The Language of Physics

Philosophy
The search for knowledge or wisdom (p. 5).

Natural philosophy
The study of the natural or physical world (p. 6).

Physics
The Greek word for "natural" is *physikos*. Therefore, the word physics came to mean the study of the entire natural or physical world (p. 6).

Scientific method
The application of a logical process of reasoning to arrive at a model of nature that is consistent with experimental results. The scientific method consists of five steps: (1) observation, (2) hypothesis, (3) experiment, (4) theory or law, and (5) prediction (p. 6).

Fundamental quantities
The most basic quantities that can be used to describe the physical world. When we look out at the world, we observe that the world occupies space, and within that space we find matter, and that space and matter exists within something we call time. So the observation of the world can be made in terms of space, matter, and time. The fundamental quantity of length is used to describe space, the fundamental quantities of mass and electrical charge are used to describe matter, and the fundamental quantity of time is used to describe time. All other quantities, called derived quantities, can be described in terms of some combination of the fundamental quantities (p. 10).

International System (SI) of units
The internationally adopted system of units used by all the scientists and almost all the countries of the world (p. 12).

Meter
The standard of length. It is defined as the length of the path traveled by light in a vacuum during an interval of 1/299,792,458 of a second (p. 11).

Mass
The measure of the quantity of matter in a body (p. 13).

Kilogram
The unit of mass. It is defined as the amount of matter in a specific platinum iridium cylinder 39 mm high and 39 mm in diameter (p. 13).

Second
The unit of time. It is defined as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium-133 atom of the atomic clock (p. 15).

Coulomb
The unit of electrical charge. It is defined in terms of the unit of current, the ampere. The ampere is a flow of 1 coulomb of charge per second. The ampere is defined as that constant current that, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed one meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newtons per meter of length (p. 16).

Conversion factor
A factor by which a quantity expressed in one set of units must be multiplied in order to express that quantity in different units (p. 17).

Questions for Chapter 1

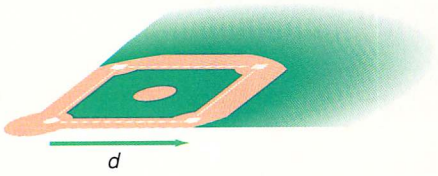
1. Why should physics have separated from philosophy at all?
† 2. What were Aristotle's ideas on physics, and what was their effect on science in general, and on physics in particular?
3. Is the scientific method an oversimplification?
4. How does a law of physics compare with a civil law?
† 5. Is there a difference between saying that an experiment validates a law of nature and that an experiment verifies a law of nature? Where does the concept of truth fit in the study of physics?
6. How does physics relate to your field of study?
7. In the discussion of hot and cold in section 1.3, what would happen if you placed your right hand in the hot water and your left hand in the cold water, and then placed both of them in the mixture simultaneously?
8. Can you think of any more examples that show the need for quantitative measurements?
9. Compare the description of the world in terms of earth, air, fire, and water with the description in terms of length, mass, electrical charge, and time.
10. Discuss the pros and cons of dividing the day into decidays. Do you think this idea should be reintroduced into society? Using yes and no answers, have your classmates vote on a change to a deciday. Is the result surprising?
11. Discuss the difference between mass and weight.

Problems for Chapter 1

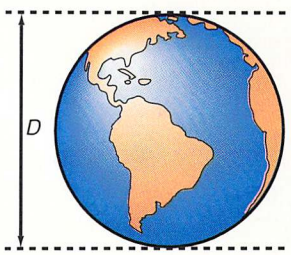
In all the examples and problems in this book we assume that whole numbers, such as 2 or 3, have as many significant figures as are necessary in the solution of the problem.

1. How many cubic centimeters are there in a cubic inch?
2. A liter contains 1000 cm^3. How many liters are there in a cubic meter?
3. A speed of 60.0 miles per hour (mph) is equal to how many ft/s?
4. The density of 1 g/cm^3 is equal to how many kg/liter?
5. How many seconds are there in a day? a month? a year?
6. Calculate your height in meters.
7. What is 90 km/hr expressed in mph?
8. How many square meters are there in 1 acre, if 1 acre is equal to 43,560 ft^2?
9. How many feet are there in 1 km?

10. Express the age of the earth (approximately 4.6×10^9 years) in seconds.
11. The speed of sound in air is 331 m/s at 0°C. Express this speed in ft/s and mph.
12. The speedometer of a new car is calibrated in km/hr. If the speed limit is 55 mph, how fast can the car go in km/hr and still stay below the speed limit?
13. A floor has an area of 144 ft^2. What is this area expressed in m^2?
14. A tank contains a volume of 50 ft^3. Express this volume in cubic meters.
15. Assuming that an average person lives for 75 yrs, how many (a) seconds and (b) minutes are there in this lifetime? If the heart beats at an average of 70 pulses/min, how many beats does the average heart have?
16. A cube is 50 cm on each side. Find its surface area in m^2 and ft^2 and its volume in m^3 and ft^3.
17. The speed of light in a vacuum is approximately 186,000 miles/s. Express this speed in mph and m/s.
18. The distance from home plate to first base on a baseball field is 90 ft. What is this distance in meters?



19. In the game of football, a first down is 10 yd long. What is this distance in meters? If the field is 100 yd long, what is the length of the field in meters?
20. The diameter of a sphere is measured as 6.28 cm. What is its volume in cm^3, m^3, $in.^3$, and ft^3?
21. The Empire State Building is 1245 ft tall. Express this height in meters, miles, inches, and millimeters.
22. A drill is 1/4 in. in diameter. Express this in centimeters, and then millimeters.
23. The average diameter of the earth is 7927 miles. Express this in km.



24. A 31-story building is 132 m tall. What is the average height of each story in feet?
25. Light of a certain color has a wavelength of 589 nm. Express this wavelength in (a) pm, (b) mm, (c) cm, (d) m. How many of these 589 nm waves are there in an inch?
26. Calculate the average distance to the moon in meters if the distance is 239,000 miles.
27. A basketball player is 7 ft tall. What is this height in meters?
28. The mass of a hydrogen atom is 1.67×10^{-24} g. Calculate the number of atoms in 1 g of hydrogen.
29. The Washington National Monument is 555 ft high. Express this height in meters.
30. The Statue of Liberty is 305 ft high. Express this height in meters.
31. Cells found in the human body have a volume generally in the range of 10^4 to 10^6 cubic microns. A micron is an older name of the unit that is now called a micrometer and is equal to 10^{-6} m. Express this volume in cubic meters and cubic inches.
32. The diameter of a deoxyribonucleic acid (DNA) molecule is about 20 angstroms. Express this diameter in picometers, nanometers, micrometers, millimeters, centimeters, meters, and inches. Note that the old unit angstrom is equal to 10^{-10} m.
33. A glucose molecule has a diameter of about 8.6 angstroms. Express this diameter in millimeters and inches.
34. Muscle fibers range in diameter from 10 microns to 100 microns. Express this range of diameters in centimeters and inches.
35. The axon of the neuron, the nerve cell of the human body, has a diameter of approximately 0.2 microns. Express this diameter in terms of (a) pm, (b) nm, (c) μm, (d) mm, and (e) cm.
36. The Sears Tower in Chicago, the world's tallest building, is 1454 ft high. Express this height in meters.
37. A baseball has a mass of 145 g. Express this mass in slugs.
38. One shipping ton is equal to 40 ft^3. Express this volume in cubic meters.
39. A barrel of oil contains 42 U.S. gallons, each of 231 $in.^3$. What is its volume in cubic meters?
40. The main span of the Verrazano Narrows Bridge in New York is 1298.4 m long. Express this distance in feet and miles.
41. The depth of the Mariana Trench in the Pacific Ocean is 10,911 m. Express this depth in feet.
42. Mount McKinley is 6194 m high. Express this height in feet.
43. The average radius of the earth is 6371 km. Find the area of the surface of the earth in m^2 and in ft^2. Find the volume of the earth in m^3 and ft^3. If the mass of the earth is 5.97×10^{24} kg, find the average density of the earth in kg/m^3.
44. Cobalt-60 has a half-life of 5.27 yr. Express this time in (a) months, (b) days, (c) hours, (d) seconds, and (e) milliseconds.
45. On a certain European road in a quite residential area, the speed limit is posted as 40 km/hr. Express this speed limit in miles per hour.
46. In a recent storm, it rained 6.00 in. of rain in a period of 2.00 hr. If the size of your property is 100 ft by 100 ft, find the total volume of water that fell on your property. Express your answer in (a) cubic feet, (b) cubic meters, (c) liters, and (d) gallons.
47. A cheap wrist watch loses time at the rate of 8.5 seconds a day. How much time will the watch be off at the end of a month? A year?
48. A ream of paper contains 500 sheets of 8½ in. by 11 in. paper. If the package is 1 and ⅞ in. high, find (a) the thickness of each sheet of paper in inches and millimeters, (b) the dimensions of the page in millimeters, and (c) the area of a page in square meters and square millimeters.

Interactive Tutorials

49. Conversion Calculator. The Conversion Calculator will allow you to convert from a quantity in one system of units to that same quantity in another system of units and/or to convert to different units within the same system of units.