CHAPTER 1

1. (*a*) Assuming one significant figure, we have
   10 billion yr = 10×10^{9} yr = 1×10^{10} yr.
   (*b*) $(1 \times 10^{10}$ yr$)(3 \times 10^{7}$ s/yr$)$ = 3×10^{17} s.

2. (*a*) 8.69×10^{4} = 86,900.
   (*b*) 7.1×10^{3} = 7,100.
   (*c*) 6.6×10^{ñ1} = 0.66.
   (*d*) 8.76×10^{2} = 876.
   (*e*) 8.62×10^{ñ5} = 0.000 086 2.

3. (*a*) Assuming the zeros are not significant, we have 1,156,000 = 1.156×10^{6}.
   (*b*) 218 = 2.18×10^{2}.
   (*c*) 0.0068 = 6.8×10^{ñ3}.
   (*d*) 27.635 = 2.7635×10^{1}.
   (*e*) 0.21 = 2.1×10^{ñ1}.
   (*f*) 22 = 2.2×10^{1}.

4. (*a*) 3 significant figures.
   (*b*) Because the zero is not needed for placement, we have 4 significant figures.
   (*c*) 3 significant figures.
   (*d*) Because the zeros are for placement only, we have 1 significant figure.
   (*e*) Because the zeros are for placement only, we have 2 significant figures.
   (*f*) 4 significant figures.
   (*g*) 2, 3, or 4 significant figures, depending on the significance of the zeros.

5. % uncertainty = [(0.25 m)/(2.26 m)] 100 = 11%.
   Because the uncertainty has 2 significant figures, the % uncertainty has 2 significant figures.

6. We assume an uncertainty of 1 in the last place, i. e., 0.01, so we have
   % uncertainty = [(0.01)/(1.67)] 100 = 0.6%.
   Because the uncertainty has 1 significant figure, the % uncertainty has 1 significant figure.

7. We assume an uncertainty of 0.5 s.
   (*a*) % uncertainty = [(0.5 s)/(5 s)] 100 = 1×10^{1}%.
   Because the uncertainty has 1 significant figure, the % uncertainty has 1 significant figure.
   (*b*) % uncertainty = [(0.5 s)/(50 s)] 100 = 1%.
   Because the uncertainty has 1 significant figure, the % uncertainty has 1 significant figure.
   (*c*) % uncertainty = [(0.5 s)/(5 min)(60 s/min)] 100 = 0.2%.
   Because the uncertainty has 1 significant figure, the % uncertainty has 1 significant figure.

8. For multiplication, the number of significant figures in the result is the least number from the multipliers; in this case 2 from the second value.
   $(2.079 \times 10^{2}$ m$)(0.072 \times 10^{ñ1}) = 0.15 \times 10^{1}$ m = 1.5 m.

9. To add, we make all of the exponents the same:

7.2×10^3 s + 8.3×10^4 s + 0.09×10^6 s = 0.72×10^4 s + 8.3×10^4 s + 9×10^4 s
= 18.02×10^4 s = 1.8×10^5 s.

Because we are adding, the location of the uncertain figure for the result is the one furthest to the left. In this case, it is fixed by the third value.

10. We assume an uncertainty of 0.1×10^4 cm. We compare the area for the specified radius to the area for the extreme radius.

A_1 = ¹R_1^2 = ¹(2.8×10^4 cm)^2 = 2.46×10^9 cm^2 ; A_2 = ¹R_2^2 = ¹[(2.8 + 0.1) $\times 10^4$ cm]^2 = 2.64×10^9 cm^2 ,

so the uncertainty in the area is ÆA = A_2 ñ A_1 = 0.18×10^9 cm^2 = 0.2×10^9 cm^2.

We write the area as A = (2.5 ± 0.2) $\times 10^9$ cm^2.

11. We compare the volume with the specified radius to the volume for the extreme radius.

V_1 = 9¹R_1^3 = 9¹(3.86 m)^3 = 241 m^3; V_2 = 9¹R_2^3 = 9¹(3.86 m + 0.08 m)^3 = 256 m^3,

so the uncertainty in the volume is ÆV = V_2 ñ V_1 = 15 m^3; and the % uncertainty is

% uncertainty = [(15 m^3)/(241 m^3)] 100 = 6%.

12. (*a*) 10^6 volts = 1 megavolt = 1 Mvolt.
(*b*) $10^{ñ6}$ meters = 1 micrometer = 1 μm.
(*c*) 5×10^3 days = 5 kilodays = 5 kdays.
(*d*) 8×10^2 bucks = 8 hectobucks = 0.8 kbucks.
(*e*) 8×10^9 pieces = 8 nanopieces = 8 npieces.

13. (*a*) 86.6 mm = 86.6×10^{ñ3} m = 0.086 6 m.
(*b*) 35 μV = 35×10^{ñ6} V = 0.000 035 V.
(*c*) 860 mg = 860×10^{ñ3} g = 0.860 g. This assumes that the last zero is significant.
(*d*) 600 picoseconds = 600×10^{ñ12} s = 0.000 000 000 600 s. This assumes that both zeros are significant.
(*e*) 12.5 femtometers = 12.5×10^{ñ15} m = 0.000 000 000 000 012 5 m.
(*f*) 250 gigavolts = 250×10^9 volts = 250,000,000,000 volts.

14. 50 hectokisses = 50×10^2 kisses = 5,000 kisses.
1 megabuck/yr = 1×10^6 bucks/yr = 1,000,000 bucks/yr (millionaire).

15. If we assume a height of 5 ft 10 in, we have

height = 5 ft 10 in = 70 in = (70 in)[(1 m)/(39.37 in)] = 1.8 m.

16. (*a*) 93 million mi = 93×10^6 mi = (93×10^6 mi)[(1610 m)/(1 mi)] = 1.5×10^{11} m.
(*b*) 1.5×10^{11} m = 150×10^9 m = 150 Gm.

17. (*a*) 1.0×10^{ñ10} m = (1.0×10^{ñ10} m)[(1 in)/(2.54 cm)][(100 cm)/(1 m)] = 3.9×10^{ñ9} in.
(*b*) We let the units lead us to the answer:

(1.0 cm)[(1 m)/(100 cm)][(1 atom)/(1.0×10^{ñ10} m)] = 1.0×10^8 atoms.

18. To add, we make all of the units the same:

    1.00 m + 142.5 cm + 1.24×10^5 μm = 1.00 m + 1.425 m + 0.124 m

    = 2.549 m = 2.55 m.

    Because we are adding, the location of the uncertain figure for the result is the one furthest to the left. In this case, it is fixed by the first value.

19. (*a*) 1 km/h = (1 km/h)[(0.621 mi)/(1 km)] = 0.621 mi/h.

    (*b*) 1 m/s = (1 m/s)[(1 ft)/(0.305 m)] = 3.28 ft/s.

    (*c*) 1 km/h = (1 km/h)[(1000 m)/(1 km)][(1 h)/(3600 s)] = 0.278 m/s.

    A useful alternative is

    1 km/h = (1 km/h)[(1 h)/(3.600 ks)] = 0.278 m/s.

20. For the length of a one-mile race in m, we have

    1 mi = (1 mi)[(1610 m)/(1 mi)] = 1610 m; so the difference is 110 m.

    The % difference is

    % difference = [(110 m)/(1500 m)] 100 = 7.3%.

21. (*a*) 1.00 ly = (2.998×10^8 m/s)(1.00 yr)[(365.25 days)/(1 yr)][(24 h)/(1 day)][(3600 s)/(1 h)]

    = 9.46×10^{15} m.

    (*b*) 1.00 ly = (9.46×10^{15} m)[(1 AU)/(1.50×10^8 km)][(1 km)/(1000 m)] = 6.31×10^4 AU.

    (*c*) speed of light = (2.998×10^8 m/s)[(1 AU)/(1.50×10^8 km)][(1 km)/(1000 m)][(3600 s)/(1 h)]

    = 7.20 AU/h.

22. For the surface area of a sphere, we have

    $A_{moon} = 4^1 r_{moon}^2 = 4^1[!(3.48 \times 10^6\ m)]^2$ = 3.80×10^{13} m^2.

    We compare this to the area of the earth by finding the ratio:

    $A_{moon}/A_{Earth} = 4^1 r_{moon}^2 / 4^1 r_{Earth}^2 = (r_{moon}/r_{Earth})^2$ = [(1.74×10^3 km)/(6.38×10^3 km)]^2 = 7.42 x $10^{ñ2}$.

    Thus we have

    A_{moon} = 7.42 x $10^{ñ2}$ A_{Earth}.

23. (*a*) 7800 = $7.8 \times 10^3 \approx 10 \times 10^3$ = 10^4.

    (*b*) $9.630 \times 10^2 \approx 10 \times 10^2$ = 10^3.

    (*c*) 0.00076 = $0.76 \times 10^{ñ3} \approx$ $10^{ñ3}$.

    (*d*) $150 \times 10^8 = 1.50 \times 10^{10} \approx$ 10^{10}.

24. We assume that a good runner can run 6 mi/h (equivalent to a 10-min mile) for 5 h/day. Using 3000 mi for the distance across the U. S., we have

    time = (3000 mi)/(6 mi/h)(5 h/day) $\approx$ 100 days.

25. We assume a rectangular house 40 ft $\times$ 30 ft, 8 ft high; so the total wall area is

    A_{total} = [2(40 ft) + 2(30 ft)](8 ft) $\approx$ 1000 ft^2.

    If we assume there are 12 windows with dimensions 3 ft $\times$ 5 ft, the window area is

    A_{window} = 12(3 ft)(5 ft) $\approx$ 200 ft^2.

    Thus we have

% window area = $[A_{\text{window}}/A_{\text{total}}](100) = [(200\ \text{ft}^2)/(1000\ \text{ft}^2)](100) \approx$ 20%.

26. If we take an average lifetime to be 70 years and the average pulse to be 60 beats/min, we have

N = (60 beats/min)(70 yr)(365 day/yr)(24 h/day)(60 min/h) ≈ 2×10^9 beats.

27. If we approximate the body as a box with dimensions 6 ft, 1 ft, and 8 in, we have

volume = (72 in)(12 in)(8 in)(2.54 cm/in)^3 ≈ 1×10^5 cm^3.

28. We assume the distance from Beijing to Paris is 10,000 mi.

(*a*) If we assume that todayís race car can travel for an extended period at an average speed of 40 mi/h, we have

time = [(10,000 mi)/(40 mi/h)](1 day/24 h) ≈ 10 days.

(*b*) If we assume that in 1906 a race car could travel for an extended period at an average speed of 5 mi/h, we have

time = [(10,000 mi)/(5 mi/h)](1 day/24 h) ≈ 80 days.

29. We assume that 12 patients visit a dentist each day. If a dentist works 5 days/wk for 48 wk/yr, the total number of visits per year for a dentist is

n_{visits}= (12 visits/day)(5 days/wk)(48 wk/yr) ≈ 3000 visits/yr.

We assume that each person visits a dentist 2 times/yr.

(*a*) We assume that the population of San Francisco is 700,000. We let the units lead us to the answer:

N = (700,000 persons)(2 visits/yr ·person)/(3000 visits/yr ·dentist) ≈ 500 dentists.

(*b*) Left to the reader to estimate the population.

30. If we assume that the person can mow at a speed of 1 m/s and the width of the mower cut is 0.5 m, the rate at which the field is mown is (1 m/s)(0.5 m) = 0.5 m^2/s.

If we take the dimensions of the field to be 110 m by 50 m, we have

time = [(110 m)(50 m)/(0.5 m^2/s)]/(3600 s/h) ≈ 3 h.

31. We assume an average time of 3 yr for the tire to wear d = 1 cm and the tire has a radius of r = 30 cm and a width of w = 10 cm. Thus the volume of rubber lost by a tire in 3 yr is $V = wd2^{1}r$. If we assume there are 100 million vehicles, each with 4 tires, we have

m = (100 × 10^6 vehicles)(4 tires/vehicle)(0.1 m)(0.01 m)2^{1}(0.3 m)(1200 kg/m^3)/(3 yr)

≈ 3×10^8 kg/yr.

32. (*a*) 1.0 Å = (1.0 × $10^{ñ10}$ m)/($10^{ñ9}$ m/nm) = 0.10 nm.

(*b*) 1.0 Å = ($10^{ñ10}$ m)/($10^{ñ15}$ m/fm) = 1.0×10^5 fm.

(*c*) 1.0 m = (1.0 m)/($10^{ñ10}$ m/Å) = 1.0×10^{10} Å.

(*d*) From the result for Problem 21, we have

1.0 ly = (9.5 × 10^{15} m)/($10^{ñ10}$ m/Å) = 9.5×10^{25} Å.

33. (*a*) 1.00 yr = (365.25 days)(24 h/day)(3600 s/h) = 3.16×10^7 s.

(*b*) 1.00 yr = (3.16 × 10^7 s)/($10^{ñ9}$ s/ns) = 3.16×10^{16} ns.

(*c*) 1.00 s = (1.00 s)/(3.16 × 10^7 s/yr) = 3.17×10^{ñ8} yr.

34. (*a*) The maximum number of buses is needed during rush hour. If we assume that at any time there are 40,000 persons commuting by bus and each bus has 30 passengers, we have

N = (40,000 commuters)/(30 passengers/bus) ≈ 1000 buses ≈ 1,000 drivers.

(*b*) Left to the reader.

35. If we ignore any loss of material from the slicing, we find the number of wafers from

(30 cm)(10 mm/cm)/(0.60 mm/wafer) = 500 wafers.

For the maximum number of chips, we have

(500 wafers)(100 chips/wafer) = 50,000 chips.

36. If we assume there is 1 automobile for 2 persons and a U. S. population of 250 million, we have 125 million automobiles. We estimate that each automobile travels 15,000 miles in a year and averages 20 mi/gal. Thus we have

N = (125×10^6 automobiles)(15,000 mi/yr)/(20 mi/gal) ≈ 1×10^{11} gal/yr.

37. We let D represent the diameter of a gumball. Because there are air gaps around the gumballs, we estimate the volume occupied by a gumball as a cube with volume D^3 . The machine has a square cross-section with sides equivalent to 10 gumballs and is about 14 gumballs high, so we have

N = volume of machine/volume of gumball = $(14D)(10D)^2/D^3$ ≈ 1.4×10^3 gumballs.

38. The volume used in one year is

V = [(40,000 persons)/(4 persons/family)](1200 L/family ·day)(365 days/yr)(10^{ñ3} m^3/L)

≈ 4×10^6 m^3.

If we let d represent the loss in depth, we have

$d = V$/area = (4×10^6 m^3)/(50 km^2)(10^3 m/km)^2 ≈ 0.09 m ≈9 cm.

39. For the volume of a 1-ton rock, we have

V = (2000 lb)/(3)(62 lb/ft^3) ≈ 11 ft^3.

If we assume the rock is a sphere, we find the radius from

11 ft^3 = 9¹r^3, which gives r ≈ 1.4 ft, so the diameter would be ≈ 3 ft ≈ 1 m.

40. We find the amount of water from its volume:

m = (5 km)(8 km)(1.0 cm)(10^5 cm/km)^2(10^{ñ3} kg/cm^3)/(10^3 kg/t) = 40×10^4 t ≈ 4×10^5 t.

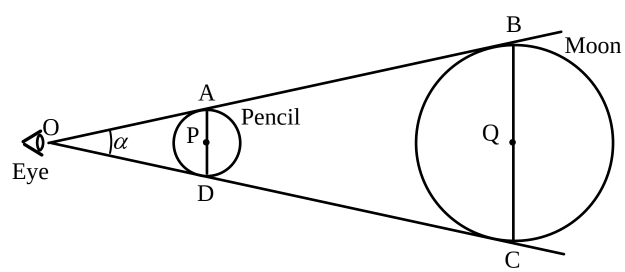
41. We will use a pencil with a diameter of 5 mm and assume that it is held 0.5 m from the eye. Because the triangles AOD and BOC are similar, we can equate the ratio of distances:

BC/AD = OQ/OP;

BC/(0.005 m) = (3.8×10^5 km)/(0.5 m),

which gives

BC ≈ 4×10^3 km.



42. (*a*) $V = (1{,}000\ \text{m}^3)(10^2\ \text{cm/m})^3 =$ $1.00 \times 10^9\ \text{cm}^3$.
    (*b*) $V = (1{,}000\ \text{m}^3)(3.28\ \text{ft/m})^3 =$ $3.53 \times 10^3\ \text{ft}^3$.
    (*c*) $V = (1{,}000\ \text{m}^3)(10^2\ \text{cm/m})^3/(2.54\ \text{cm/in})^3 =$ $6.10 \times 10^7\ \text{in}^3$.

43. We assume that we can walk an average of 15 miles a day. If we ignore the impossibility of walking on water and travel around the equator, the time required is
    time = $2^1 R_{\text{Earth}}/\text{speed} = 2^1(6 \times 10^3\ \text{km})(0.621\ \text{mi/km})/(15\ \text{mi/day})(365\ \text{days/yr})$ ≈ 4 yr.

44. If we use 0.5 m for the cubit, for the dimensions we have
    150 m long, 25 m wide, and 15 m high.