-Rite Pets and Fish Friends. Several of the managers at the pet store suspect that the lengths of the fish from Fish Friends are consistently greater than the lengths of the fish from Buy-Rite Pets. Random samples of 8 adult fish of the species from Buy-Rite Pets and 10 adult fish of the same species from Fish Friends were selected and the lengths of the fish, in inches, were recorded, as shown in the table below.

	Length of Fish	Mean	Standard Deviation
Buy-Rite Pets ($n_B = 8$)	3.4 2.7 3.3 4.1 3.5 3.4 3.0 3.8	3.40	0.434
Fish Friends ($n_F = 10$)	3.3 2.9 4.2 3.1 4.2 4.0 3.4 3.2 3.7 2.6	3.46	0.550

Do the data provide convincing evidence that the mean length of the adult fish of the species from Fish Friends is greater than the mean length of the adult fish of the same species from Buy-Rite Pets?

STATISTICS
SECTION II
Part B
Question 6
Spend about 25 minutes on this part of the exam.
Percent of Section II score—25

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.

6. Hurricane damage amounts, in millions of dollars per acre, were estimated from insurance records for major hurricanes for the past three decades. A stratified random sample of five locations (based on categories of distance from the coast) was selected from each of three coastal regions in the southeastern United States. The three regions were Gulf Coast (Alabama, Louisiana, Mississippi), Florida, and Lower Atlantic (Georgia, South Carolina, North Carolina). Damage amounts in millions of dollars per acre, adjusted for inflation, are shown in the table below.

HURRICANE DAMAGE AMOUNTS IN MILLIONS OF DOLLARS PER ACRE

	Distance from Coast				
	< 1 mile	1 to 2 miles	2 to 5 miles	5 to 10 miles	10 to 20 miles
Gulf Coast	24.7	21.0	12.0	7.3	1.7
Florida	35.1	31.7	20.7	6.4	3.0
Lower Atlantic	21.8	15.7	12.6	1.2	0.3

(a) Sketch a graphical display that compares the hurricane damage amounts per acre for the three different coastal regions (Gulf Coast, Florida, and Lower Atlantic) and that also shows how the damage amounts vary with distance from the coast.

(b) Describe differences and similarities in the hurricane damage amounts among the three regions.

AP® STATISTICS
2010 SCORING GUIDELINES

Question 5

Intent of Question

The primary goal of this question was to assess students' ability to set up, perform and interpret the results of a significance test. More specific goals were to assess students' ability to (1) state appropriate hypotheses; (2) identify the name of an appropriate statistical test and check appropriate assumptions/conditions; (3) compute the appropriate test statistic and *p*-value; (4) draw an appropriate conclusion, with justification, in the context of the study.

Solution

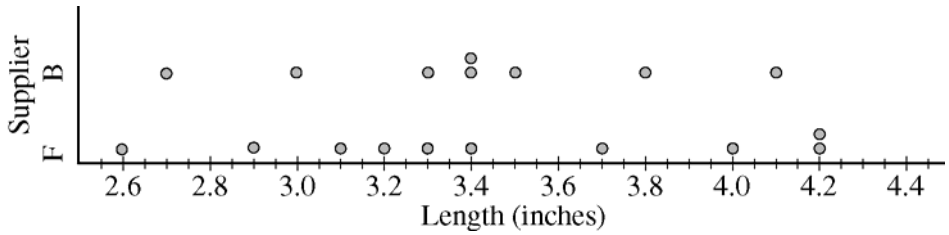
Step 1: States a correct pair of hypotheses

Let μ_B represent the population mean length of all adult fish of this species from Buy-Rite Pets, and
let μ_F represent the population mean length of all adult fish of this species from Fish Friends.

The hypotheses to be tested are H_0: $\mu_B = \mu_F$ versus H_a: $\mu_B < \mu_F$.

Step 2: Identifies a correct test procedure (by name or by formula) and checks appropriate conditions

The appropriate test is a two-sample *t*-test. The first condition is that the samples are independent random samples from the two populations. This was stated in the question. The second condition is that the population distributions of fish lengths are normal. The following dotplots reveal no obvious departures from normality, so it appears reasonable to proceed with the two-sample *t*-test.



Step 3: Demonstrates correct mechanics, including the value of the test statistic, df and *p*-value (or rejection region)

The test statistic is: $t = \dfrac{\bar{x}_B - \bar{x}_F}{\sqrt{\dfrac{s_B^2}{n_B} + \dfrac{s_F^2}{n_F}}} = \dfrac{3.40 - 3.46}{\sqrt{\dfrac{0.434^2}{8} + \dfrac{0.550^2}{10}}} \approx -0.259$

With df = 15.99999, *p*-value = 0.3996.

Step 4: States a correct conclusion in the context of the problem, using the result of the statistical test

Because this *p*-value is larger than any conventional significance level (such as $\alpha = 0.10$ or $\alpha = 0.05$), we fail to reject H_0. The sample data do not provide convincing evidence to conclude that the mean length of the adult fish of the species from Fish Friends is greater than the mean length of the adult fish of the same species from Buy-Rite Pets.

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2010 SCORING GUIDELINES

Question 5 (continued)

Scoring

Each of steps 1, 2, 3 and 4 is scored as essentially correct (E), partially correct (P) or incorrect (I).

General Note: If a two-sample *t*-interval approach is taken without addressing the one-sided versus two-sided discrepancy, the student will lose credit for step 1 but still may earn full credit for steps 2, 3 and 4. The correct 95 percent confidence interval with df = 16 is from –0.55 to 0.43 inches.

Step 1 is scored as follows:

Essentially correct (E) if the student uses correct parameters *AND* states correct hypotheses.

Partially correct (P) if the student uses correct parameters *OR* states correct hypotheses but not both.

Incorrect (I) otherwise.

Notes

- If the null hypothesis is wrong, reduce the score in this step by one level (i.e., E to P, or P to I).
- If the alternative hypothesis is two-sided or in the wrong direction, the student does not get credit for the hypotheses.
- If standard symbols are used for the parameters with appropriate group labels (e.g., μ_B, μ_F), the parameter component is considered correct.
  - If *generic* standard symbols are used for the parameters (e.g., μ_1, μ_2), students must clearly identify the parameters with the suppliers.
  - If standard symbols (either with context or generic) are used for the parameters *and* the student attempts to define them, the definitions must be correct and in context, including the concept of mean.
  - If *nonstandard* symbols are used for the parameters, they must be explicitly defined in context and include the concepts of mean and population.
  - If a student does not use symbols in the hypotheses, the response can still receive an E as long as the alternative hypothesis is in the correct direction and it clearly refers to population means in context.

Step 2 is scored as follows:

Essentially correct (E) if the student correctly completes all three of the following components:

- Identifies the correct test procedure (by name or by formula)
- Checks for independent random samples
- Checks for normality

Partially correct (P) if the student correctly completes two of the three components listed above.

Incorrect (I) otherwise.

Question 5 (continued)

Notes

- A two-sample *z*-test is not a correct test procedure in this case, but if both conditions are checked correctly, this step is scored as partially correct.
- If a student chooses to conduct a pooled *t*-test, the equal variance condition must be addressed (e.g., by commenting on similarity of standard deviations or conducting a test for equality of variances) to get credit for choosing the appropriate test procedure.
- To get credit for the check of independent random samples, students must indicate that *more than one* random sample was taken.
- To get credit for the normality condition, students must include correct graphs of both distributions and include an appropriate comment about shape or outliers, such as "neither has outliers," "both are roughly symmetric," "no obvious departures from normality," "approximately normal," etc.
- Ignore additional conditions listed, as long as they are correct, such as "the sample sizes must be less than 10 percent of the population sizes." However, if the student includes additional *incorrect* conditions, such as $np > 10$, reduce the score in this step by one level (i.e., E to P, or P to I).

Step 3 is scored as follows:

Essentially correct (E) if the student correctly calculates both the test statistic and *p*-value.

Partially correct (P) if the student correctly calculates the test statistic but not the *p*-value *OR* omits the test statistic but correctly calculates the *p*-value.

Incorrect (I) otherwise.

Notes

- It is acceptable for students to use the conservative df (df = 7) or use the *t*-table to get a *p*-value > 0.25.
- Students who incorrectly choose a two-sample *z*-test lose credit for identifying the correct test procedure in step 2 but can earn full credit in step 3 if they provide the correct *z*-statistic ($z = -0.259$) and *p*-value (*p*-value = 0.3978).
- If the alternative hypothesis is two-sided, the *p*-value must be approximately 0.8 to get credit for the *p*-value component.
- If a student provides the correct test statistic and/or *p*-value but shows additional incorrect work, such as a wrong formula, reduce the score in this step by one level (i.e., E to P, or P to I).

Step 4 is scored as follows:

Essentially correct (E) if the student provides a correct conclusion in context, also providing justification based on linkage between the *p*-value and conclusion.

Partially correct (P) if the student provides a correct conclusion, with linkage to the *p*-value, but not in context *OR* provides a correct conclusion in context, but without justification based on linkage to the *p*-value.

Incorrect (I) otherwise.

AP® STATISTICS
2010 SCORING GUIDELINES

Question 5 (continued)

Notes

- The conclusion must be about the *mean* fish lengths to get credit for context unless the student already lost credit in step 1 for neglecting to include the concept of mean.
- The conclusion must be consistent with the alternative hypothesis to get credit for context unless the student was already penalized for inconsistency with the alternative hypothesis in step 3.
- If the conclusion is consistent with an incorrect *p*-value from step 3, and also in context, with justification based on linkage to the *p*-value, then this step is scored essentially correct.
- If both a significance level α and a *p*-value are given together, the linkage between the *p*-value and the conclusion is implied. If no α level is given, the solution must be explicit about the linkage by giving a correct interpretation of the *p*-value or explaining how the conclusion follows from the *p*-value, such as saying: "Because the *p*-value is small, we reject the null hypothesis" or "Because the *p*-value is large, we do not reject the null hypothesis."
- If the student chooses to "retain the null hypothesis," with linkage and/or context, this should be scored partially correct (P). If the student goes on to say something equivalent to "fail to reject" (e.g., "we should not conclude the mean length of fish is greater at Fish Friends") in context, with linkage, then the response should be scored essentially correct.
- A conclusion in step 4 that is equivalent to "accept H_0" (such as "we conclude that the mean fish length is the same from both suppliers") cannot be scored essentially correct. Such a response should be scored partially correct, provided that the conclusion is in context, with justification based on linkage to the *p*-value. Such a response should be scored incorrect if it lacks either context or linkage to the *p*-value.
- If a student attempts to interpret the *p*-value, but does so incorrectly, then do not give credit for the linkage component.

Each essentially correct (E) step counts as 1 point. Each partially correct (P) step counts as ½ point.

4 **Complete Response**

3 **Substantial Response**

2 **Developing Response**

1 **Minimal Response**

If a response is between two scores (for example, 2½ points), use a holistic approach to determine whether to score up or down, depending on the overall strength of the response and communication.