

Chapter 1 – Student Solutions Manual

3. Using the given conversion factors, we find

(a) the distance d in rods to be

$$d = 4.0 \text{ furlongs} = \frac{(4.0 \text{ furlongs})(201.168 \text{ m/furlong})}{5.0292 \text{ m/rod}} = 160 \text{ rods},$$

(b) and that distance in chains to be

$$d = \frac{(4.0 \text{ furlongs})(201.168 \text{ m/furlong})}{20.117 \text{ m/chain}} = 40 \text{ chains}.$$

5. Various geometric formulas are given in Appendix E.

(a) Expressing the radius of the Earth as

$$R = (6.37 \times 10^6 \text{ m})(10^{-3} \text{ km/m}) = 6.37 \times 10^3 \text{ km},$$

its circumference is $s = 2\pi R = 2\pi(6.37 \times 10^3 \text{ km}) = 4.00 \times 10^4 \text{ km}$.

(b) The surface area of Earth is $A = 4\pi R^2 = 4\pi (6.37 \times 10^3 \text{ km})^2 = 5.10 \times 10^8 \text{ km}^2$.

(c) The volume of Earth is $V = \frac{4\pi}{3} R^3 = \frac{4\pi}{3} (6.37 \times 10^3 \text{ km})^3 = 1.08 \times 10^{12} \text{ km}^3$.

17. None of the clocks advance by exactly 24 h in a 24-h period but this is not the most important criterion for judging their quality for measuring time intervals. What is important is that the clock advance by the same amount in each 24-h period. The clock reading can then easily be adjusted to give the correct interval. If the clock reading jumps around from one 24-h period to another, it cannot be corrected since it would be impossible to tell what the correction should be. The following gives the corrections (in seconds) that must be applied to the reading on each clock for each 24-h period. The entries were determined by subtracting the clock reading at the end of the interval from the clock reading at the beginning.

CLOCK	Sun. -Mon.	Mon. -Tues.	Tues. -Wed.	Wed. -Thurs.	Thurs. -Fri.	Fri. -Sat.
A	-16	-16	-15	-17	-15	-15
B	-3	+5	-10	+5	+6	-7
C	-58	-58	-58	-58	-58	-58
D	+67	+67	+67	+67	+67	+67

E	+70	+55	+2	+20	+10	+10
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Clocks C and D are both good timekeepers in the sense that each is consistent in its daily drift (relative to WWF time); thus, C and D are easily made “perfect” with simple and predictable corrections. The correction for clock C is less than the correction for clock D, so we judge clock C to be the best and clock D to be the next best. The correction that must be applied to clock A is in the range from 15 s to 17s. For clock B it is the range from -5 s to +10 s, for clock E it is in the range from -70 s to -2 s. After C and D, A has the smallest range of correction, B has the next smallest range, and E has the greatest range. From best to worst, the ranking of the clocks is C, D, A, B, E.

21. We introduce the notion of density:

$$\rho = \frac{m}{V}$$

and convert to SI units: $1 \text{ g} = 1 \times 10^{-3} \text{ kg}$.

(a) For volume conversion, we find $1 \text{ cm}^3 = (1 \times 10^{-2} \text{ m})^3 = 1 \times 10^{-6} \text{ m}^3$. Thus, the density in kg/m^3 is

$$1 \text{ g/cm}^3 = \left(\frac{1 \text{ g}}{\text{cm}^3} \right) \left(\frac{10^{-3} \text{ kg}}{\text{g}} \right) \left(\frac{\text{cm}^3}{10^{-6} \text{ m}^3} \right) = 1 \times 10^3 \text{ kg/m}^3.$$

Thus, the mass of a cubic meter of water is 1000 kg.

(b) We divide the mass of the water by the time taken to drain it. The mass is found from $M = \rho V$ (the product of the volume of water and its density):

$$M = (5700 \text{ m}^3) (1 \times 10^3 \text{ kg/m}^3) = 5.70 \times 10^6 \text{ kg}.$$

The time is $t = (10\text{h})(3600 \text{ s/h}) = 3.6 \times 10^4 \text{ s}$, so the *mass flow rate* R is

$$R = \frac{M}{t} = \frac{5.70 \times 10^6 \text{ kg}}{3.6 \times 10^4 \text{ s}} = 158 \text{ kg/s}.$$

35. (a) Dividing 750 miles by the expected “40 miles per gallon” leads the tourist to believe that the car should need 18.8 gallons (in the U.S.) for the trip.

(b) Dividing the two numbers given (to high precision) in the problem (and rounding off) gives the conversion between U.K. and U.S. gallons. The U.K. gallon is larger than the U.S gallon by a factor of 1.2. Applying this to the result of part (a), we find the answer for part (b) is 22.5 gallons.

39. Using the (exact) conversion $2.54 \text{ cm} = 1 \text{ in.}$ we find that $1 \text{ ft} = (12)(2.54)/100 = 0.3048 \text{ m}$ (which also can be found in Appendix D). The volume of a cord of wood is $8 \times 4 \times 4 = 128 \text{ ft}^3$, which we convert (multiplying by 0.3048^3) to 3.6 m^3 . Therefore, one cubic meter of wood corresponds to $1/3.6 \approx 0.3 \text{ cord}$.

41. (a) The difference between the total amounts in “freight” and “displacement” tons, $(8 - 7)(73) = 73 \text{ barrels bulk}$, represents the extra M&M’s that are shipped. Using the conversions in the problem, this is equivalent to $(73)(0.1415)(28.378) = 293 \text{ U.S. bushels}$.

(b) The difference between the total amounts in “register” and “displacement” tons, $(20 - 7)(73) = 949 \text{ barrels bulk}$, represents the extra M&M’s are shipped. Using the conversions in the problem, this is equivalent to $(949)(0.1415)(28.378) = 3.81 \times 10^3 \text{ U.S. bushels}$.

45. We convert meters to astronomical units, and seconds to minutes, using

$$\begin{aligned} 1000 \text{ m} &= 1 \text{ km} \\ 1 \text{ AU} &= 1.50 \times 10^8 \text{ km} \\ 60 \text{ s} &= 1 \text{ min.} \end{aligned}$$

Thus, $3.0 \times 10^8 \text{ m/s}$ becomes

$$\left(\frac{3.0 \times 10^8 \text{ m}}{\text{s}} \right) \left(\frac{1 \text{ km}}{1000 \text{ m}} \right) \left(\frac{\text{AU}}{1.50 \times 10^8 \text{ km}} \right) \left(\frac{60 \text{ s}}{\text{min}} \right) = 0.12 \text{ AU/min.}$$

57. (a) When θ is measured in radians, it is equal to the arc length s divided by the radius R . For a very large radius circle and small value of θ , such as we deal with in Fig. 1–9, the arc may be approximated as the straight line-segment of length 1 AU. First, we convert $\theta = 1 \text{ arcsecond}$ to radians:

$$(1 \text{ arcsecond}) \left(\frac{1 \text{ arcminute}}{60 \text{ arcsecond}} \right) \left(\frac{1^\circ}{60 \text{ arcminute}} \right) \left(\frac{2\pi \text{ radian}}{360^\circ} \right)$$

which yields $\theta = 4.85 \times 10^{-6} \text{ rad}$. Therefore, one parsec is

$$R_0 = \frac{s}{\theta} = \frac{1 \text{ AU}}{4.85 \times 10^{-6}} = 2.06 \times 10^5 \text{ AU.}$$

Now we use this to convert $R = 1 \text{ AU}$ to parsecs:

$$R = (1 \text{ AU}) \left(\frac{1 \text{ pc}}{2.06 \times 10^5 \text{ AU}} \right) = 4.9 \times 10^{-6} \text{ pc}.$$

(b) Also, since it is straightforward to figure the number of seconds in a year (about $3.16 \times 10^7 \text{ s}$), and (for constant speeds) distance = speed $\times$ time, we have

$$1 \text{ ly} = (186,000 \text{ mi/s}) (3.16 \times 10^7 \text{ s}) = 5.9 \times 10^{12} \text{ mi}$$

which we convert to AU by dividing by 92.6×10^6 (given in the problem statement), obtaining $6.3 \times 10^4 \text{ AU}$. Inverting, the result is $1 \text{ AU} = 1/6.3 \times 10^4 = 1.6 \times 10^{-5} \text{ ly}$.