

(d) Letter grade is a variable measured at the ordinal level because the values of the variable can be ranked, but differences in values have no meaning. For example, an A is better than a B, but $A - B$ has no meaning.

Now Work Problem 37

When classifying variables according to their level of measurement, it is extremely important to be careful to recognize what the variable is intended to measure. For example, suppose we want to know whether cars with 4-cylinder engines get better gas mileage than cars with 6-cylinder engines. Here, engine size represents a category of data and so the variable is nominal. On the other hand, if we want to know the average number of cylinders in cars in the United States, the variable is classified as ratio (an 8-cylinder engine has twice as many cylinders as a 4-cylinder engine).

IN CLASS ACTIVITY

Validity, Reliability, and Variability

Divide the class into groups of four to six students.

(a) Select one student to be the group leader. Each student in the group measures the length of the right arm of the group leader.

As the group leader is being measured, the other students in the group do not look on. Do not share the measurements obtained with others in the group until everyone has obtained a measurement! Record the results.

(b) The group leader measures the length of the right arm of each of the other students in the group. Record the results.

(c) **Validity** of a variable or measurement represents how close to the true value the measurement is. In other words, a variable is valid if it measures what it is supposed to measure. For example, if a student measured arm length from the shoulder to the wrist and another student measured arm length from the shoulder to the tip of the middle finger, the variable is not valid. How valid are the results obtained from part (a)? What could have been done by the group to increase the validity of the variable?

(d) **Reliability** of a variable or measurement represents the ability of different measurements of the same individual to yield the same results. How reliable are the measurements obtained in part (b)?

Why is it likely that the results from part (b) are valid, but may not be reliable?

(e) Which set of data appears to have more variability, the data from part (a) or the data from part (b)? Why?

(f) Compare the results of all the groups. Which group do you think has the most valid results? Which group has the most reliable results?

1.1 ASSESS YOUR UNDERSTANDING

Concepts and Vocabulary

- Define statistics.
- Explain the difference between a population and a sample.
- A(n) _____ is a person or object that is a member of the population being studied.
- _____ statistics consists of organizing and summarizing information collected, while _____ statistics uses methods that generalize results obtained from a sample to the population and measure the reliability of the results.
- A(n) _____ is a numerical summary of sample.
A(n) _____ is a numerical summary of a population.
- _____ are the characteristics of the individuals of the population being studied.

7. Contrast the differences between qualitative and quantitative variables.
8. Discuss the differences between discrete and continuous variables.
9. In your own words, define the four levels of measurement of a variable. Give an example of each.
10. Explain what is meant when we say “data vary.” How does this variability affect the results of statistical analysis?
11. Explain the process of statistics.
12. The age of a person is commonly considered to be a continuous random variable. Could it be considered a discrete random variable instead? Explain.

Skill Building

In Problems 13–20, determine whether the underlined value is a parameter or a statistic.

- 13. State Government** Following the 2006 national midterm election, 18% of the governors of the 50 United States were female.

Source: National Governors Association

- 14. Calculus Exam** The average score for a class of 28 students taking a calculus midterm exam was 72%.

- 15. Illegal Drugs** In a national survey of high school students (grades 9 to 12), 25% of respondents reported that someone had offered, sold, or given them an illegal drug on school property.

Source: Bureau of Justice Statistics jointly with the U.S. Department of Education, *Indicators of School Crime and Safety, 2006*, December 2006

- 16. Alcohol Use** In a national survey on substance abuse, 66.4% of respondents who were full-time college students aged 18 to 22 reported using alcohol within the past month.

Source: Substance Abuse and Mental Health Services Administration, *Results from the 2006 National Survey on Drug Use and Health: National Findings*, September 2007

- 17. Batting Average** Ty Cobb is one of Major League Baseball’s greatest hitters of all time, with a career batting average of 0.366.

Source: baseball-almanac.com

- 18. Moonwalkers** Only 12 men have walked on the moon. The average age of these men at the time of their moonwalks was 39 years, 11 months, 15 days.

Source: Wikipedia.org

- 19. Hygiene Habits** A study of 6,076 adults in public rest rooms (in Atlanta, Chicago, New York City, and San Francisco) found that 23% did not wash their hands before exiting.

Source: American Society for Microbiology and the Soap and Detergent Association, *Press Release: Hygiene Habits Stall: Public Handwashing Down*, September 17, 2007

- 20. Public Knowledge** Telephone interviews of 1,502 adults 18 years of age or older, conducted nationwide February 1–13, 2007, found that only 69% could identify the current vice-president.

Source: The Pew Research Center, *Public Knowledge of Current Affairs Little Changed by News and Information Revolutions: What Americans Know: 1989–2007*, April 15, 2007

In Problems 21–28, classify the variable as qualitative or quantitative.

- 21.** Nation of origin

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- 22.** Number of siblings

- 23.** Grams of carbohydrates in a doughnut

- 24.** Number on a football player’s jersey

- 25.** Number of unpopped kernels in a bag of ACT microwave popcorn

- 26.** Assessed value of a house

- 27.** Phone number

- 28.** Student ID number

In Problems 29–36, determine whether the quantitative variable is discrete or continuous.

- 29.** Runs scored in a season by Albert Pujols

NW

- 30.** Volume of water lost each day through a leaky faucet

- 31.** Length (in minutes) of a country song

- 32.** Number of sequoia trees in a randomly selected acre of Yosemite National Park

- 33.** Temperature on a randomly selected day in Memphis, Tennessee

- 34.** Internet connection speed in kilobytes per second

- 35.** Points scored in an NCAA basketball game

- 36.** Air pressure in pounds per square inch in an automobile tire

In Problems 37–44, determine the level of measurement of each variable.

- 37.** Nation of origin

NW

- 38.** Movie ratings of one star through five stars

- 39.** Volume of water used by a household in a day

- 40.** Year of birth of college students

- 41.** Highest degree conferred (high school, bachelor’s, and so on)

- 42.** Eye color

- 43.** Assessed value of a house

- 44.** Time of day measured in military time

In Problems 45–50, a research objective is presented. For each research objective, identify the population and sample in the study.

- 45.** The Gallup Organization contacts 1,028 teenagers who are 13 to 17 years of age and live in the United States and asks whether or not they had been prescribed medications for any mental disorders, such as depression or anxiety.

- 46.** A quality-control manager randomly selects 50 bottles of Coca-Cola that were filled on October 15 to assess the calibration of the filling machine.

- 47.** A farmer wanted to learn about the weight of his soybean crop. He randomly sampled 100 plants and weighed the soybeans on each plant.

- 48.** Every year the U.S. Census Bureau releases the *Current Population Report* based on a survey of 50,000 households. The

goal of this report is to learn the demographic characteristics of all households within the United States, such as income.

- 49. Folate and Hypertension** Researcher John P. Forman and co-workers wanted to determine whether or not higher folate intake is associated with a lower risk of hypertension (high blood pressure) in younger women (27 to 44 years of age). To make this determination, they looked at 7,373 cases of hypertension in younger women and found that younger women who consumed at least 1,000 micrograms per day ($\mu\text{g}/\text{d}$) of total folate (dietary plus supplemental) had a decreased risk of hypertension compared with those who consumed less than 200 $\mu\text{g}/\text{d}$.

Source: John P. Forman, MD; Eric B. Rimm, ScD; Meir J. Stampfer, MD; Gary C. Curhan, MD, ScD, "Folate Intake and the Risk of Incident Hypertension among US Women," *Journal of the American Medical Association* 293:320–329, 2005

- 50.** A large community college has noticed that an increasing number of full-time students are working while attending the school. The administration randomly selects 128 students and asks this question: How many hours per week do you work?

In Problems 51–54, identify the individuals, variables, and data corresponding to the variables. Determine whether each variable is qualitative, continuous, or discrete.

- 51. Widescreen TVs** The following data relate to widescreen **NW** high-definition televisions.

Model	Size (in.)	Screen Type	Price (\$)
Hitachi #P50X901	50	Plasma	4,000
Mitsubishi #WD-73833	73	Projection	4,300
Sony #KDF-50E3000	50	Projection	1,500
Panasonic #TH-65PZ750U	65	Plasma	9,000
Phillips #60PP9200D37	60	Projection	1,600
Samsung #FP-T5884	58	Plasma	4,200
LG #52LB5D	52	Plasma	3,500

Source: bestbuy.com

- 52. BMW Cars** The following information relates to the 2008 model year product line of BMW automobiles.

Model	Body Style	Weight (lb)	Number of Seats
3 Series	Coupe	3,351	4
5 Series	Sedan	3,505	5
6 Series	Convertible	4,277	4
7 Series	Sedan	4,486	5
X3	Sport utility	4,012	5
Z4 Roadster	Coupe	3,087	2

Source: www.motortrend.com

- 53. Driver's License Laws** The following data represent driver's license laws for various states.

State	Minimum Age for Driver's License (unrestricted)	Mandatory Belt Use Seating Positions	Maximum Allowable Speed Limit (cars on rural interstate), mph, 2007
Alabama	17	Front	70
Colorado	17	Front	75
Indiana	18	All	70
North Carolina	16	All	70
Wisconsin	18	All	65

Source: Governors Highway Safety Association

- 54. Media Players** The following information concerns various digital media players that can be purchased online at circuitcity.com.

Product	Memory Size (GB)	Weight (oz)	Price (\$)
Samsung YP-U3	2	0.8	79.99
SanDisk Sansa c200	2	10.4	74.99
Microsoft Zune	4	8.3	149.99
SanDisk Sansa Connect	4	1.7	129.99
Apple iPod nano	4	1.7	149.99
Apple iPod touch	8	4.2	299.99
Archos 605	30	6.7	299.99

Applying the Concepts

- 55. A Cure for the Common Wart** A study conducted by researchers was designed "to determine if application of duct tape is as effective as cryotherapy in the treatment of common warts." The researchers randomly divided 51 patients into two groups. The 26 patients in group 1 had their warts treated by applying duct tape to the wart for 6.5 days and then removing the tape for 12 hours, at which point the cycle was repeated for a maximum of 2 months. The 25 patients in group 2 had their warts treated by cryotherapy (liquid nitrogen applied to the wart for 10 seconds every 2 to 3 weeks) for a maximum of six treatments. Once the treatments were complete, it was determined that 85% of the patients in group 1 and 60% of the patients in group 2 had complete resolution of their warts. The researchers concluded that duct tape is significantly more effective in treating warts than cryotherapy.

Source: Dean R. Focht III, Carole Spicer, Mary P. Fairchok. "The Efficacy of Duct Tape vs. Cryotherapy in the Treatment of Verruca Vulgaris (The Common Wart)," *Archives of Pediatrics and Adolescent Medicine*, 156(10), 2002

- What is the research objective?
- What is the population being studied? What is the sample?
- What are the descriptive statistics?
- What are the conclusions of the study?

- 56. Early Epidurals** A study was conducted at Northwestern University in Chicago to determine if pregnant women in first-time labor could receive early low-dose epidurals, an anesthesia to control pain during childbirth, without raising