Rationale: In Example 1, the unsigned ranks of 1 through 11 have a total of 66, so if there are no significant differences, each of the two signed-rank totals should be around 66 ÷ 2, or 33. That is, the negative ranks and positive ranks should split up as 33–33 or something close, such as 32–34. The table of critical values shows that at the 0.05 significance level with 11 pairs of data, a split of 11–55 represents a significant departure from the null hypothesis, and any split that is farther apart (such as 10–56 or 2–64) will also represent a significant departure from the null hypothesis. Conversely, splits like 12–54 do not represent significant departures from a 33–33 split, and they would not justify rejecting the null hypothesis. The Wilcoxon signed-ranks test is based on the lower rank total, so instead of analyzing both numbers constituting the split, we consider only the lower number.

The sum of all the ranks $1 + 2 + 3 + \cdots + n$ is equal to $n(n + 1)/2$. If this rank sum is to be divided equally between two categories (positive and negative), each of the two totals should be near $n(n + 1)/4$, which is half of $n(n + 1)/2$. Recognition of this principle helps us understand the test statistic used when $n > 30$.

using TECHNOLOGY

STATDISK First enter the columns of data in the data window. Select **Analysis** from the main menu bar, then select **Wilcoxon Tests.** Now select **Wilcoxon (Matched Pairs),** and proceed to select the columns of data. Click on **Evaluate.**

MINITAB First create a column C3 consisting of the differences between the matched pairs. Enter the paired data in columns C1 and C2. Click on the Session portion of the screen, then click on **Editor,** then **Enable Command Editor,** and enter the command **LET C3 = C1 − C2.** Press the **Enter** key.

Select the options **Stat, Nonparametrics,** and **1-Sample Wilcoxon.** Enter C3 for the variable and click on the button for **Test Median.** The Minitab display will include the *P*-value.

EXCEL Excel is not programmed for the Wilcoxon signed-ranks test, but XLSTAT can be used by selecting **Nonparametric tests,** then **Comparison of two samples.** Because XLSTAT uses a different procedure than the one described in this section, results may be somewhat different, especially for small samples.

TI-83/84 PLUS The TI-83/84 Plus calculator is not programmed for the Wilcoxon signed-ranks test, but the program SRTEST can be used. The program SRTEST (by Michael Lloyd) is on the CD included with this book, or it can be downloaded from the site www.addisonwesley.com/triola. First download and install the program. (Also download the program ZZRANK, which is used by the program SRTEST.) Next, create a list of differences between values in the matched pairs. (The first set of values can be entered in list L1, the second set of values can be entered in list L2, then the differences can be stored in list L3 by entering L1 − L2 → L3, where the **STO** key is used for the arrow.) Press PRGM and select **SRTEST.** Press ENTER ENTER. When given the prompt of DATA =, enter the list containing the differences. Press ENTER to see the sum of the positive ranks and the sum of the negative ranks. Press ENTER again to see the mean and standard deviation, and press ENTER once again to see the *z* score. If $n \leq 30$, get the critical *T* value from Table A-8, but if $n > 30$, get the critical *z* values from Table A-2.

STATCRUNCH You can use StatCrunch to test the claim that a single list of values is from a population with a median equal to some specified value. Click on **Open StatCrunch.** First enter the column of data or open a data set. Click on **Stat,** select **Nonparametrics,** then select **Wilcoxon Signed Ranks Test.** Identify the column to be used, click on **Next,** and enter the value of the claimed population median. Click on **Calculate** and the display will include the *P*-value.

13-3 Basic Skills and Concepts

Statistical Literacy and Critical Thinking

1. Wilcoxon Signed-Ranks Test for Freshman 15 The following table lists some of the weights from Data Set 4 in Appendix B. Those weights were measured from college students in September and later in April of their freshman year. Assume that we plan to use the Wilcoxon signed-ranks test to test the claim of no difference between September weights and April weights. What requirements must be satisfied for this test? Is there any requirement that the populations must have a normal distribution or any other specific distribution? In what sense is this Wilcoxon signed-ranks test a "distribution-free test"?