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. A professional sports team evaluates potential players for a certain position based on two main characteristics, speed and strength.

   (a) Speed is measured by the time required to run a distance of 40 yards, with smaller times indicating more desirable (faster) speeds. From previous speed data for all players in this position, the times to run 40 yards have a mean of 4.60 seconds and a standard deviation of 0.15 seconds, with a minimum time of 4.40 seconds, as shown in the table below.

	Mean	Standard Deviation	Minimum
Time to run 40 yards	4.60 seconds	0.15 seconds	4.40 seconds

   Based on the relationship between the mean, standard deviation, and minimum time, is it reasonable to believe that the distribution of 40-yard running times is approximately normal? Explain.

   (b) Strength is measured by the amount of weight lifted, with more weight indicating more desirable (greater) strength. From previous strength data for all players in this position, the amount of weight lifted has a mean of 310 pounds and a standard deviation of 25 pounds, as shown in the table below.

	Mean	Standard Deviation
Amount of weight lifted	310 pounds	25 pounds

   Calculate and interpret the z-score for a player in this position who can lift a weight of 370 pounds.

   (c) The characteristics of speed and strength are considered to be of equal importance to the team in selecting a player for the position. Based on the information about the means and standard deviations of the speed and strength data for all players and the measurements listed in the table below for Players A and B, which player should the team select if the team can only select one of the two players? Justify your answer.

	Player A	Player B
Time to run 40 yards	4.42 seconds	4.57 seconds
Amount of weight lifted	370 pounds	375 pounds

GO ON TO THE NEXT PAGE.

2. The table below shows the political party registration by gender of all 500 registered voters in Franklin Township.

PARTY REGISTRATION–FRANKLIN TOWNSHIP

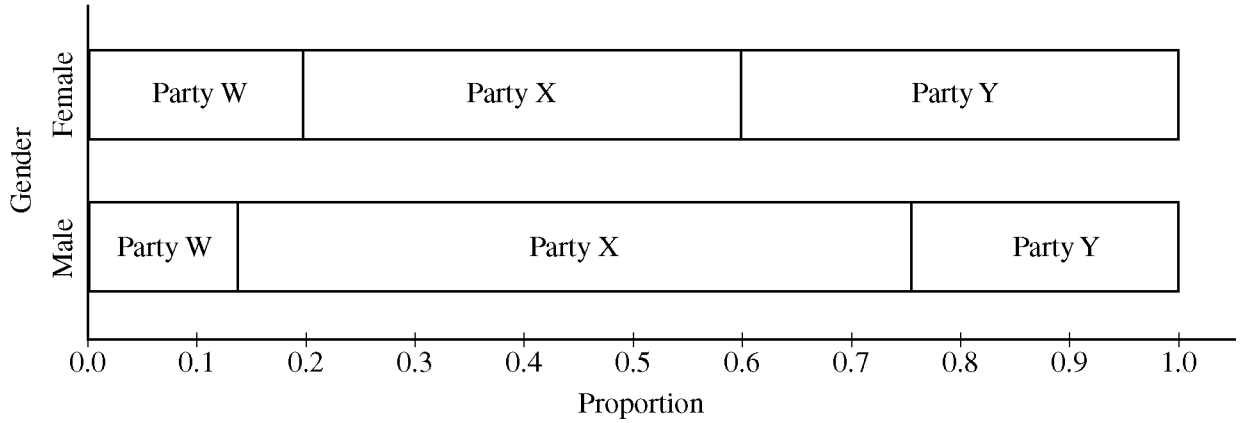
	Party W	Party X	Party Y	Total
Female	60	120	120	300
Male	28	124	48	200
Total	88	244	168	500

(a) Given that a randomly selected registered voter is a male, what is the probability that he is registered for Party Y?

(b) Among the registered voters of Franklin Township, are the events "is a male" and "is registered for Party Y" independent? Justify your answer based on probabilities calculated from the table above.

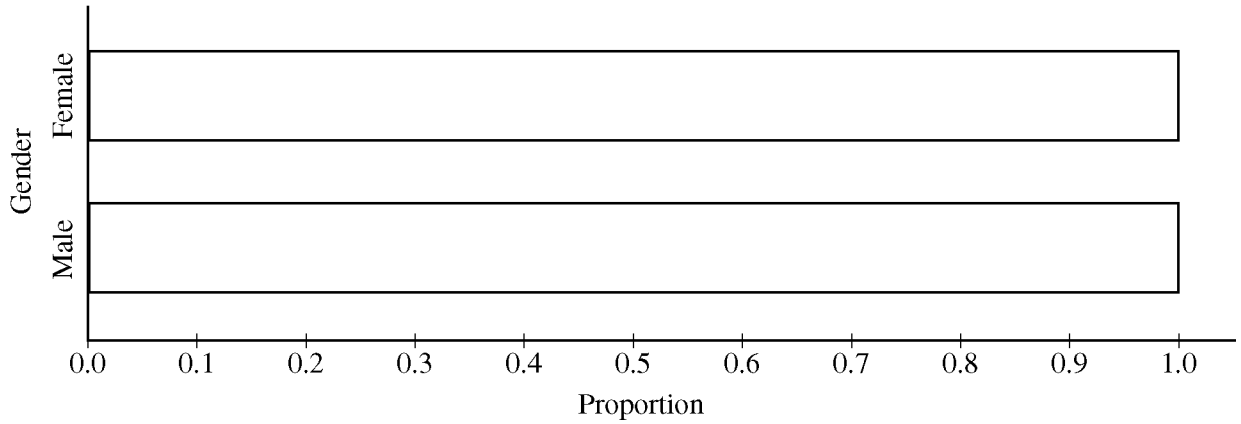
(c) One way to display the data in the table is to use a segmented bar graph. The following segmented bar graph, constructed from the data in the party registration–Franklin Township table, shows party-registration distributions for males and females in Franklin Township.

FRANKLIN TOWNSHIP



In Lawrence Township, the proportions of all registered voters for Parties W, X, and Y are the same as for Franklin Township, and party registration is independent of gender. Complete the graph below to show the distributions of party registration by gender in Lawrence Township.

LAWRENCE TOWNSHIP



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2011 SCORING GUIDELINES

Question 1

Intent of Question

The primary goals of this question were to assess students' ability to (1) relate summary statistics to the shape of a distribution; (2) calculate and interpret a *z*-score; (3) make and justify a decision that involves comparing variables that are recorded on different scales.

Solution

Part (a):

No, it is not reasonable to believe that the distribution of 40-yard running times is approximately normal, because the minimum time is only 1.33 standard deviations below the mean $\left(z = \frac{4.4 - 4.6}{0.15} \approx -1.33\right)$. In a normal distribution, approximately 9.2 percent of the *z*-scores are below -1.33. However, there are no running times less than 4.4 seconds, which indicates that there are no running times with a *z*-score less than -1.33. Therefore, the distribution of 40-yard running times is not approximately normal.

Part (b):

The *z*-score for a player who can lift a weight of 370 pounds is $z = \frac{370 - 310}{25} = 2.4$. The *z*-score indicates that the amount of weight the player can lift is 2.4 standard deviations above the mean for all previous players in this position.

Part (c):

Because the two variables — time to run 40 yards and amount of weight lifted — are recorded on different scales, it is important not only to compare the players' values but also to take into account the standard deviations of the distributions of the variables. One reasonable way to do this is with *z*-scores.

The *z*-scores for the 40-yard running times are as follows:

$$\text{Player A: } z = \frac{4.42 - 4.60}{0.15} = -1.2$$

$$\text{Player B: } z = \frac{4.57 - 4.60}{0.15} = -0.2$$

The *z*-scores for the amount of weight lifted are as follows:

$$\text{Player A: } z = \frac{370 - 310}{25} = 2.4$$

$$\text{Player B: } z = \frac{375 - 310}{25} = 2.6$$

Question 1 (continued)

- Either the formula with correct symbols or with correct numerical values is needed in addition to the value 2.4 in the calculation of the *z*-score.
- A diagram can show direction from the mean, if the quantities are appropriately labeled.

Part (c) is scored as follows:

Essentially correct (E) if the response addresses the following three components:

1. Correct selection of Player A.
2. Numerical adjustments of the scales so that the players' values can be compared for *BOTH* variables: time to run 40 yards and amount of weight lifted.
3. Justification of the selection in component 1 by using the players' values on both variables with respect to the adjusted scales.

Partially correct (P) if the response has exactly two of the three components listed above.

Incorrect (I) if the response fails to meet the criteria for E or P.

Notes

- It is not necessary to calculate *z*-scores. For example, the following response is scored as essentially correct (E): "Players A and B are close in weight lifting, because the difference of 5 pounds is much less than 1 standard deviation (25 pounds), but much less close in running time because the difference is 0.15 seconds, which is exactly one standard deviation. Therefore, player A should be selected since he is considerably faster and almost as strong as player B."
- Component 3 is not satisfied by the statement, "Player A should be selected since the weights lifted are close and running times are less close," because the adjusted scales are not mentioned. Such a statement could apply to the original data, where the values are on different scales.
- The justification in component 3 must reference the adjusted scale for at least one variable *AND* at least be implied for the other variable.
- Normal probability calculations can be used in establishing the numerical scale adjustments for component 2 and for justifying the selection of the players in component 3. However, this results in a lowering of scores (that is, from E to P or from P to I) unless the student has concluded in part (a) that it was reasonable to believe that the distribution of running times was approximately normal.
- Conceptual miscalculation of *z*-scores or probabilities (for example, using the wrong mean, reversing the order of subtraction, or multiplying probabilities) results in the loss of credit for component 2, whereas minor arithmetic mistakes are overlooked.

4 Complete Response

All three parts essentially correct

3 Substantial Response

Two parts essentially correct and one part partially correct

Question 1 (continued)

2 Developing Response

Two parts essentially correct and one part incorrect

OR

One part essentially correct and one or two parts partially correct

OR

Three parts partially correct

1 Minimal Response

One part essentially correct and two parts incorrect

OR

Two parts partially correct and one part incorrect