Organizing Data Graphical and Tabular

Descriptive Techniques

1. Numerical/Quantitative Data
2. Qualitative/Categorical Data
3. Graphical Presentation of Qualitative Data
4. Organizing and Graphing Quantitative Data
5. Frequency Distributions
6. Process of Constructing a Frequency Table
7. Graphing Grouped Data
8. Ogive
9. Stem-and-Leaf Displays

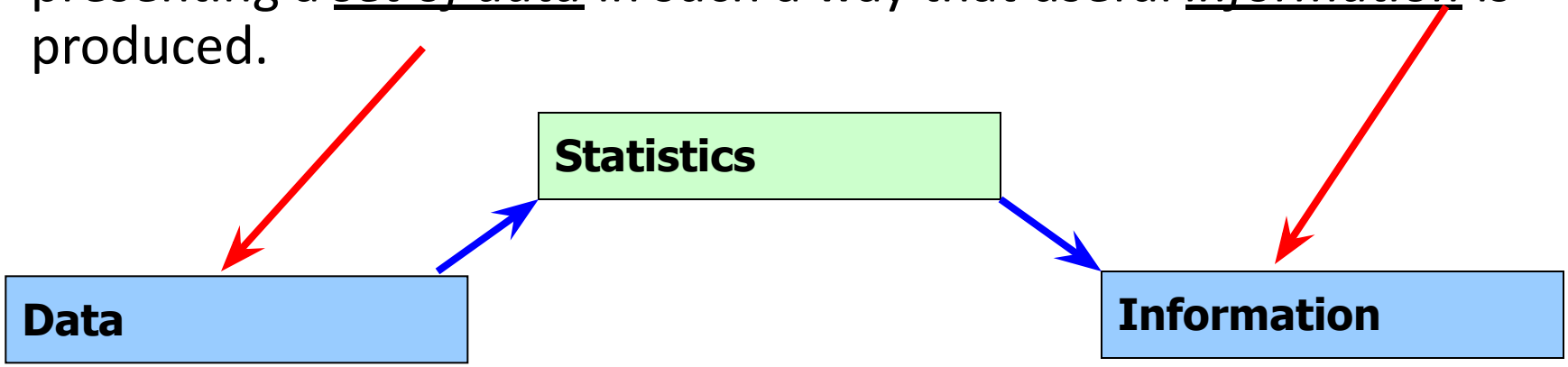
Learning Objectives

Overall: To give students a basic understanding of best way of presentation of data

Specific: Students will be able to

- Understand Types of data
- Draw Tables
- Draw Graphs
- Make Frequency distribution…….

- **Descriptive statistics** involves arranging, summarizing, and presenting a *set of data* in such a way that useful *information* is produced.



- Descriptive statistics make use of graphical techniques and numerical techniques (such as averages) to summarize and present the data.

DATA MINING

- Most companies routinely collect data – at the cash register for each purchase, on the factory floor from each step of production, or on the Internet from each visit to its website – resulting in huge databases containing potentially useful information about how to increase sales, how to improve production, or how to turn mouse clicks into purchases.

- **DATA MINING** is a collection of methods for obtaining useful knowledge by analyzing large amounts of data, often by searching for hidden patterns. Once a business has collected information for some purpose, it would be wasteful to leave it unexplored when it might be useful in many other ways. The goal of data mining is to obtain value from these vast stores of data, in order to improve the company with higher sales, lower costs, and better products. Here are just a few of the many areas of business in which data mining can be helpful:

1. **Marketing and sales**: companies have lots of information about past contacts with potential customers and their results. These data can be mined for guidance on how (and when) to better reach customers in the future. One example is the difficult decision of when a store should reduce prices: reduce too soon and you lose money (on items that might have been sold for more); reduce too late and you may be stuck (with items no longer in season).

- **Finance**: Mining of financial data can be useful in forming and evaluating investment strategies and in hedging (or reducing) risk. In the stock markets alone, there are many companies: about 3,298 listed on the New York Stock Exchange and about 2,942 companies listed on the NASDAQ Stock Market. Historical information on price and volume (number of shares traded) is easily available to anyone interested in exploring investment strategies.

- Statistical methods, such as hypothesis testing, are helpful as part of data mining distinguish random from systematic behavior because stock that performed well last year will not necessarily perform well next year. Imagine that you toss 100 coins six times each and then carefully choose the one that came up “heads” all six times – this coin is not as special as it might seem!

3. Product design: What particular combinations of features are customers ordering in larger-than-expected quantities? The answers could help you create products to appeal to a group of potential customers who would not take the trouble to place special orders.

- 4. **Production**

  Imagine a factory running 24/7 with thousands of partially completed units, each with its bar code, being carefully tracked by the computer system, with efficiency and quality being recorder as well. This is a tremendous source of information that can tell you about the kinds of situations that cause trouble (such as finding a machine that needs adjustment by noticing clusters of units that don't work) or the kinds of situations that lead to extra-fast production of the highest quality.

5. Fraud detections:

- Fraud can affect many areas of business, including consumer finance, insurance, and networks (including telephone and the Internet). One of the best methods of protection involves mining data to distinguish between ordinary and fraudulent patterns of usage, then using the results to classify new transactions, and looking carefully at suspicious new occurrences to decide where or not fraud is actually involved.

- YOU once received a telephone call from your credit card company asking you to verify recent transactions – identified by its statistical analysis – that departed from your typical pattern of spending. One fraud risk identification system that helps detect fraudulent use of credit card is Falcon Fraud Manager from Fair Isaac, which uses the flexible “neural network” data-mining technique

- Data mining is a large task that involves combining resources from many fields. Here is how statistics, computer science, and optimization are used in data mining.

- ***Statistics***: All of the basic activities of statistics are involved: a design for collecting the data, exploring for patterns, a modeling framework, estimation of features, and hypothesis testing to assess significance of patterns as a “reality check” on the results. Nearly every method in the rest of this lectures has the potential to be useful in data mining, depending on the database and the needs of the company.

- Some specialized statistical methods are particularly useful, including *classification analysis* (also called *discriminant analysis*) to assign a new case to a category (such as “likely purchaser” or “fraudulent”), *cluster analysis* to identify homogeneous group of individuals, and *prediction analysis* (also called *regression analysis*).

- ***Computer science***: Efficient algorithms (computer instructions) are needed for collecting, maintaining, organizing, and analyzing data. Creative methods involving *artificial intelligence* are useful, including *machine learning* techniques for prediction analysis such as *neural networks* and *boosting*, to learn from the data by identifying useful patterns automatically. Some of these methods from computer science are closely related to statistical prediction analysis.

- ***Optimization:***
- These methods help you achieve a goal, which might be very specific such as maximizing profits, lowering production cost, finding new customers, developing profitable new product models, or increasing sales volume.

- Alternatively, the goal might be more vague such as obtaining a better understanding of the different types of customers you serve, characterizing the differences in production quality that occur under different circumstances, or identifying relationships that occur more or less consistently throughout the data. Optimization is often accomplished by *adjusting the parameters of a model* until the objective is achieved.

WHAT IS PROBABILITY?

- Probability is a what if tool for understanding risk and uncertainty. **Probability** shows you the likelihood, or chances, for each of the various potential future events, based on a set of assumptions about how the world works. For example, you might assume that you know basically how the world works (i.e., all of the details of process that will produce success or failure or payoffs in between). Probabilities of various outcomes would then be computed for each of several strategies to indicate how successful each strategy would be.

- You might learn, for example, that an international project has only an 8% chance of success (i.e. the probability of success is 0.08), but if you assume that the government can keep inflation low, then the chance of success rises to 35% - still very risky, but a much better situation than the 8% chance. Probability will not tell you whether to invest in the project, but it will help you keep your eyes open to the realities of the situation.

Here are additional examples of situations where finding the appropriate answer requires computing or estimating a probability number:

1. Given the nature of an investment portfolio and a set of assumptions that describe how financial markets work, what are the chances that you will profit over a one-year horizon?
2. What are the chances of rain tomorrow? What are the chances that next winter will be cold enough so that your heating-oil business will make a profit?

3. What are the chances that a foreign country (where you have a manufacturing plant) will become involved in civil war over the next two years?
4. What are the chances that the college student you just interviewed for a job will become a valued employee over the coming months?

- Probability is the inverse of statistics. Whereas statistics helps you go from observed data to generalizations about how the world works, probability goes the other direction: if you assume you know how the world works, then you can figure out what kinds of data you are likely to see and the likelihood for each.

$$\left(\textit{How the world works}\right) \xrightarrow{\textit{PROBABILITY}} \left(\textit{What is likely to happen}\right)$$

$$\left(\textit{What happened}\right) \xrightarrow{\textit{STATISTICAL INFERENCE}} \left(\textit{How the word works}\right)$$

- Probability also works together with statistics by providing a solid foundation for statistical inference. When there is uncertainty, you cannot know exactly what will happen, and there is some chance of error. Using probability, you will learn ways to control the error rate so that it is, say, less than 5% or less than 1% of the time.

Definitions…

- A **variable** **[Typically called a "random" variable since we do not know it's value until we observe it]** is some characteristic of a population or sample.
- E.g. student grades, weight of a potato, # heads in 10 flips of a coin, etc.
- Typically denoted with a capital letter: X, Y, Z…
- The **values** of the variable are the range of possible values for a variable.
- E.g. student marks (0..100)
- **Data** are the ***observed values*** of a random variable.
- E.g. student marks: {67, 74, 71, 83, 93, 55, 48}

We Deal with “2” Types of Data

- **Numerical/Quantitative Data** [Real Numbers]:
- * height
- * weight
- * temperature
- **Qualitative/Categorical Data** [Labels rather than numbers]:
- * favorite color
- * Gender
- * SES

Quantitative/Numerical Data…

- Quantitative Data is further broken down into

Continuous Data – Data can be any real number within a given range. Normally measurement data [weights, Age, Prices, etc]

Discrete Data – Data can only be very specific values which we can list. Normally count data [# of firecrackers in a package of 100 that fail to pop, # of accidents on the UTA campus each week, etc]

Qualitative/Categorical Data

- **Nominal Data** [has no natural order to the values].
- E.g. responses to questions about marital status: Single = 1, Married = 2, Divorced = 3, Widowed = 4
- Arithmetic operations don't make any sense (e.g. does Widowed ÷ 2 = Married?!)
- **Ordinal Data** [values have a natural ***order***]:
- E.g. College course rating system: poor = 1, fair = 2, good = 3, very good = 4, excellent = 5

Graphical & Tabular Techniques for Nominal Data…

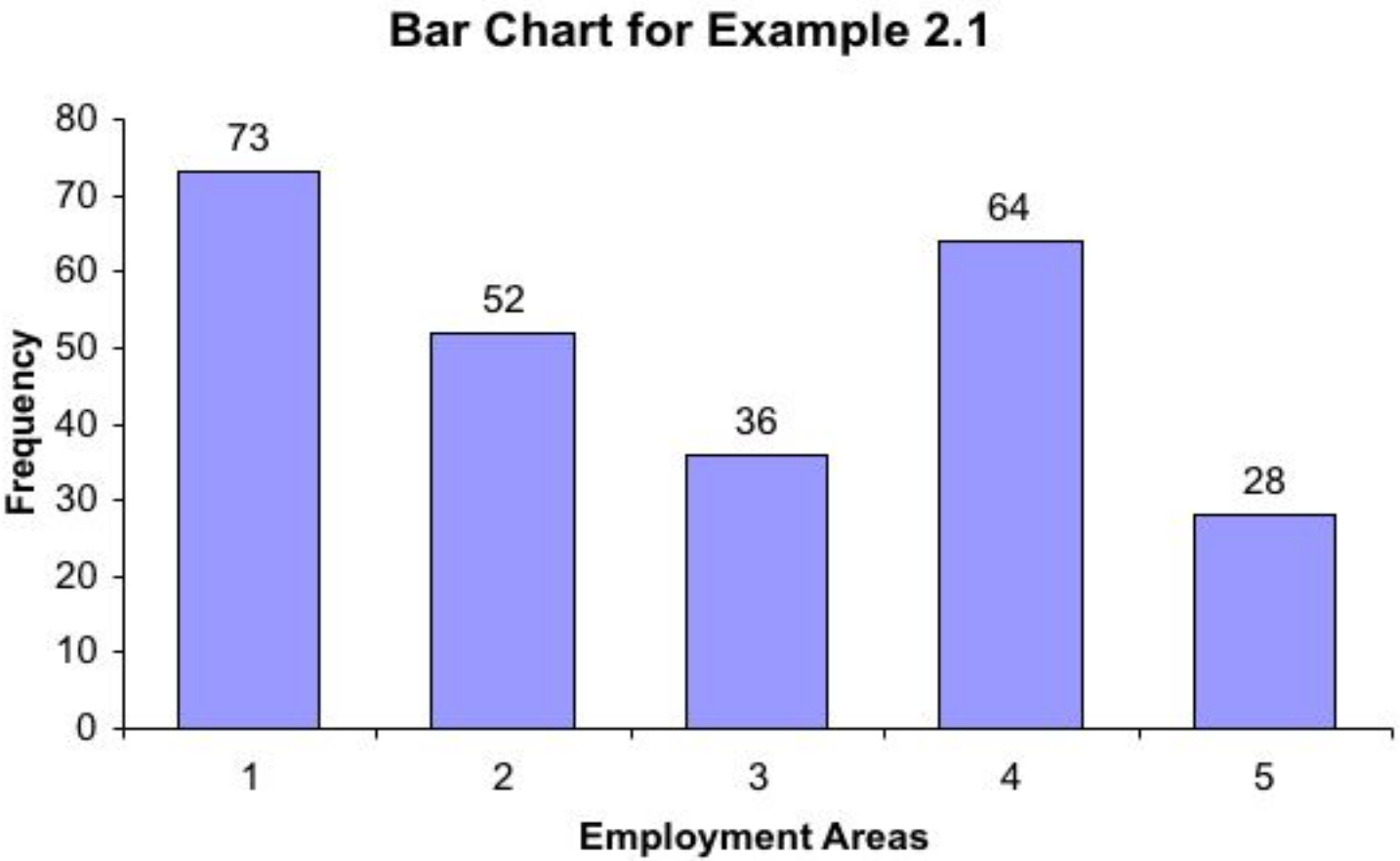
- The only allowable calculation on nominal data is to count the frequency of each value of the variable.
- We can summarize the data in a table that presents the categories and their counts called a ***frequency distribution.***
- A ***relative frequency distribution*** lists the categories and the proportion with which each occurs.
- Since Nominal data has no order, if we arrange the outcomes from the most frequently occurring to the least frequently occurring, we call this a "pareto chart"

Nominal Data (Tabular Summary) -

Table 2.1 Frequency and Relative Frequency Distributions for Example 2.1

Area	Frequency	Relative Frequency
Accounting	73	28.9%
Finance	52	20.6
General management	36	14.2
Marketing/Sales	64	25.3
Other	28	11.1
Total	253	100

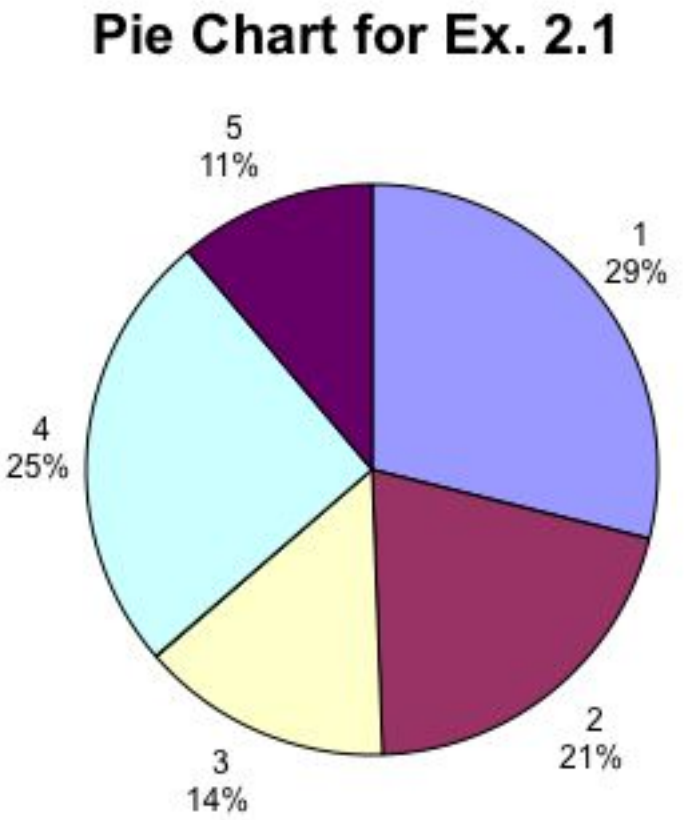
Nominal Data (Frequency)



Bar Charts are often used to display *frequencies…*

Is there a better way to order these? Would Bar Chart look different if we plotted "relative frequency" rather than "frequency"?

Nominal Data (Relative Frequency)



Pie Charts show *relative frequencies…*

Frequency Distributions

- Definition
- A ***frequency distribution*** for qualitative data lists all categories and the number of elements that belong to each of the categories.

Example 2.2

- A sample of 30 employees from large companies was selected, and these employees were asked how stressful their jobs were. The responses of these employees are recorded next where *very* represents very stressful, *somewhat* means somewhat stressful, and *none* stands for not stressful at all.

Example 2.2

Some what	None	Somewhat	Very	Very	None
Very	Somewhat	Somewhat	Very	Somewhat	Somewhat
Very	Somewhat	None	Very	None	Somewhat
Somewhat	Very	Somewhat	Somewhat	Very	None
Somewhat	Very	very	somewhat	None	Somewhat

Construct a frequency distribution table for these data.

Solution 2.2

Table 2.2 Frequency Distribution of Stress on Job

Stress on Job	Tally	Frequency (f)
Very	𝍸 𝍸	10
Somewhat	𝍸 𝍸 𝍸	14
None	𝍸 |	6
		Sum = 30

Relative Frequency and Percentage Distributions

- **Calculating Relative Frequency of a Category**

$$\text{Relative frequency of a category} = \frac{\text{Frequency of that category}}{\text{Sum of all frequencies}}$$

Relative Frequency and Percentage Distributions cont.

- **Calculating Percentage**

Percentage =

= (Relative frequency) · 100

Example 2.3

- Determine the relative frequency and percentage for the data in Table 2.4.

Solution 2-2

Table 2.3 Relative Frequency and Percentage Distributions of Stress on Job

Stress on Job	Relative Frequency	Percentage
Very	10/30 = .333	.333(100) = 33.3
Somewhat	14/30 = .467	.467(100) = 46.7
None	6/30 = .200	.200(100) = 20.0
	Sum = 1.00	Sum = 100

Graphical Presentation of Qualitative Data

- Definition
- A graph made of bars whose heights represent the frequencies of respective categories is called a ***bar graph***.

Figure 2.2 **Bar graph** for the frequency distribution of Table 2.3

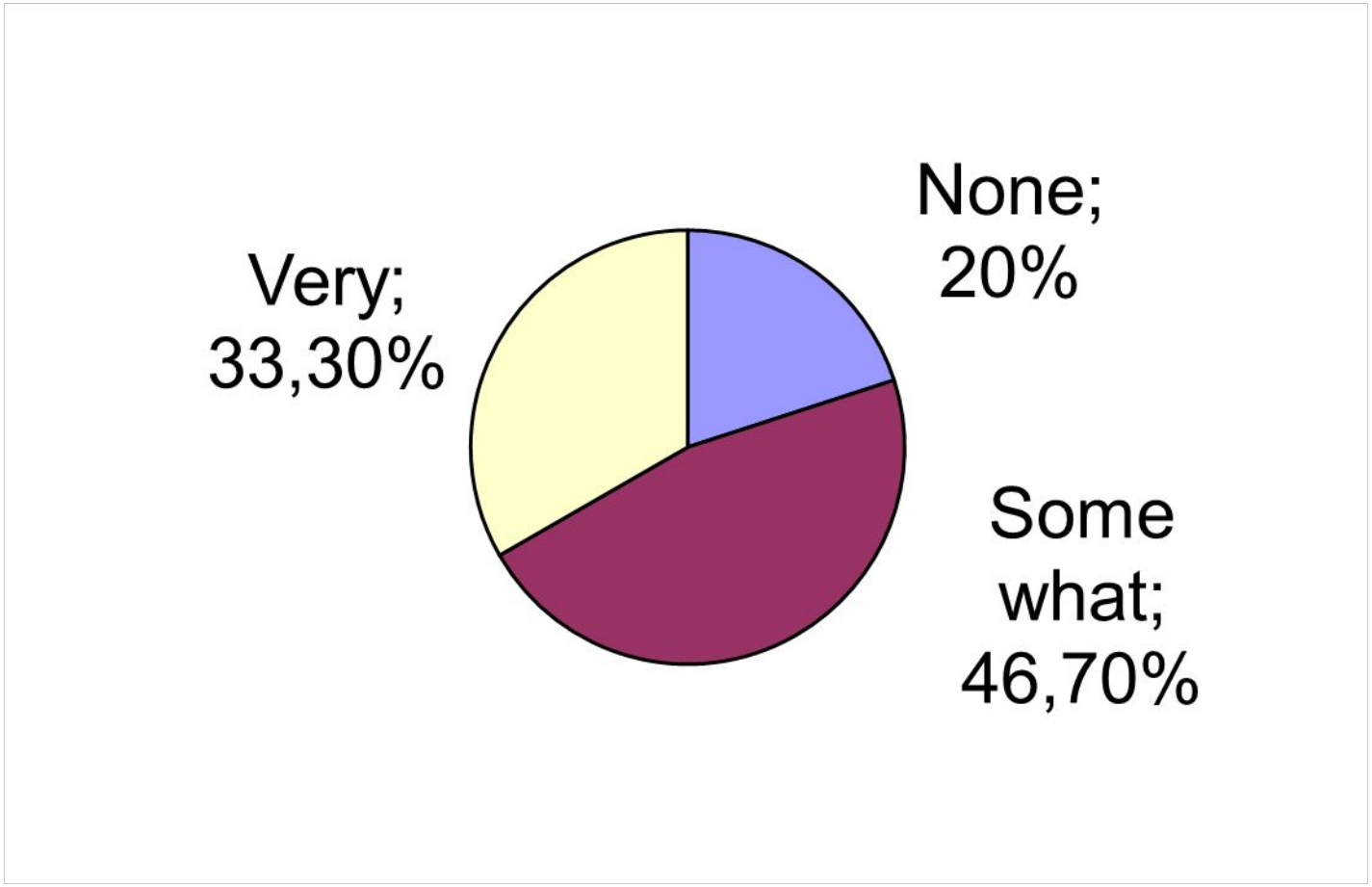
Graphical Presentation of Qualitative Data cont.

- Definition
- A circle divided into portions that represent the relative frequencies or percentages of a population or a sample belonging to different categories is called a ***pie chart***.

Table 2.4 **Calculating Angle Sizes for the Pie Chart**

Stress on Job	Relative Frequency	Angle Size
Very	.333	360(.333) = 119.88
Somewhat	.467	360(.467) = 168.12
None	.200	360(.200) = 72.00
	Sum = 1.00	Sum = 360

Figure 2.4 Pie chart for the percentage distribution of Table 2.5.

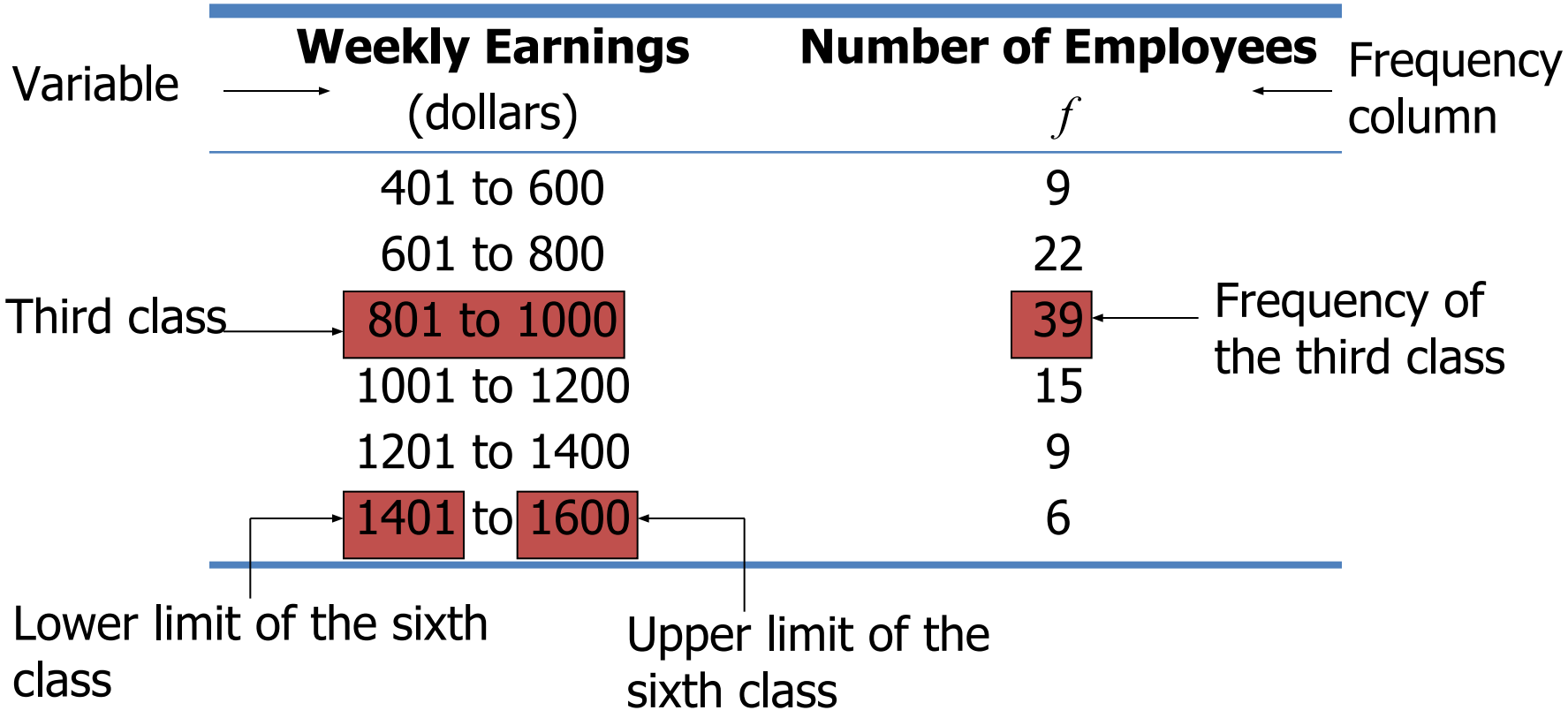


ORGANIZING AND GRAPHING QUANTITATIVE DATA

- Frequency Distributions
- Constructing Frequency Distribution Tables
- Relative and Percentage Distributions
- Graphing Grouped Data
  - Histograms
  - Polygons

Frequency Distributions

Table 2.7 **Weekly Earnings of 100 Employees of a Company**



Frequency Distributions cont.

- Definition
- A ***frequency distribution*** for quantitative data lists all the classes and the number of values that belong to each class. Data presented in the form of a frequency distribution are called ***grouped data***.

Essential Question :

- How do we construct a frequency distribution table?

- Process of Constructing a Frequency Table
  - STEP 1: Determine the range.
  - **R = Highest Value – Lowest Value**

- STEP 2. Determine the **tentative number of classes (k)**

- **$k = 1 + 3.322 \log N$**

- Always round – off

- Note: The number of classes should be between 5 and 20. The actual number of classes may be affected by convenience or other subjective factors

- STEP 3. Find the class width by dividing the range by the number of classes.

$$class\ width = \frac{Range}{number\ of\ classes} \quad \Leftrightarrow \quad c = \frac{R}{k}$$

- (Always round – off)

- STEP 4. Write the classes or categories starting with the lowest score. Stop when the class already includes the highest score.

- Add the class width to the starting point to get the second lower class limit. Add the class width to the second lower class limit to get the third, and so on. List the lower class limits in a vertical column and enter the upper class limits, which can be easily identified at this stage.

- STEP 5. Determine the frequency for each class by referring to the tally columns and present the results in a table.

- When constructing **frequency tables**, the following guidelines should be followed.

1. The classes must be mutually exclusive. That is, each score must belong to exactly one class.
2. Include all classes, even if the frequency might be zero.

- 3. All classes should have the same width, although it is sometimes impossible to avoid open – ended intervals such as “65 years or older”.

- 4. The number of classes should be between 5 and 20.

Let's Try!!!

- Time magazine collected information on all 464 people who died from gunfire in the Philippines during one week. Here are the ages of 50 men randomly selected from that population. Construct a frequency distribution table.

- 19 18 30 40 41 33 73 25
- 23 25 21 33 65 17 20 76
- 47 69 20 31 18 24 35 24
- 17 36 65 70 22 25 65 16
- 24 29 42 37 26 46 27 63
- 21 27 23 25 71 37 75 25
- 27 23

- Determine the range.
- R = Highest Value – Lowest Value
- R = 76 – 16 = 60

- Determine the tentative number of classes (K).
- K = 1 + 3. 322 log N
- = 1 + 3.322 log 50
- = 1 + 3.322 (1.69897) = 6.64
- *Round – off the result to the next integer if the decimal part exceeds 0.
    - K = 7

- Find the class width (c).

$$class\ width = \frac{Range}{number\ of\ classes} \quad \Leftrightarrow \quad c = \frac{R}{k}$$

$$c = \frac{60}{7} = 8.57 = 9$$

- * Round – off the quotient if the decimal part exceeds 0.

Write the classes starting with lowest score.

Classes	Tally Marks	Freq.
70 – 78	/////	5
61 – 69	/////	5
52 – 60		0
43 – 51	//	2
34 – 42	/////-//	7
25 – 33	/////-/////-////	14
16 – 24	/////-/////-/////-//	17

- Using Table:
  - What is the lower class limit of the highest class?
  - Upper class limit of the lowest class?
  - Find the class mark of the class 43 – 51.
  - What is the frequency of the class 16 – 24?

Classes	Class boundaries	Tally Marks	Freq.	x
70 – 78	69.5 – 78.5	/////	5	74
61 – 69	60.5 – 69.5	/////	5	65
52 – 60	51.5 – 60.5		0	56
43 – 51	42.5 – 51.5	//	2	47
34 – 42	33.5 – 42.5	/////-//	7	38
25 – 33	24.5 – 33.5	/////-/////-////	14	29
16 – 24	15.5 – 24.5	/////-/////-/////-//	17	20

Example

- Table 2.9 gives the total home runs hit by all players of each of the 30 Major League Baseball teams during the 2012 season. Construct a frequency distribution table.

Table 2.9 Home Runs Hit by Major League Baseball Teams During the 2012 Season

Team	Home Runs	Team	Home Runs
Anaheim	152	Milwaukee	139
Arizona	165	Minnesota	167
Atlanta	164	Montreal	162
Baltimore	165	New York Mets	160
Boston	177	New York Yankees	223
Chicago Cubs	200	Oakland	205
Chicago White Sox	217	Philadelphia	165
Cincinnati	169	Pittsburgh	142
Cleveland	192	St. Louis	175
Colorado	152	San Diego	136
Detroit	124	San Francisco	198
Florida	146	Seattle	152
Houston	167	Tampa Bay	133
Kansas City	140	Texas	230
Los Angeles	155	Toronto	187

Solution 2-3

$$\text{Approximate width of each class} =$$

$$= \frac{230 - 124}{5} = 21.2$$

Now we round this approximate width to a convenient number – say, 22.

Solution 2-3

The lower limit of the first class can be taken as 124 or any number less than 124. Suppose we take 124 as the lower limit of the first class. Then our classes will be

124 – 145, 146 – 167, 168 – 189,
190 – 211, and 212 - 233

Table 2.10 Frequency Distribution for the Data of Table 2.9

Total Home Runs	Tally	f
124 – 145	𝍸 |	6
146 – 167	𝍸 𝍸 |||	13
168 – 189	||||	4
190 – 211	||||	4
212 - 233	|||	3
		$\sum f = 30$

Relative Frequency and Percentage Distributions

Relative Frequency and Percentage Distributions

$$\text{Relative frequency of a class} = \frac{\text{Frequency of that class}}{\text{Sum of all frequencies}} = \frac{f}{\sum f}$$

$$\text{Percentage} = (\text{Relative frequency}) \cdot 100$$

Example 2-4

- Calculate the relative frequencies and percentages for Table 2.10

Solution 2-4

Table 2.11 Relative Frequency and Percentage Distributions for Table 2.10

Total Home Runs	Class Boundaries	Relative Frequency	Percentage
124 – 145	123.5 to less than 145.5	.200	20.0
146 – 167	145.5 to less than 167.5	.433	43.3
168 – 189	167.5 to less than 189.5	.133	13.3
190 – 211	189.5 to less than 211.5	.133	13.3
212 - 233	211.5 to less than 233.5	.100	10.0
		Sum = .999	Sum = 99.9%

Graphing Grouped Data

- Definition
- A ***histogram*** is a graph in which classes are marked on the horizontal axis and the frequencies, relative frequencies, or percentages are marked on the vertical axis. The frequencies, relative frequencies, or percentages are represented by the heights of the bars. In a histogram, the bars are drawn adjacent to each other.

Figure 2.3 Frequency histogram for Table 2.10.

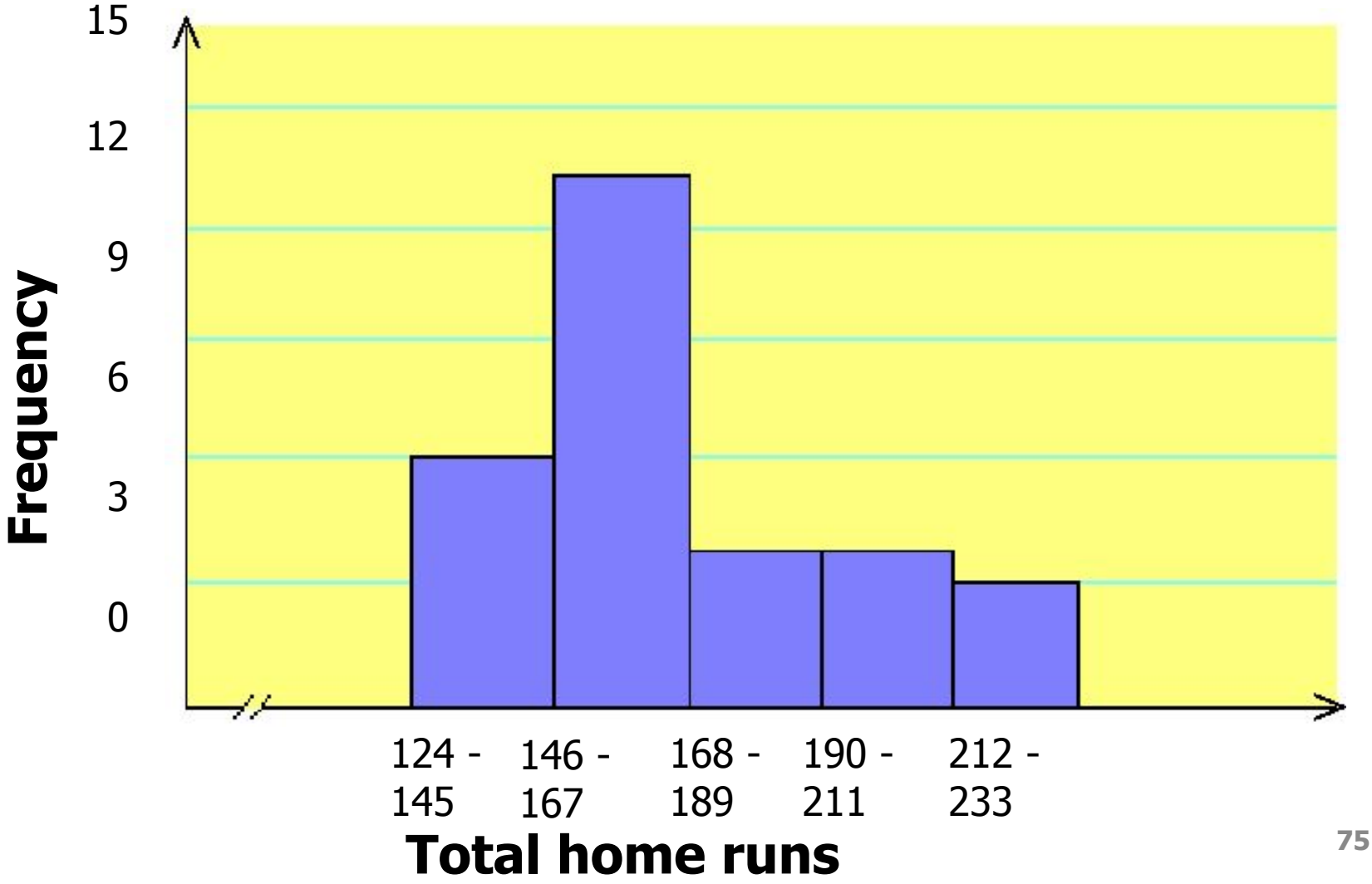
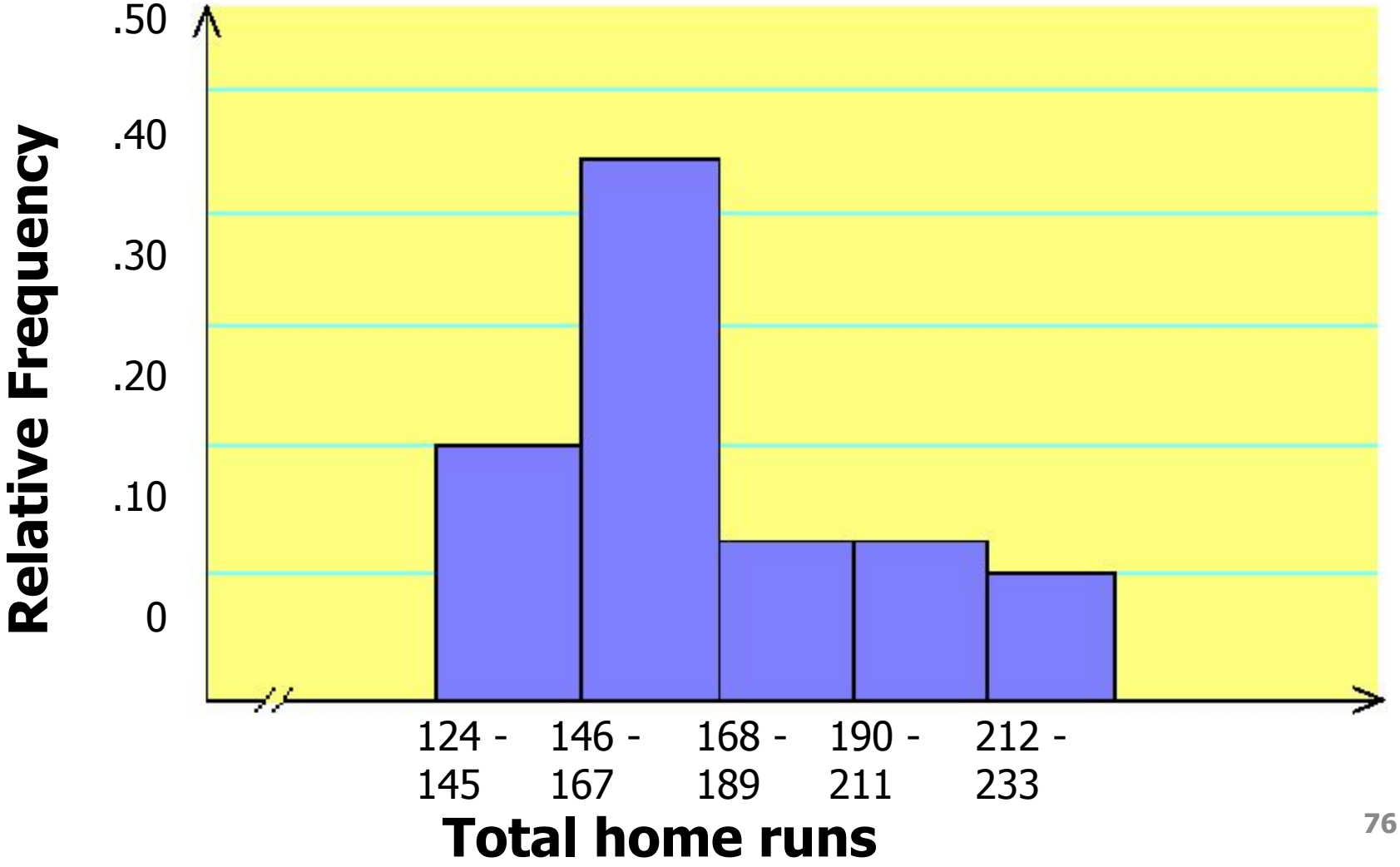


Figure 2.4 Relative frequency histogram for Table 2.10.



Graphing Grouped Data cont.

- Definition
- A graph formed by joining the midpoints of the tops of successive bars in a histogram with straight lines is called a ***polygon***.

Figure 2.5 Frequency polygon for Table 2.10.

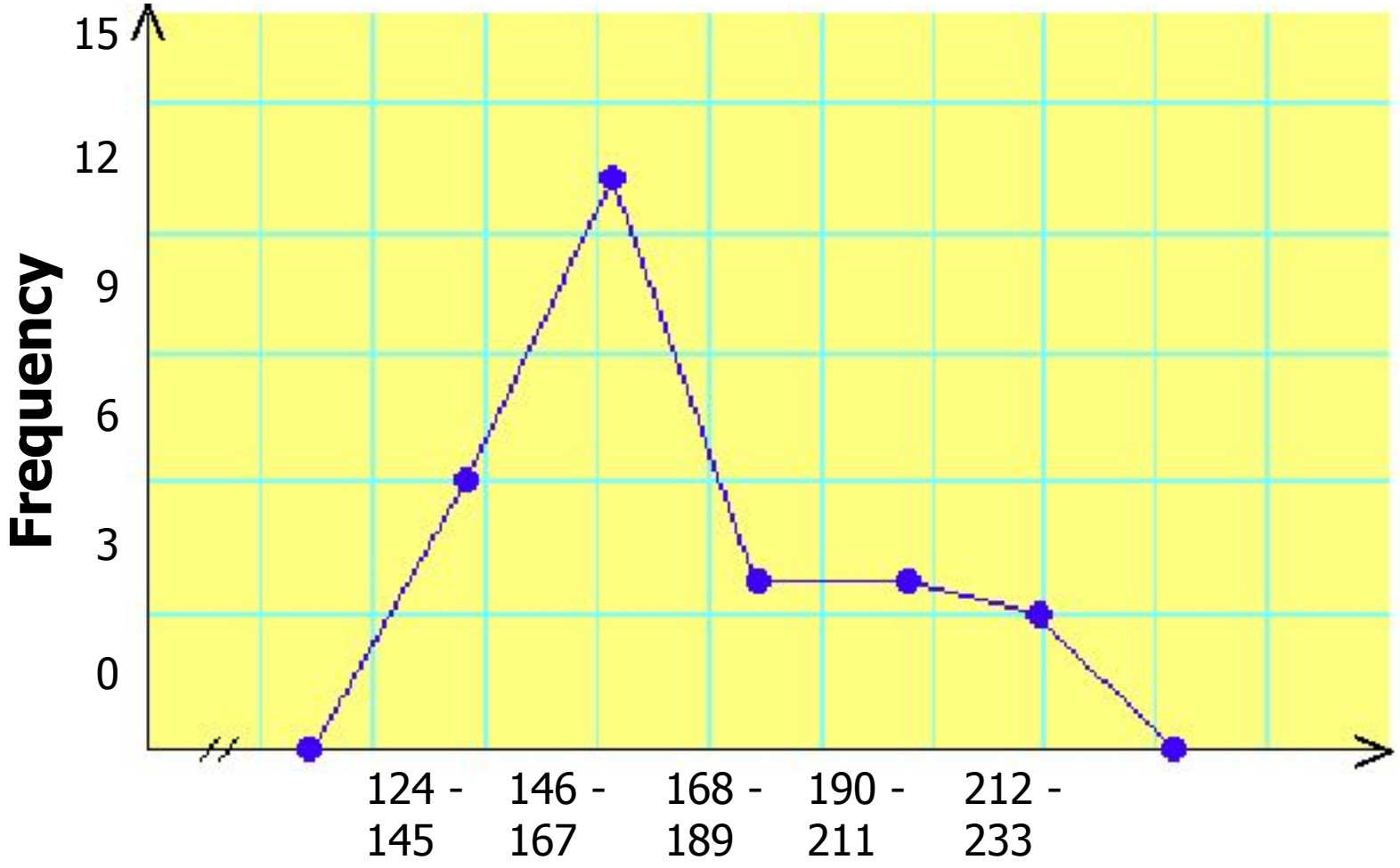
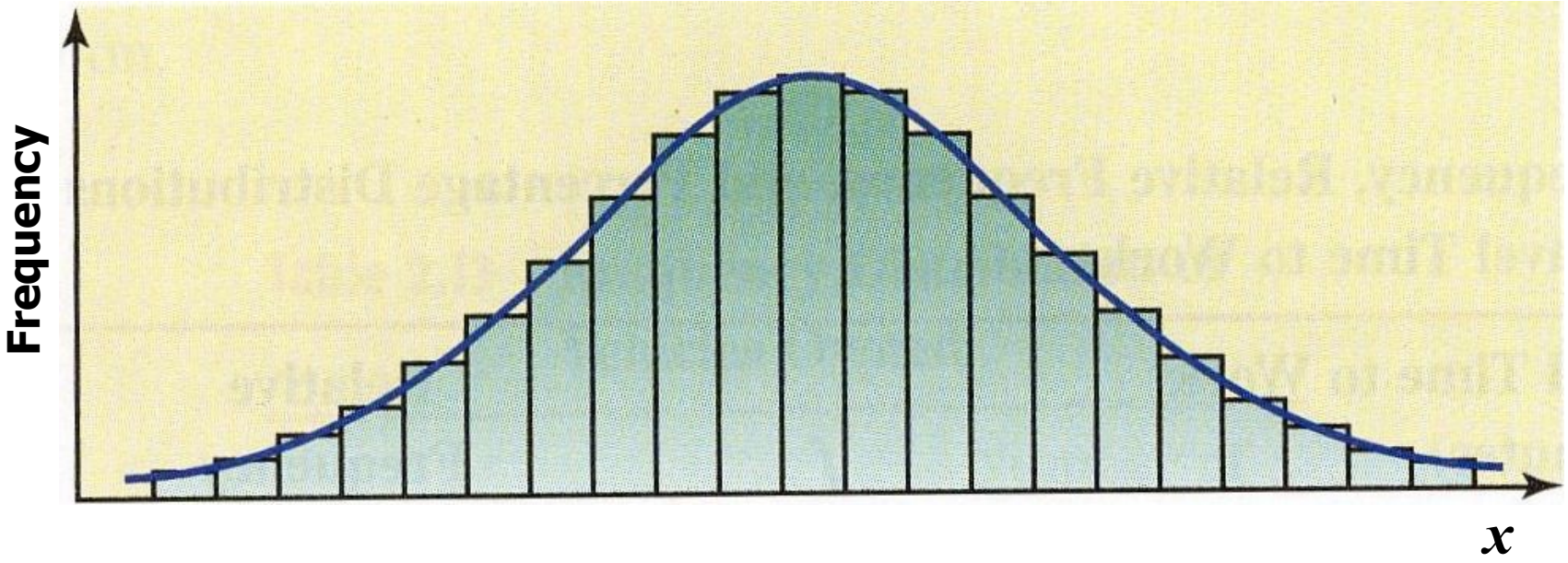


Figure 2.6 Frequency Distribution curve



Example 2-5

- The following data give the average travel time from home to work (in minutes) for 50 states. The data are based on a sample survey of 700,000 households conducted by the Census Bureau (USA TODAY, August 6, 2013).

Example 2-5

22.4	18.2	23.7	19.8	26.7	23.4	23.5	22.5	24.3	26.7	24.2
19.7	27.0	21.7	17.6	17.7	22.5	23.7	21.2	29.2	26.1	22.7
21.6	21.9	23.2	16.0	16.1	22.3	24.4	28.7	19.9	31.2	22.6
15.4	22.1	19.6	21.4	23.8	21.9	21.9	15.6	22.7	23.6	20.8
21.1	25.4	24.9	25.5	20.1	17.1					

Construct a frequency distribution table. Calculate the relative frequencies and percentages for all classes.

Solution 2-5

$$\text{Approximate width of each class} =$$

$$= \frac{31.2 \ -15.4}{6} = 2.63$$

Solution 2-5

Table 2.12 Frequency, Relative Frequency, and Percentage Distributions of Average Travel Time to Work

Class Boundaries	f	Relative Frequency	Percentage
15 to less than 18	7	.14	14
18 to less than 21	7	.14	14
21 to less than 24	23	.46	46
24 to less than 27	9	.18	18
27 to less than 30	3	.06	6
30 to less than 33	1	.02	2
	$\sum f = 50$	Sum = 1.00	Sum = 100%

Example 2-6

The administration in a large city wanted to know the distribution of vehicles owned by households in that city. A sample of 40 randomly selected households from this city produced the following data on the number of vehicles owned:

5	1	1	2	0	1	1	2	1	1
1	3	3	0	2	5	1	2	3	4
2	1	2	2	1	2	2	1	1	1
4	2	1	1	2	1	1	4	1	3

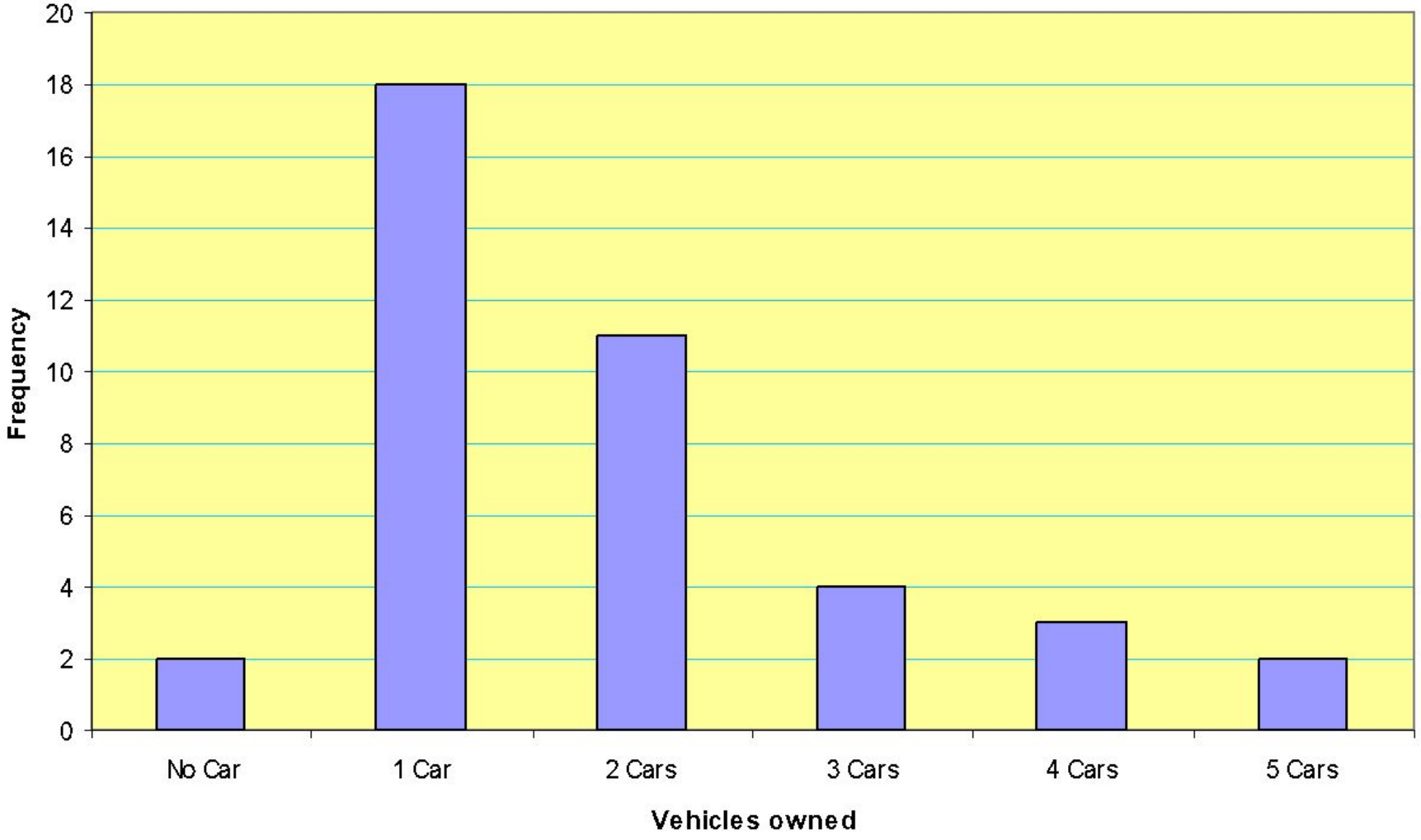
Construct a frequency distribution table for these data, and draw a bar graph.

Solution 2-6

Table 2.13 Frequency Distribution of Vehicles Owned

Vehicles Owned	Number of Households (f)
0	2
1	18
2	11
3	4
4	3
5	2
	$\Sigma f = 40$

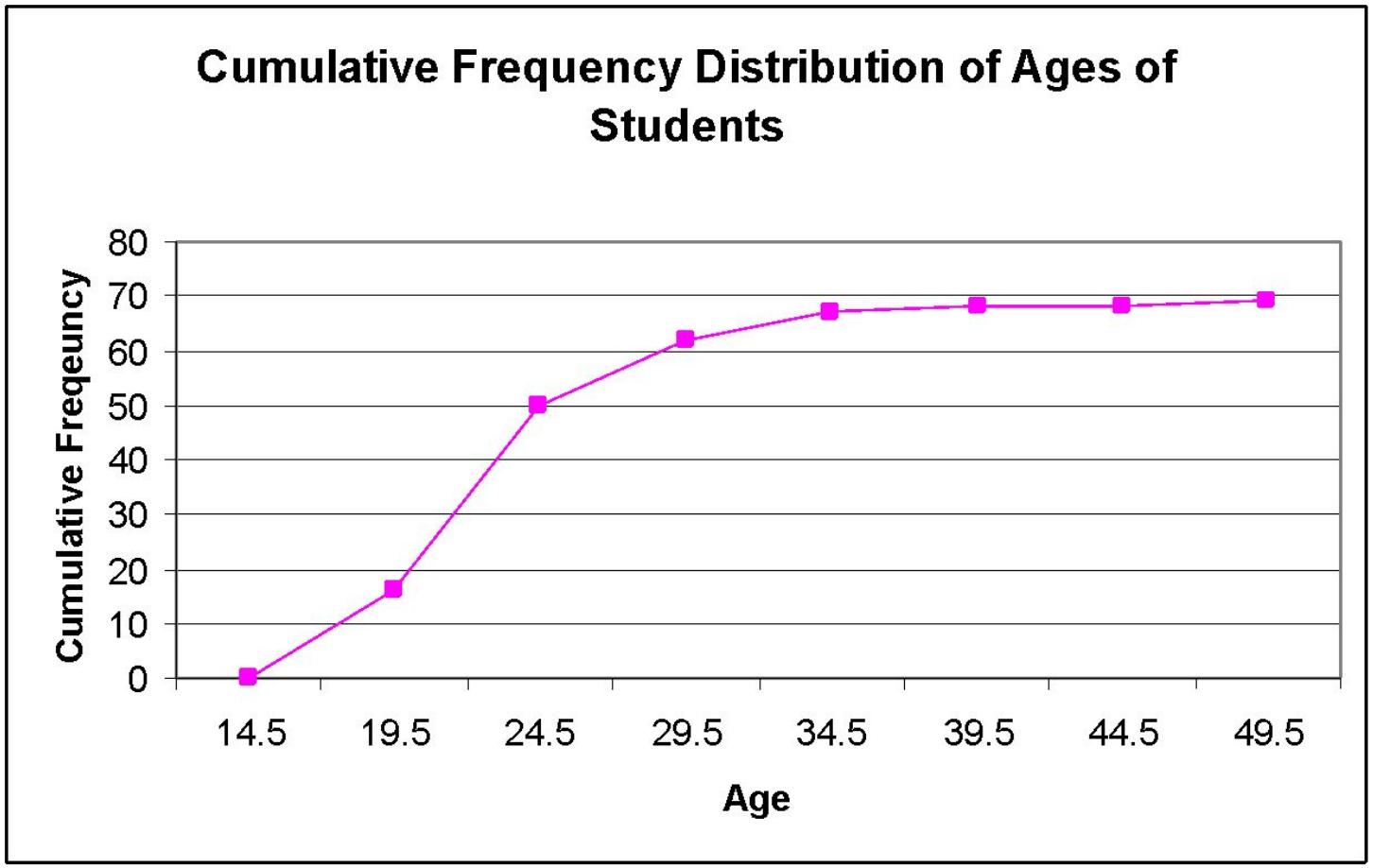
Figure 2.7 Bar graph for Table 2.13.



Ogive

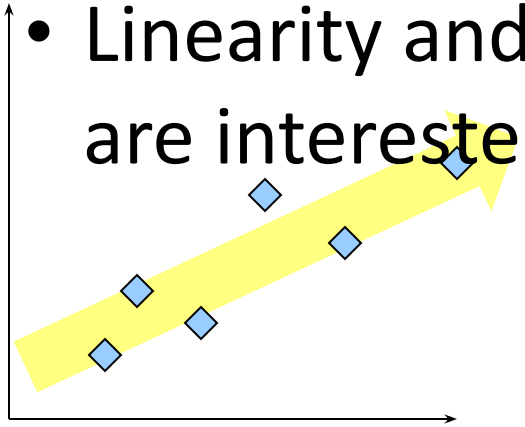
- The **ogive** is a graph that represents the cumulative frequencies for the classes in a frequency distribution
- Step 1. Find the cumulative frequency for each class.
- Step 2. Draw the x and y axes. Label the x-axis with the class boundaries.
- Step 3. Plot the cumulative frequency at each ***upper class boundary***.

Ogive

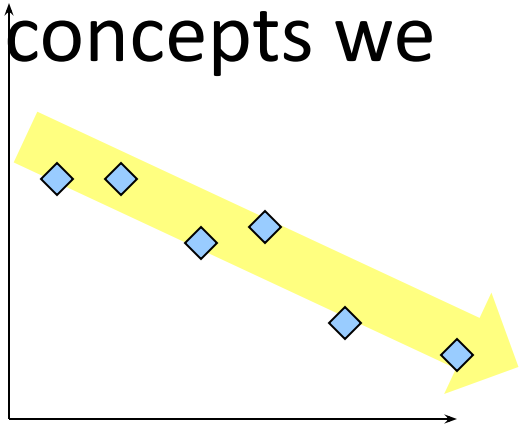

Cumulative Frequency Distribution of Ages of Students
Cumulative Freqeuncy
80
70
60
50
40
30
20
10
0
14.5
19.5
24.5
29.5
34.5
39.5
44.5
49.5
Age

Patterns of Scatter Diagrams…

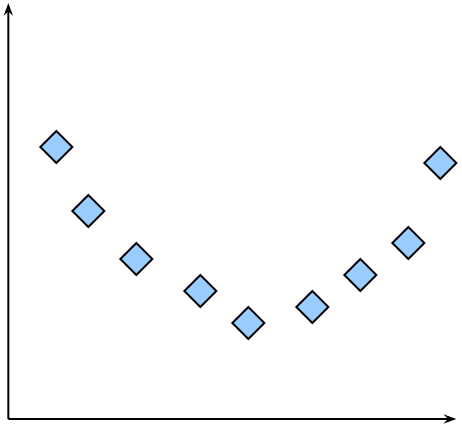
- Linearity and Direction are two concepts we are interested in



Positive Linear Relationship



Negative Linear Relationship



Weak or Non-Linear Relationship