

and (2) places where the taxpayer reported income dishonestly. Discuss whether each problem involves random or systematic errors.

- 10. Safe Air Travel.** Before taking off, a pilot is supposed to set the aircraft altimeter to the elevation of the airport. A pilot leaves from Denver (altitude 5,280 feet) with her altimeter set to 2,500 feet. Explain how this affects the altimeter readings throughout the flight. What kind of error is this?
- 11. Technical Specifications.** An iPod battery is supposed to provide 3.7 volts. An aftermarket supplier manufactures 5,000 replacement batteries and finds that they have a mean of 3.7 V, but about half of the batteries have less than 3.7 volts and half have more than 3.7 volts. Does the error appear to be random or systematic? Explain.
- 12. Drunk Driving Data.** For data collected on car driving fatalities, a researcher claims that while many fatalities are recorded as involving alcohol, many others are missed because the deceased are not tested for alcohol consumption. If this is true, what kind of error is introduced and how does it affect the values of the data?

Sources of Errors. For each measurement described in Exercises 13–20, identify at least one likely source of random errors and also identify at least one likely source of systematic errors.

- 13. Contributions.** A survey asks people for the amount of money they donated to charity in the past year.
- 14. Tax Returns.** The annual incomes of 200 people are obtained from their tax returns.
- 15. Passenger Weights.** For a flight on a small plane, the pilot asks passengers what they weigh.
- 16. M&Ms.** The weights of individual M&M plain candies were obtained by placing each candy in a paper cup, then obtaining the weight without accounting for the weight of the cup.
- 17. Radar Speeds.** Speeds of cars are recorded by a police officer who uses a radar gun.
- 18. Counterfeit Products.** The police commissioner in New York City estimates the annual value of counterfeit goods sold in the city.
- 19. Cigarette Sales.** The health commissioner of Los Angeles estimates the number of cigarettes smoked in her city from data for taxes collected on sales of cigarettes.
- 20. Measuring Length.** A groundskeeper measures the length and width of a school's athletic field using a ruler that is 1 foot long.

Absolute and Relative Errors. In Exercises 21–24, find the values of the absolute and relative errors.

- 21. Credit Card Bill.** You receive a Visa credit card bill for \$2,995, but it includes a charge of \$1,750 that was not valid. (That is, the true value is \$1,750 less than the bill claims.)
- 22. Steak Weight.** A steak at a restaurant actually weighs 18 ounces (the true value), but the menu claims that it is a 20-ounce steak.

23. Wrong Change. When purchasing lunch in a cafeteria, the actual (true value) of change due is \$2.75, but the incorrect amount of \$1.75 is given instead.

24. Baker's Dozen. The bakery menu claims that there are 12 doughnuts in a bag, but the baker always puts 13 doughnuts (the true value) in each bag.

25. Minimizing Errors. Twenty-five people, including yourself, are to measure the length of a room to the nearest tenth of a millimeter. Assume that everyone uses the same well-calibrated measuring device, such as a tape measure.

- All 25 measurements are not likely to be exactly the same; thus, the measurements will contain some sources of error. Are these errors systematic or random? Explain.
- If you want to minimize the effect of random errors in determining the length of the room, which is the better choice: to report your own personal measurement as the length of the room or to report the average of all 25 measurements? Explain.
- Describe any possible sources of systematic errors in the measurement of the room length.
- Can the process of averaging all 25 measurements help reduce any systematic errors? Why or why not?

26. Minimizing Errors. When weighing a model 22F car battery, the measuring instrument is very precise, and the weight is obtained 10 consecutive times.

- All 10 measurements are not likely to be exactly the same; thus, the measurements will contain some sources of error. Are these errors systematic or random? Explain.
- If you want to minimize the effect of random errors in determining the true weight of the battery, which is the better choice: to choose one of the 10 measurements at random or to report the average of all 10 measurements? Explain.
- Describe any possible sources of systematic errors in the 10 measurements.
- Can the process of averaging all 10 weights help reduce any systematic errors? Why or why not?

27. Accuracy and Precision in Corvette Weight. A new Corvette weighs 3,273 lb. A manufacturer's scale that is accurate to the nearest 10 lb gives the weight as 3,250 lb, while the U.S. Department of Transportation uses a scale that is accurate to the nearest 0.1 lb and obtains a weight of 3,298.2 lb. Which measurement is more *precise*? Which is more *accurate*? Explain.

28. Accuracy and Precision in Height. Assume that your statistics professor has a height of exactly 175.2 cm. Assume that this height is measured with a tape measure that can be read to the nearest mm (or 1/10 cm) and results from two different measurements are reported as 175 cm and 175.5 cm. Which measurement is more *precise*? Which is more *accurate*? Explain.