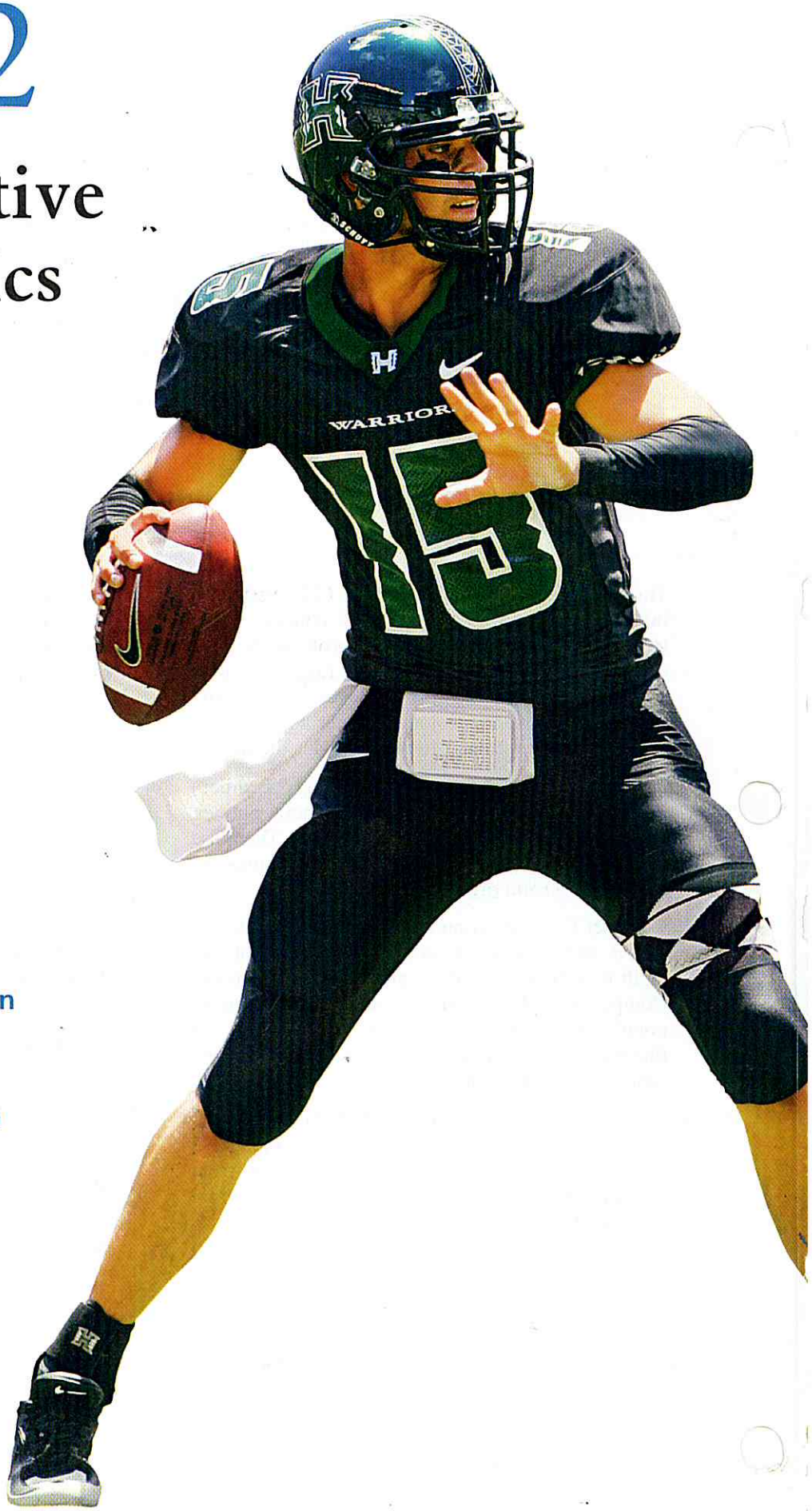
CHAPTER 2

Descriptive Statistics



In 2006, quarterback Colt Brennan of the University of Hawaii set an NCAA record for most touchdown passes in a single season (58).

WHERE YOU'VE BEEN

In Chapter 1, you learned that there are many ways to collect data. Usually, researchers must work with sample data in order to analyze populations, but occasionally it is possible to collect all the data for a given population. For instance, the following represents the number of touchdowns scored by all 119 NCAA Division 1A football teams for the 2006 season.

89, 68, 65, 61, 63, 63, 61, 61, 59, 60, 54, 55, 54, 49, 53, 55, 59, 50, 52, 48, 53, 46, 55, 57, 48, 47, 48, 46, 44, 50, 55, 48, 45, 44, 46, 46, 47, 41, 39, 41, 45, 44, 45, 43, 42, 42, 48, 43, 40, 39, 44, 37, 40, 45, 43, 37, 38, 38, 36, 34, 37, 36, 35, 35, 35, 40, 31, 34, 35, 39, 38, 32, 35, 32, 32, 32, 33, 33, 33, 32, 34, 31, 31, 30, 34, 32, 31, 27, 32, 26, 28, 29, 28, 29, 31, 27, 29, 28, 27, 30, 25, 23, 24, 26, 22, 25, 20, 21, 21, 22, 21, 24, 21, 17, 15, 18, 18, 15, 15

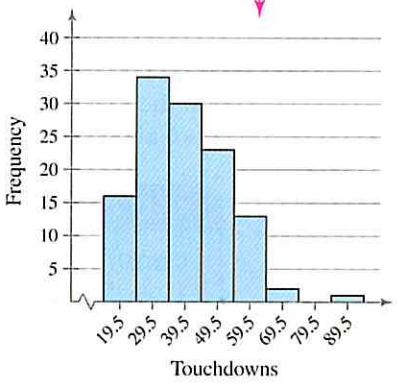
WHERE YOU'RE GOING

In Chapter 2, you will learn ways to organize and describe data sets. The goal is to make the data easier to understand by describing trends, averages, and variations. For instance, in the raw data showing the number of touchdowns scored by all NCAA Division 1A football teams, it is not easy to see any patterns or special characteristics. Here are some ways you can organize and describe the data.

Make a frequency distribution table.

Class	Frequency, f
15–24	16
25–34	34
35–44	30
45–54	23
55–64	13
65–74	2
75–84	0
85–94	1

Draw a histogram.



$$\text{Mean} = \frac{15 + 15 + 15 + 17 + 18 + \cdots + 63 + 65 + 68 + 89}{119}$$

$$= \frac{4624}{119}$$

$$\approx 38.9 \text{ touchdowns}$$

Find an average.

$$\text{Range} = 89 - 15$$

$$= 74 \text{ touchdowns}$$

Find how the data vary.

2.1 Frequency Distributions and Their Graphs

What You SHOULD LEARN

- How to construct a frequency distribution including limits, midpoints, relative frequencies, cumulative frequencies, and boundaries
- How to construct frequency histograms, frequency polygons, relative frequency histograms, and ogives

Frequency Distributions ▸ Graphs of Frequency Distributions

▸ Frequency Distributions

You will learn that there are many ways to organize and describe a data set. Important characteristics to look for when organizing and describing a data set are its **center,** its **variability** (or spread), and its **shape.** Measures of center and shapes of distributions are covered in Lesson 2.3.

When a data set has many entries, it can be difficult to see patterns. In this section, you will learn how to organize data sets by grouping the data into intervals called classes and forming a frequency distribution. You will also learn how to use frequency distributions to construct graphs.

DEFINITION

A **frequency distribution** is a table that shows **classes** or **intervals** of data entries with a count of the number of entries in each class. The **frequency** f of a class is the number of data entries in the class.

Example of a Frequency Distribution

Class	Frequency, f
1–5	5
6–10	8
11–15	6
16–20	8
21–25	5
26–30	4

In the frequency distribution shown to the left there are six classes. The frequencies for each of the six classes are 5, 8, 6, 8, 5, and 4. Each class has a **lower class limit,** which is the least number that can belong to the class, and an **upper class limit,** which is the greatest number that can belong to the class. In the frequency distribution shown, the lower class limits are 1, 6, 11, 16, 21, and 26, and the upper class limits are 5, 10, 15, 20, 25, and 30. The **class width** is the distance between lower (or upper) limits of consecutive classes. For instance, the class width in the frequency distribution shown is $6 - 1 = 5$.

The difference between the maximum and minimum data entries is called the **range.** In the frequency table shown, suppose the maximum data entry is 29, and the minimum data entry is 1. The range then is $29 - 1 = 28$. You will learn more about the range in Section 2.4.

GUIDELINES

Constructing a Frequency Distribution from a Data Set

1. Decide on the number of classes to include in the frequency distribution. The number of classes should be between 5 and 20; otherwise, it may be difficult to detect any patterns.
2. Find the class width as follows. Determine the range of the data, divide the range by the number of classes, and *round up to the next convenient number.*
3. Find the class limits. You can use the minimum data entry as the lower limit of the first class. To find the remaining lower limits, add the class width to the lower limit of the preceding class. Then find the upper limit of the first class. Remember that classes cannot overlap. Find the remaining upper class limits.
4. Make a tally mark for each data entry in the row of the appropriate class.
5. Count the tally marks to find the total frequency f for each class.

Study Tip

In a frequency distribution, it is best if each class has the same width. Answers shown will use the minimum data value for the lower limit of the first class. Sometimes it may be more convenient to choose a value that is slightly lower than the minimum value. The frequency distribution produced will vary slightly.

EXAMPLE 1

Constructing a Frequency Distribution from a Data Set

The following sample data set lists the number of minutes 50 Internet subscribers spent on the Internet during their most recent session. Construct a frequency distribution that has seven classes.

50	40	41	17	11	7	22	44	28	21	19	23	37	51	54	42	86
41	78	56	72	56	17	7	69	30	80	56	29	33	46	31	39	20
18	29	34	59	73	77	36	39	30	62	54	67	39	31	53	44	

Solution

1. The number of classes (7) is stated in the problem.
2. The minimum data entry is 7 and the maximum data entry is 86, so the range is $86 - 7 = 79$. Divide the range by the number of classes and round up to find the class width.

$$\text{Class width} = \frac{79}{7} \qquad \frac{\text{Range}}{\text{Number of classes}}$$

$$\approx 11.29 \qquad \text{Round up to 12.}$$

3. The minimum data entry is a convenient lower limit for the first class. To find the lower limits of the remaining six classes, add the class width of 12 to the lower limit of each previous class. The upper limit of the first class is 18, which is one less than the lower limit of the second class. The upper limits of the other classes are $18 + 12 = 30$, $30 + 12 = 42$, and so on. The lower and upper limits for all seven classes are shown.

Lower limit	Upper limit
7	18
19	30
31	42
43	54
55	66
67	78
79	90

4. Make a tally mark for each data entry in the appropriate class. For example, the data entry 51 is in the 43–54 class, so make a tally mark in that class. Continue until you have made a tally mark for each of the 50 data entries.
5. The number of tally marks for a class is the frequency for that class.

The frequency distribution is shown in the following table. The first class, 7–18, has six tally marks. So, the frequency for this class is 6. Notice that the sum of the frequencies is 50, which is the number of entries in the sample data set. The sum is denoted by Σf, where Σ is the uppercase Greek letter **sigma.**

Frequency Distribution for Internet Usage (in minutes)

Minutes online

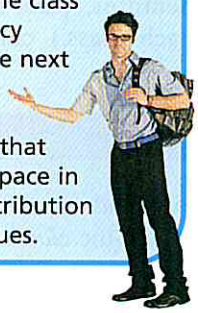
Number of subscribers

Class	Tally	Frequency, f
7–18	𝍸 |	6
19–30	𝍸 𝍸	10
31–42	𝍸 𝍸 |||	13
43–54	𝍸 |||	8
55–66	𝍸	5
67–78	𝍸 |	6
79–90	||	2
		$\Sigma f = 50$

Check that the sum of the frequencies equals the number in the sample.

Insight

If you obtain a whole number when calculating the class width of a frequency distribution, use the next whole number as the class width. Doing this ensures that you have enough space in your frequency distribution for all the data values.



Study Tip

The uppercase Greek letter sigma (Σ) is used throughout statistics to indicate a summation of values.

Try It Yourself 1

Construct a frequency distribution using the number of touchdowns data set listed in the Chapter Opener on page 39. Use eight classes.

a. State the *number of classes*.
b. Find the minimum and maximum values and the *class width*.
c. Find the *class limits*.
d. *Tally* the data entries.
e. Write the *frequency f* for each class.

Answer: Page A32

After constructing a standard frequency distribution such as the one in Example 1, you can include several additional features that will help provide a better understanding of the data. These features, (the midpoint, relative frequency, and cumulative frequency of each class,) can be included as additional columns in your table.

DEFINITION

The **midpoint** of a class is the sum of the lower and upper limits of the class divided by two. The midpoint is sometimes called the *class mark*.

$$\text{Midpoint} = \frac{(\text{Lower class limit}) + (\text{Upper class limit})}{2}$$

The **relative frequency** of a class is the portion or percentage of the data that falls in that class. To find the relative frequency of a class, divide the frequency f by the sample size n.

$$\text{Relative frequency} = \frac{\text{Class frequency}}{\text{Sample size}} = \frac{f}{n}$$

The **cumulative frequency** of a class is the sum of the frequency for that class and all previous classes. The cumulative frequency of the last class is equal to the sample size n.

After finding the first midpoint, you can find the remaining midpoints by adding the class width to the previous midpoint. For instance, if the first midpoint is 12.5 and the class width is 12, then the remaining midpoints are

$12.5 + 12 = 24.5$
$24.5 + 12 = 36.5$
$36.5 + 12 = 48.5$
$48.5 + 12 = 60.5$

and so on.

You can write the relative frequency as a fraction, decimal, or percent. The sum of the relative frequencies of all the classes must equal 1, or 100%.

EXAMPLE 2

Finding Midpoints, Relative Frequencies, and Cumulative Frequencies

Using the frequency distribution constructed in Example 1, find the midpoint, relative frequency, and cumulative frequency for each class. Identify any patterns.

Solution The midpoint, relative frequency, and cumulative frequency for the first three classes are calculated as follows.

Class	f	Midpoint	Relative frequency	Cumulative frequency
7–18	6	$\frac{7 + 18}{2} = 12.5$	$\frac{6}{50} = 0.12$	6
19–30	10	$\frac{19 + 30}{2} = 24.5$	$\frac{10}{50} = 0.2$	$6 + 10 = 16$
31–42	13	$\frac{31 + 42}{2} = 36.5$	$\frac{13}{50} = 0.26$	$16 + 13 = 29$

The remaining midpoints, relative frequencies, and cumulative frequencies are shown in the following expanded frequency distribution.

Frequency Distribution for Internet Usage (in minutes)

Minutes online → Class

Number of subscribers → Frequency, f

Portion of subscribers → Relative frequency, Cumulative frequency

Class	Frequency, f	Midpoint	Relative frequency	Cumulative frequency
7–18	6	12.5	0.12	6
19–30	10	24.5	0.2	16
31–42	13	36.5	0.26	29
43–54	8	48.5	0.16	37
55–66	5	60.5	0.1	42
67–78	6	72.5	0.12	48
79–90	2	84.5	0.04	50
	$\Sigma f = 50$		$\Sigma \frac{f}{n} = 1$	

Interpretation There are several patterns in the data set. For instance, the most common time span that users spent online was 31 to 42 minutes.

Try It Yourself 2

Using the frequency distribution constructed in Try It Yourself 1, find the midpoint, relative frequency, and cumulative frequency for each class. Identify any patterns.

a. Use the formulas to find each *midpoint*, *relative frequency*, and *cumulative frequency*.
b. *Organize* your results in a frequency distribution.
c. *Identify* patterns that emerge from the data.

Answer: Page A32

Graphs of Frequency Distributions

Sometimes it is easier to identify patterns of a data set by looking at a graph of the frequency distribution. One such graph is a frequency histogram.

DEFINITION

A **frequency histogram** is a bar graph that represents the frequency distribution of a data set. A histogram has the following properties.

1. The horizontal scale is quantitative and measures the data values.
2. The vertical scale measures the frequencies of the classes.
3. Consecutive bars must touch.

Study Tip

If data entries are integers, subtract 0.5 from each lower limit to find the lower class boundaries. To find the upper class boundaries, add 0.5 to each upper limit. The upper boundary of a class will equal the lower boundary of the next higher class.

Because consecutive bars of a histogram must touch, bars must begin and end at class boundaries instead of class limits. **Class boundaries** are the numbers that separate classes *without* forming gaps between them. You can mark the horizontal scale either at the midpoints or at the class boundaries, as shown in Example 3.

EXAMPLE 3

Constructing a Frequency Histogram

Draw a frequency histogram for the frequency distribution in Example 2. Describe any patterns.

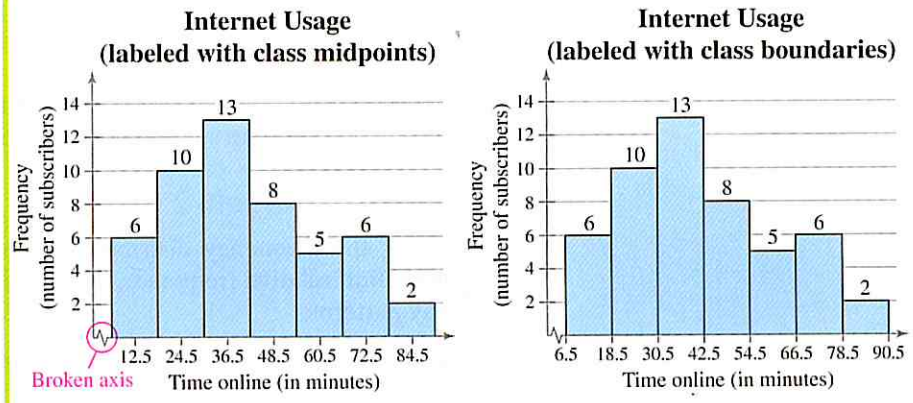
Class	Class boundaries	Frequency, f
7–18	6.5–18.5	6
19–30	18.5–30.5	10
31–42	30.5–42.5	13
43–54	42.5–54.5	8
55–66	54.5–66.5	5
67–78	66.5–78.5	6
79–90	78.5–90.5	2

Solution First, find the class boundaries. The distance from the upper limit of the first class to the lower limit of the second class is $19 - 18 = 1$. Half this distance is 0.5. So, the lower and upper boundaries of the first class are as follows:

First class lower boundary $= 7 - 0.5 = 6.5$

First class upper boundary $= 18 + 0.5 = 18.5$

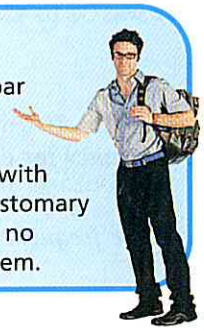
The boundaries of the remaining classes are shown in the table. Using the class midpoints or class boundaries for the horizontal scale and choosing possible frequency values for the vertical scale, you can construct the histogram.



Interpretation From either histogram, you can see that more than half of the subscribers spent between 19 and 54 minutes on the Internet during their most recent session.

Insight

It is customary in bar graphs to have spaces between the bars, whereas with histograms, it is customary that the bars have no spaces between them.



Try It Yourself 3

Use the frequency distribution from Try It Yourself 1 to construct a frequency histogram that represents the number of touchdowns scored by all Division 1A football teams. Describe any patterns.

a. Find the *class boundaries*.
b. Choose appropriate *horizontal and vertical scales*.
c. Use the frequency distribution to *find the height of each bar*.
d. *Describe* any patterns for the data.

Answer: Page A33

Another way to graph a frequency distribution is to use a frequency polygon. A **frequency polygon** is a line graph that emphasizes the continuous change in frequencies.

Study Tip

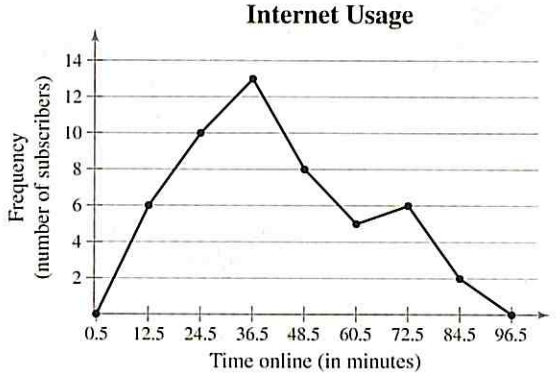
A histogram and its corresponding frequency polygon are often drawn together. If you have not already constructed the histogram, begin constructing the frequency polygon by choosing appropriate horizontal and vertical scales. The horizontal scale should consist of the class midpoints, and the vertical scale should consist of appropriate frequency values.

EXAMPLE 4

Constructing a Frequency Polygon

Draw a frequency polygon for the frequency distribution in Example 2.

Solution To construct the frequency polygon, use the same horizontal and vertical scales that were used in the histogram labeled with class midpoints in Example 3. Then plot points that represent the midpoint and frequency of each class and connect the points in order from left to right. Because the graph should begin and end on the horizontal axis, extend the left side to one class width before the first class midpoint and extend the right side to one class width after the last class midpoint.



Interpretation You can see that the frequency of subscribers increases up to 36.5 minutes and then decreases.

Try It Yourself 4

Use the frequency distribution from Try It Yourself 1 to construct a frequency polygon that represents the number of touchdowns scored by all Division 1A football teams. Describe any patterns.

a. Choose appropriate *horizontal* and *vertical scales*.
b. *Plot points* that represent the midpoint and frequency for each class.
c. *Connect the points* and extend the sides as necessary.
d. *Describe* any patterns for the data.

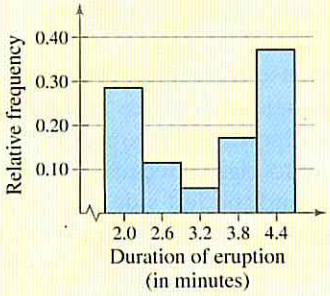
Answer: Page A33

A **relative frequency histogram** has the same shape and the same horizontal scale as the corresponding frequency histogram. The difference is that the vertical scale measures the *relative* frequencies, not frequencies.

PICTURING the WORLD

Old Faithful, a geyser at Yellowstone National Park, erupts on a regular basis. The time spans of a sample of eruptions are given in the relative frequency histogram.
(Source: Yellowstone National Park)

Old Faithful Eruptions



Fifty percent of the eruptions last less than how many minutes?

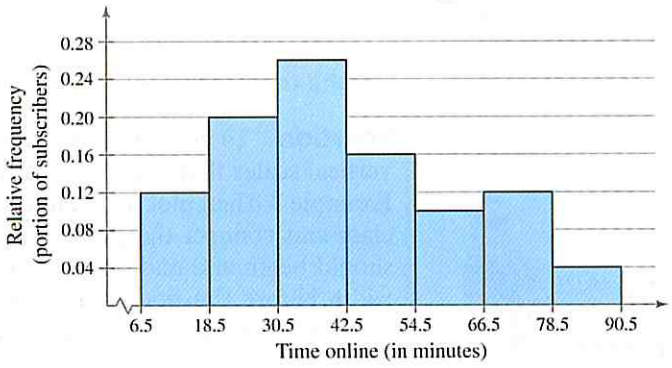
EXAMPLE 5

Constructing a Relative Frequency Histogram

Draw a relative frequency histogram for the frequency distribution in Example 2.

Solution The relative frequency histogram is shown. Notice that the shape of the histogram is the same as the shape of the frequency histogram constructed in Example 3. The only difference is that the vertical scale measures the relative frequencies.

Internet Usage



Interpretation From this graph, one piece of information you can quickly see is that 0.20 or 20% of the Internet subscribers spent between 18.5 minutes and 30.5 minutes online, which is not as immediately obvious from the frequency histogram.

Try It Yourself 5

Use the frequency distribution from Try It Yourself 1 to construct a relative frequency histogram that represents the number of touchdowns scored by all Division 1A football teams.

a. *Use the same horizontal scale* as used in the frequency histogram.
b. *Revise the vertical scale* to reflect relative frequencies.
c. Use the relative frequencies to *find the height of each bar.*

Answer: Page A33

If you want to describe the number of data entries that are equal to or below a certain value, you can easily do so by constructing a cumulative frequency graph.

DEFINITION

A **cumulative frequency graph,** or **ogive** (pronounced ō′jīve), is a line graph that displays the cumulative frequency of each class at its upper class boundary. The upper boundaries are marked on the horizontal axis, and the cumulative frequencies are marked on the vertical axis.

GUIDELINES

Constructing an Ogive (Cumulative Frequency Graph)

1. Construct a frequency distribution that includes cumulative frequencies as one of the columns.
2. Specify the horizontal and vertical scales. The horizontal scale consists of upper class boundaries, and the vertical scale measures cumulative frequencies.
3. Plot points that represent the upper class boundaries and their corresponding cumulative frequencies.
4. Connect the points in order from left to right.
5. The graph should start at the lower boundary of the first class (cumulative frequency is zero) and should end at the upper boundary of the last class (cumulative frequency is equal to the sample size).

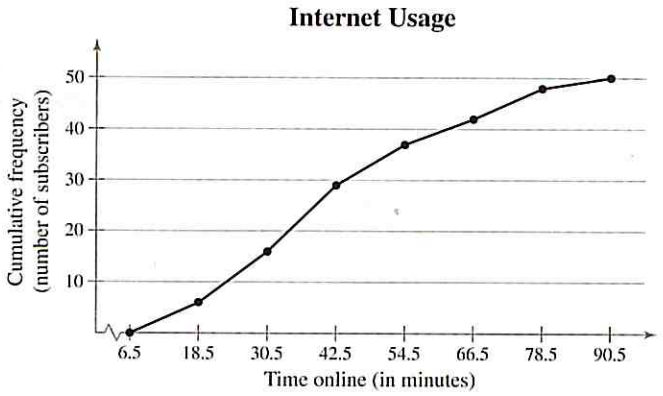
EXAMPLE 6

Constructing an Ogive

Draw an ogive for the frequency distribution in Example 2. Estimate how many subscribers spent 60 minutes or less online during their last session. Also, use the graph to estimate when the greatest increase in usage occurs.

Upper class boundary	f	Cumulative frequency
18.5	6	6
30.5	10	16
42.5	13	29
54.5	8	37
66.5	5	42
78.5	6	48
90.5	2	50

Solution Using the cumulative frequency distribution, you can construct the ogive shown. The upper class boundaries, frequencies, and cumulative frequencies are shown in the table. Notice that the graph starts at 6.5, where the cumulative frequency is 0, and the graph ends at 90.5, where the cumulative frequency is 50.



Interpretation From the ogive, you can see that about 40 subscribers spent 60 minutes or less online during their last session. It is evident that the greatest increase in usage occurs between 30.5 minutes and 42.5 minutes, as the line segment is steepest between these two class boundaries.

Another type of ogive uses percent as the vertical axis instead of frequency (see Example 5 in Section 2.5).

Try It Yourself 6

Use the frequency distribution from Try It Yourself 1 to construct an ogive that represents the number of touchdowns scored by all Division 1A football teams. Estimate the number of teams who scored 44 or fewer touchdowns.

a. Specify the *horizontal* and *vertical scales*.
b. *Plot* the points given by the upper class boundaries and the cumulative frequencies.
c. *Construct* the graph.
d. *Estimate* the number of teams who scored 44 or fewer touchdowns.
e. *Interpret* the results in the context of the data.

Answer: Page A33

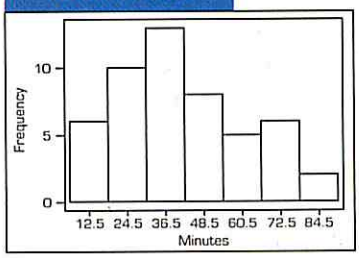
EXAMPLE 7

Using Technology to Construct Histograms

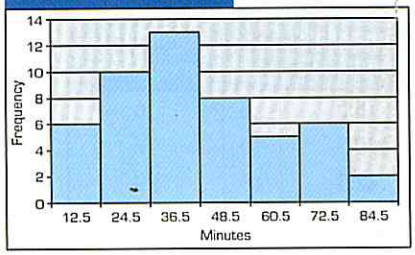
Use a calculator or a computer to construct a histogram for the frequency distribution in Example 2.

Solution MINITAB, Excel, and the TI-83/84 each have features for graphing histograms. Try using this technology to draw the histograms as shown.

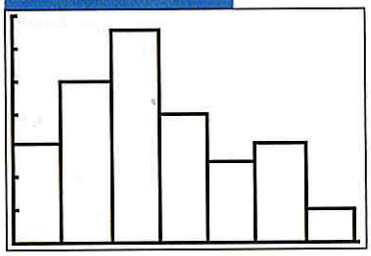
MINITAB



EXCEL



TI-83/84



Study Tip

Detailed instructions for using MINITAB, Excel, and the TI-83/84 are shown in the Technology Guide that accompanies this text. For instance, here are instructions for creating a histogram on a TI-83/84.

STAT ENTER

Enter midpoints in L1.
Enter frequencies in L2.

2nd STATPLOT

Turn on Plot 1.
Highlight Histogram.

Xlist: L1
Freq: L2

ZOOM 9
WINDOW

Xscl=12
GRAPH

Try It Yourself 7

Use a calculator or a computer to construct a frequency histogram that represents the number of touchdowns scored by all Division 1A football teams listed in the Chapter Opener on page 39. Use eight classes.

a. *Enter* the data.
b. *Construct* the histogram.

Answer: Page A33

2.1 EXERCISES

Building Basic Skills and Vocabulary

1. What are some benefits of representing data sets using frequency distributions?
2. What are some benefits of representing data sets using graphs of frequency distributions?
3. What is the difference between class limits and class boundaries?
4. What is the difference between relative frequency and cumulative frequency?

True or False? *In Exercises 5–8, determine whether the statement is true or false. If it is false, rewrite it as a true statement.*

5. In a frequency distribution, the class width is the distance between the lower and upper limits of a class.
6. The midpoint of a class is the sum of its lower and upper limits divided by two.
7. An ogive is a graph that displays relative frequency.
8. Class boundaries are used to ensure that consecutive bars of a histogram touch.

In Exercises 9–12, use the given minimum and maximum data entries, and the number of classes to find the class width, the lower class limits, and the upper class limits.

9. minimum = 7, maximum = 58, 6 classes
10. minimum = 11, maximum = 94, 8 classes
11. minimum = 15, maximum = 123, 6 classes
12. minimum = 24, maximum = 171, 10 classes

Reading a Frequency Distribution *In Exercises 13 and 14, use the given frequency distribution to find the*

(a) class width.

(b) class midpoints.

(c) class boundaries.

13. **Cleveland, OH High Temperatures (°F)**

Class	Frequency, f
20–30	19
31–41	43
42–52	68
53–63	69
64–74	74
75–85	68
86–96	24

14. **Travel Time to Work (in minutes)**

Class	Frequency, f
0–9	188
10–19	372
20–29	264
30–39	205
40–49	83
50–59	76
60–69	32

15. Use the frequency distribution in Exercise 13 to construct an expanded frequency distribution, as shown in Example 2.

16. Use the frequency distribution in Exercise 14 to construct an expanded frequency distribution, as shown in Example 2.

Graphical Analysis *In Exercises 17 and 18, use the frequency histogram to*

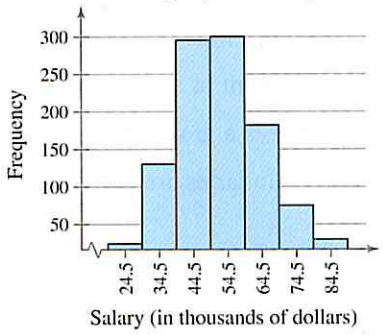
(a) determine the number of classes.

(b) estimate the frequency of the class with the least frequency.

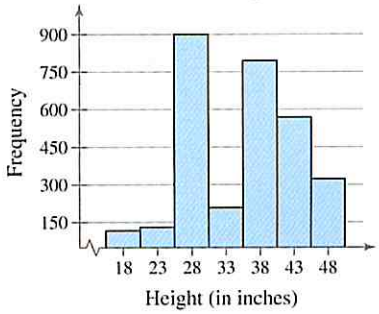
(c) estimate the frequency of the class with the greatest frequency.

(d) determine the class width.

17.



18.

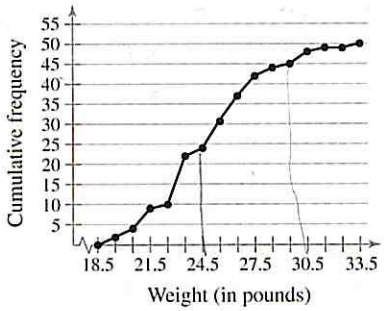


Graphical Analysis *In Exercises 19 and 20, use the ogive to approximate*

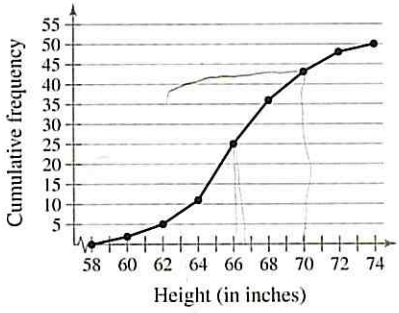
(a) the number in the sample.

(b) the location of the greatest increase in frequency.

19.



20.



21. Use the ogive in Exercise 19 to approximate

(a) the cumulative frequency for a weight of 24.5 pounds.

(b) the weight for which the cumulative frequency is 45.

22. Use the ogive in Exercise 20 to approximate

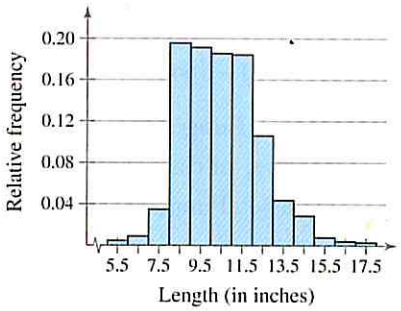
(a) the cumulative frequency for a height of 70 inches.

(b) the height for which the cumulative frequency is 25.

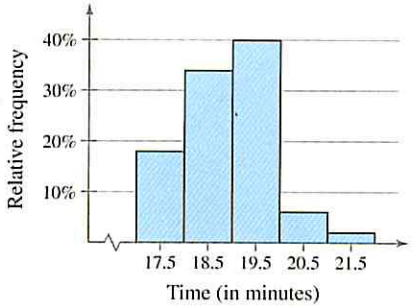
Graphical Analysis *In Exercises 23 and 24, use the relative frequency histogram to*

(a) identify the class with the greatest and the least relative frequency.
(b) approximate the greatest and least relative frequency.
(c) approximate the relative frequency of the second class.

23. **Atlantic Croaker Fish**

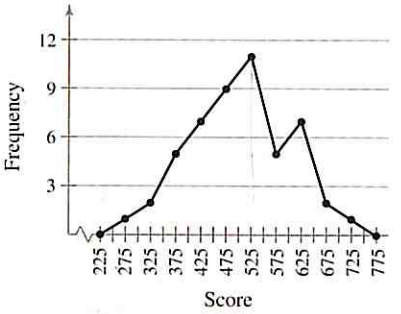


24. **Emergency Response Time**

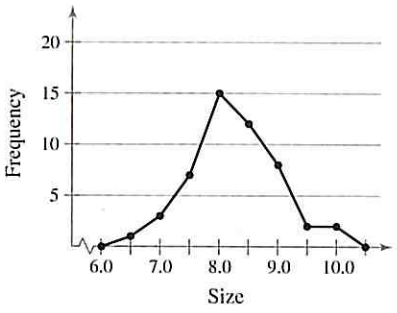


Graphical Analysis *In Exercises 25 and 26, use the frequency polygon to identify the class with the greatest and the least frequency.*

25. **SAT Scores for 50 Students**



26. **Shoe Sizes for 50 Females**



Using and Interpreting Concepts

Constructing a Frequency Distribution *In Exercises 27 and 28, construct a frequency distribution for the data set using the indicated number of classes. In the table, include the midpoints, relative frequencies, and cumulative frequencies. Which class has the greatest frequency and which has the least frequency?*

27. Newspaper Reading Times

Number of classes: 5

Data set: Time (in minutes) spent reading the newspaper in a day

7	39	13	9	25	8	22	0	2	18	2	30	7
35	12	15	8	6	5	29	0	11	39	16	15	

28. Book Spending

Number of classes: 6

Data set: Amount (in dollars) spent on books for a semester

91	472	279	249	530	376	188	341	266	199
142	273	189	130	489	266	248	101	375	486
190	398	188	269	43	30	127	354	84	

indicates that the data set for this exercise is available electronically.

Constructing a Frequency Distribution and a Frequency Histogram

In Exercises 29–32, construct a frequency distribution and a frequency histogram for the data set using the indicated number of classes. Describe any patterns.

29. Sales

Number of classes: 6

Data set: July sales (in dollars) for all sales representatives at a company

2114	2468	7119	1876	4105	3183	1932	1355
4278	1030	2000	1077	5835	1512	1697	2478
3981	1643	1858	1500	4608	1000		

30. Pepper Pungencies

Number of classes: 5

Data set: Pungencies (in 1000s of Scoville units) of 24 tabasco peppers

35	51	44	42	37	38	36	39	44	43	40	40
32	39	41	38	42	39	40	46	37	35	41	39

31. Reaction Times

Number of classes: 8

Data set: Reaction times (in milliseconds) of a sample of 30 adult females to an auditory stimulus

507	389	305	291	336	310	514	442	307	337
373	428	387	454	323	441	388	426	469	351
411	382	320	450	309	416	359	388	422	413

32. Fracture Times

Number of classes: 5

Data set: Amount of pressure (in pounds per square inch) at fracture time for 25 samples of brick mortar

2750	2862	2885	2490	2512	2456	2554	2532	2885
2872	2601	2877	2721	2692	2888	2755	2853	2517
2867	2718	2641	2834	2466	2596	2519		

Constructing a Frequency Distribution and a Relative Frequency Histogram

In Exercises 33–36, construct a frequency distribution and a relative frequency histogram for the data set using five classes. Which class has the greatest relative frequency and which has the least relative frequency?

33. Bowling Scores

Data set: Bowling scores of a sample of league members

154	257	195	220	182	240	177	228	235
146	174	192	165	207	185	180	264	169
225	239	148	190	182	205	148	188	

34. ATM Withdrawals

Data set: A sample of ATM withdrawals (in dollars)

35	10	30	25	75	10	30	20	20	10	40
50	40	30	60	70	25	40	10	60	20	80
40	25	20	10	20	25	30	50	80	20	

35. Plant Heights

Data set: Heights (in inches) of a sample of tomato plants

40	44	35	49	35	43	35	36	39
37	41	41	48	52	37	45	40	36
35	50	42	51	33	34	51	39	

36. Years of Service

Data set: Years of service of a sample of New York state troopers

12	7	9	8	9	8	12	10	9
10	6	8	13	12	10	11	7	14
12	9	8	10	9	11	13	8	

Constructing a Cumulative Frequency Distribution and an Ogive

In Exercises 37–40, construct a cumulative frequency distribution and an ogive for the data set using six classes. Then describe the location of the greatest increase in frequency.

37. Retirement Ages

Data set: Retirement ages for a sample of doctors

70	54	55	71	57	58	63	65
60	66	57	62	63	60	63	60
66	60	67	69	69	52	61	73

38. Saturated Fat Intakes

Data set: Daily saturated fat intakes (in grams) of a sample of people

38	32	34	39	40	54	32	17	29	33
57	40	25	36	33	24	42	16	31	33

39. Gasoline Purchases

Data set: Gasoline (in gallons) purchased by a sample of drivers during one fill-up

7	4	18	4	9	8	8	7	6	2
9	5	9	12	4	14	15	7	10	2
3	11	4	4	9	12	5	3		

40. Cellular Phone Calls

Data set: Lengths (in minutes) of a sample of cellular phone calls

1	20	10	20	13	23	3	7
18	7	4	5	15	7	29	10
18	10	10	23	4	12	8	6

Constructing a Frequency Distribution and a Frequency Polygon

In Exercises 41 and 42, construct a frequency distribution and a frequency polygon for the data set. Describe any patterns.

41. Exam Scores

Number of classes: 5

Data set: Exam scores for all students in a statistics class

83	92	94	82	73	98	78	85	72	90
89	92	96	89	75	85	63	47	75	82

42. Children of the Presidents

Number of classes: 6

Data set: Number of children of the U.S. presidents *(Source: presidentschildren.com)*

0	5	6	0	3	4	0	4	10	15	0	6	2	3
0	4	5	4	8	7	3	5	3	2	6	3	3	1
2	2	6	1	2	3	2	2	4	4	4	6	1	2

Extending Concepts

43. What Would You Do? You work at a bank and are asked to recommend the amount of cash to put in an ATM each day. You don't want to put in too much (security) or too little (customer irritation). Here are the daily withdrawals (in 100s of dollars) for a period of 30 days.

72	84	61	76	104	76	86	92	80	88
98	76	97	82	84	67	70	81	82	89
74	73	86	81	85	78	82	80	91	83

(a) Construct a relative frequency histogram for the data using eight classes.

(b) If you put $9000 in the ATM each day, what percent of the days in a month should you expect to run out of cash? Explain your reasoning.

(c) If you are willing to run out of cash for 10% of the days, how much cash, in hundreds of dollars, should you put in the ATM each day? Explain your reasoning.

44. What Would You Do? You work in the admissions department for a college and are asked to recommend the minimum SAT scores that the college will accept for a position as a full-time student. Here are the SAT scores for a sample of 50 applicants.

1325	1072	982	996	872	849	785	706	669	1049
885	1367	935	980	1188	869	1006	1127	979	1034
1052	1165	1359	667	1264	727	808	955	544	1202
1051	1173	410	1148	1195	1141	1193	768	812	887
1211	1266	830	672	917	988	791	1035	688	700

(a) Construct a relative frequency histogram for the data using 10 classes.

(b) If you set the minimum score at 986, what percent of the applicants will meet this requirement? Explain your reasoning.

(c) If you want to accept the top 88% of the applicants, what should the minimum score be? Explain your reasoning.

45. Writing What happens when the number of classes is increased for a frequency histogram? Use the data set listed and a technology tool to create frequency histograms with 5, 10, and 20 classes. Which graph displays the data best?

2	7	3	2	11	3	15	8	4	9	10	13	9
7	11	10	1	2	12	5	6	4	2	9	15	