By analyzing the weights of quarters in Table 14-1 with a run chart, an R chart, and an $\bar{x}$ chart, we can see that the process is out of statistical control. These values are from a new minting process, so the new procedure needs to be improved before it can be used.

using TECHNOLOGY

STATDISK See the *STATDISK Student Laboratory Manual and Workbook* that is a supplement to this book.

MINITAB **Run Chart:** To construct a run chart, such as the one shown in Figure 14-1, begin by entering all of the sample data in column C1. Select the option **Stat,** then **Quality Tools,** then **Run Chart.** In the indicated boxes, enter C1 for the single column variable, enter 1 for the subgroup size, and then click on **OK.**

***R* Chart:** First enter the individual sample values sequentially in column C1 or enter the sample values in columns and rows as in Table 14-1. Next, select the options **Stat, Control Charts, Variables Charts for Subgroups,** and **R.** Select the format of the data (one column or "observations for each subgroup are in one row of columns") and enter the appropriate column(s) in the data entry box. Click on **R Options,** then **estimate.** Select **Rbar.** (Selection of the R bar estimate causes the variation of the population distribution to be estimated with the sample ranges instead of the sample standard deviations, which is the default.) Click **OK** twice.

$\bar{x}$ Chart: First enter the individual sample values sequentially in column C1 or enter the sample values in columns and rows as in Table 14-1. Next, select the options **Stat, Control Charts, Variables Charts for Subgroups,** and **Xbar.** Select the format of the data (one column or "observations for each subgroup are in one row of columns") and enter the appropriate column(s) in the data entry box. Click on **Xbar Options,** then select **estimate** and choose the option of **Rbar.** Click **OK** twice.

EXCEL Use XLSTAT. Enter the data in individual columns, such as the five columns of data in Table 14-1. Click on **XLSTAT,** select **SPC** (for statistical process control), then select **Subgroup charts.** Click on the **General** tab and select the data format of "columns," then enter the range of data in the "Data" box, such as A1:E20. Click on the **Estimation** tab and select **R bar.** Click **OK.** Results will include an R chart and an $\bar{x}$ chart.

Excel's built-in graphics features could be used to create control charts, but the procedure is difficult. See the *Excel Student Laboratory Manual and Workbook* that is a supplement to this book.

STATCRUNCH Click on **Open StatCrunch.** First enter columns of data or open a data set. Click on **Stat,** select **Control Charts,** then select **X-bar, R.** Identify the columns to be used ("Samples in selected columns"), then click on **Calculate.** After the control charts are displayed, click on **Next** to get the values of the upper and lower control limits and the centerlines.

14-2 Basic Skills and Concepts

Statistical Literacy and Critical Thinking

1. Product Specs Table 14-1 lists process data consisting of the weights (g) of quarters, and the United States Mint uses a manufacturing process designed to result in a mean weight equal to 5.670 g. If recent $\bar{x}$ and R control charts show that the process of manufacturing quarters is within statistical control, does that indicate that the quarters have weights that are reasonably close to 5.670 g? Why or why not?

2. Notation and Terminology Consider process data consisting of the amounts of Coke (in oz) in randomly selected cans of regular Coke. The process is to be monitored with $\bar{x}$ and R control charts based on samples of 50 cans randomly selected each day for 20 consecutive days of production. What are $\bar{x}$ and R control charts, and what do $\bar{\bar{x}}$, $\bar{R}$, UCL, and LCL denote?

3. Control Charts When using control charts to monitor a process, why is it necessary to include an $\bar{x}$ chart and an R chart? Why can't we use just one of those control charts?

4. Lake Mead Elevations Shown below are an $\bar{x}$ chart (top) and an R chart (bottom) obtained by using the monthly elevations of Lake Mead at Hoover Dam (based on data from the U.S. Department of the Interior). The elevations are in feet above sea level. The control charts are based on the 12 monthly elevations for each of the 75 consecutive and recent years available as of this writing. What do the control charts tell us about Lake Mead?