Chapter 1

Measurement

Chapter 1 is important because all quantitative knowledge about our physical environment is based on measurement. Some chapter sections have been reorganized and rewritten for clarity. The 1.2 Section, “Scientific Investigation,” introduces the student to the procedures for scientific investigation.Major terms such as experiment, law, hypothesis, theory and scientific method are introduced. The idea that physical science deals with quantitative knowledge should be stressed. It is not enough to know that a car is going “fast”; it is necessary to know how fast.

A good understanding of units is of the utmost importance, particularly with the metric-British use in the United States today. The metric SI is introduced and explained. Both the metric and the British systems are used in the book in the early chapters for familiarity. The instructor may decide to do examples primarily in the metric system, but the student should get some practice in converting between the systems. This provides knowledge of the comparative size of similar units in the different systems and makes the student feel comfortable using what may be unfamiliar metric units. The Highlight, “Is Unit Conversion Important? It Sure Is,” illustrates the importance of unit conversion.

The general theme of the chapter and the textbook is the students’ position in his or her physical world. Show the students that they know about their environment and themselves through measurements. Measurements are involved in the answers to such questions as, How old are you? How much do you weigh? How tall are you? What is the normal body temperature? How much money do you have? These and many other technical questions are resolved or answered by measurements and quantitative analyses.

DEMONSTRATIONS

Have a meter stick, a yardstick, a timer, one or more kilogram masses, a one-liter beaker or a liter soda container, a one-quart container, and a balance or scales available on the instructor’s desk. Demonstrate the comparative units. The meter stick can be compared to the yardstick to show the difference between them, along with the subunits of inches and centimeters. The liter and quart also can be compared. Pass the kilogram mass around the classroom so that students can get some idea of the amount of mass in one kilogram. Mass and weight may be compared on the balance and scales.

When discussing Section 1.6, “Derived Units and Conversion Factors,” have class members guess the length of the instructor’s desk in metric and British units. Then have several students independently measure the length with the meter stick and yardstick. Compare the measurements in terms of significant figures and units. Compare the averages of the measurements and estimates. Convert the average metric measurement to British units, and vice versa, to practice conversion factors and to see how the measurements compare.

Various metric unit demonstrations are available from commercial sources.

ANSWERS TO MATCHING QUESTIONS

a. 19 b. 13 c. 21 d. 14 e. 15 f. 8 g. 10 h. 2 i. 21 j. 1 k. 9 l. 4 m. 18 n. 6 o. 11 p. 3 q. 20 r. 16 s. 22 t. 7 u. 23 v. 17 w. 5

ANSWERS TO MULTIPLE-CHOICE QUESTIONS

1. c 2. b 3. d 4. b 5. b 6. b 7. d 8. c 9. d 10. c 11. d 12. c 13. a

ANSWERS TO FILL-IN-THE-BLANK QUESTIONS

1. biological 2. hypothesis 3. scientific method 4. sight 5. limitations 6. greater than   
7. shorter 8. fundamental 9. time or second 10. one-millionth, 10-6 11. liter

12. mass

ANSWERS TO SHORT-ANSWER QUESTIONS

1. An organized body of knowledge about the natural universe by which knowledge is acquired and tested.

2. Physics, chemistry, astronomy, meteorology, and geology.

3. Observations and Measurements.

4. Hypothesis.

5. A law is a concise statement about a fundamental relationship of nature. A theory is a well-tested explanation of a broad segment of natural phenomena.

6. That phenomena must be investigated, not speculated.

7. Sight, hearing, touch, taste, and smell.

8. They have limitations and can be deceived.

9. (a) No. (b) Yes. (c) Good luck. (Use a couple of straight edges to determine.)

10. They are the most basic quantities of which we can think.

11. A fixed and reproducible value.

12. A group of standard units and their combinations.

13. km/hour

14. Yes, officially adopted in 1899.

15.Kilogram, a platinum-iridium cylinder.

16. Mass. Weight varies with gravity.

17. Meter-kilogram-second, International System of Units, centimeter-gram-second.

18. Base 10 easier to use (factors of 10).

19. mega- (M), kilo- (k), centi- (c), milli- (m)

20. Mass of a cubic liter of water.

21. Cubic meter.

22. kg, m, s, and C (electric charge).

23. The compactness of matter.

24. It is given a new name.

25. No. An equation must be equal in magnitude and units.

26. Yes. And it could be confused with “meters” instead of “miles.”

27. To express measured numbers properly.

28. By reading a measurement value from an instrument and rounding according to the  
general rules.

29. Two.

ANSWERS TO VISUAL CONNECTION

a. meter, b. kilogram, c. second, d. mks, e. foot, f. pound, g. second, h. fps

ANSWERS TO APPLYING-YOUR-KNOWLEDGE QUESTIONS

1. Scientific laws explain nature, not to regulate society (legal laws), and scientific laws do not compel, just describe.

2. The liter is larger than the quart, and the kilogram is larger than the pound. However, the kilometer itself is shorter than the mile.

3. Intrinsic properties are invariant. Kilogram cylinder and meterstick subject to wear, dirt, and change.

4. A liter, because it is larger than a quart.

5. (a) No, gold would weigh about 20 times more. (b) Solving for mass from the density equation, this would be 19320 g or 19.32 kg. No playing catch, as weight is about 45 lb.   
(1 kg = 2.2 lb).

6. 1 m = 3.28 ft. 830 m (3.28 ft/m) = 2.72 x 103 ft; 508 m (3.28 ft/m) = 1.67 x 103 ft.

Δ = 1.05 x 103 ft

ANSWERS TO EXERCISES

1. 10,000 cm or 105 cm

2. 2 x l03 Mb

3. 106 mm3

4. 1 m3 = 103 L. 1 m3 = 102 cm x 102 cm x 102 cm = 106 cm3 (1 L/103 cm3) = 103 L = 1000 L.

5. 0.50 L (1 kg/L) = 0.50 kg = 500 g

6. 25 cm25 cm35 cm = 22103 cm3 or mL = 22 L and 12 L (1 kg/L) = 12 kg = 12,000 g

7. (a) 0.55 Ms = 0.55106 s (b) 2.8 km = 2.8103 m (c) 12 mg = 1210–3 g = 1.210–6 kg

(d) 100 cm = 1.00 m

8. (a) 40 Mb (b) 572.2 mL (c) 540.0 x 102 cm (d) 5.5 kilobucks

9. 6 ft 5 in. = 77 in (2.54 cm/in.) = 196 cm = 1.963 m

10. 6 ft, 7 in.

11. Yes, to two significant figures

12. (a) 55 mi/h (1.61 km/mi) = 89 km/h (90 km/h). (b) 65 mi/h (1.61 km/mi) = 106 km/h (110 km/h)

13. No, 300 L ~ 300 qt (1 gal/4 qt) = 75 gal

14. No. Room would be about 12 m10 m, which would be about 36 ft.30 ft. Much too large for a dorm room.

15. See AYK # 6, 1,67 x 103 ft.

16. 890 ft (1 m/3.28 ft) 271 m; 1,900 ft = 579 m

17. cm, km

18. 103 kg (2.2 lb/kg) = 2,200 lb. 103 kg heavier by 200 lb

19. = *m/V* = 500 g/63 cm3 = 7.9 g/cm3 (the density of iron)

20. *V = * = 500 g/ 7.9 g/cm2 = 63 cm3

21. (a) 7,7 (b) 0.0021 (c) 9400 (d) 0.00034

22. (a) 0.00999 (b) 645 (c) 0.0106 (c) 8430

23. (a) 1.00 (b) 7380 (c) 0.00179 (d) 47.6

24. (a) 3.142 (b) 0.006907 (c) 483.6 (d) 0.02350

25. (3.15 m1.53 m)/0.78 m = 6.2 m

26. 6.75 (3 sf)