1 E SSM Earth is approximately a sphere of radius 6.37×10^6 m. What are (a) its circumference in kilometers, (b) its surface area in square kilometers, and (c) its volume in cubic kilometers?

$R = 6{,}37 \times 10^6 \text{ m} = 6{,}37 \times 10^3 \text{ km}$

$1 \text{ m} = 10^{-3} \text{ km}$

a) $C = 2\pi R = 2 \times 3{,}14 \times 6{,}37 \times 10^3 \simeq 40{,}00 \times 10^3 \text{ km} \Rightarrow C = 4{,}00 \times 10^4 \text{ km}$

$40{,}00 \times 10 = 4{,}00 \times 10$

b) $S = 4\pi R^2 = 4 \times 3{,}14 \times (6{,}37 \times 10^3)^2 = 509{,}64 \times 10^6 \text{ km}^2 \Rightarrow S \simeq 5{,}10 \times 10^8 \text{ km}^2$

$509{,}64 \times 10^6 = 5{,}0964 \times 10^2$

c) $V = \frac{4}{3}\pi R^3 = \frac{4}{3} \times 3{,}14 \times (6{,}37 \times 10^3)^3 \simeq 1082{,}15 \times 10^9 \Rightarrow V = 1{,}08 \times 10^{12} \text{ km}^3$

$1082{,}15 \times 10^3 = 1{,}08215 \times 10^6$

2 E A *gry* is an old English measure for length, defined as 1/10 of a line, where *line* is another old English measure for length, defined as 1/12 inch. A common measure for length in the publishing business is a *point*, defined as 1/72 inch. What is an area of 0.50 gry^2 in points squared (points^2)?

$A = 0{,}50 \text{ gry}^2 \rightarrow \text{point}^2$

$1 \text{ gry} = \frac{1}{10} \text{ line}$

$1 \text{ line} = \frac{1}{12} \text{ inch}$

$1 \text{ point} = \frac{1}{72} \text{ inch} \rightarrow 1 \text{ inch} = 72 \text{ point}$

$1 \text{ gry} = \frac{1}{10} \text{ line} = \frac{1}{10} \times \frac{1}{12} \text{ inch} = 0{,}6 \text{ point}$

$\frac{1}{12} \text{ inch}$ $\quad$ 72 point

$\Rightarrow 1 (\text{gry})^2 = (0{,}6)^2 (\text{point})^2 = 0{,}36 (\text{point})^2$

$\Rightarrow A = 0{,}5 \text{ gry}^2 = 0{,}5 \times 0{,}36 \text{ point}^2 \Rightarrow A \simeq 0{,}18 (\text{point})^2$

3 E The micrometer (1 μm) is often called the *micron*. (a) How many microns make up 1.0 km? (b) What fraction of a centimeter equals 1.0 μm? (c) How many microns are in 1.0 yd?

$1 \text{ m} = 10^6 \mu\text{m}$

$1 \text{ km} = 10^3 \text{ m}$

$\Rightarrow$ a) $1 \text{ km} = 10^3 \text{ m} = 10^9 \mu\text{m}$

$10^3 \text{ m} = 10^6 \mu\text{m}$

b) $1 \text{ cm} = 10^{-2} \text{ m}$, $1 \text{ m} = 10^6 \mu\text{m}$ $\Rightarrow 1 \text{ cm} = 10^{-2} \text{ m} = 10^4 \mu\text{m} \Rightarrow 1 \mu\text{m} = \frac{1}{10^4} \text{ cm} = 10^{-4} \text{ cm}$

$10^{-2} \text{ m} = 10^6 \mu\text{m}$

c) $1 \text{ yrd} = 0{,}914 \text{ m} = 0{,}914 \times 10^6 \mu\text{m} \Rightarrow 1 \text{ yrd} = 9{,}14 \times 10^5 \mu\text{m}$

$10^6 \mu\text{m}$ $\quad$ $0{,}914 \times 10^6 = 9{,}14 \times 10^{-1}$

4 E Spacing in this book was generally done in units of points and picas: 12 points = 1 pica, and 6 picas = 1 inch. If a figure was misplaced in the page proofs by 0.80 cm, what was the misplacement in (a) picas and (b) points?

12 point = 1 pica *

6 pica = 1 inch $\quad d = 0{,}80$ cm

a) 1 inch = 2,54 cm = 6 pica

$1\text{ cm} = \frac{6}{2{,}54}$ pica $\Rightarrow d = 0{,}80 \times \frac{6}{2{,}54} \simeq 1{,}89 = 1{,}9$ pica

b) * $\rightsquigarrow$ $d = 1{,}9$ pica $= 1{,}9 \times 12 \simeq 22{,}68 = 23$ point

5 E SSM Horses are to race over a certain English meadow for a distance of 4.0 furlongs. What is the race distance in (a) rods and (b) chains? (1 furlong = 201.168 m, 1 rod = 5.0292 m, and 1 chain = 20.117 m.)

1 furlong = 201,168 m

1 rod = 5,0292 m *

1 chain = 20,117 m **

$d = 4$ furlong

a) * $\rightarrow$ $1\text{ m} = \frac{1}{5{,}0292}$ rod

1 furlong = 201,168 (m) $= \frac{201{,}168}{5{,}0292}$ rod $\Rightarrow d = 4$ furlong $= 4 \times \frac{201{,}168}{5{,}0292} \simeq 160$ rod

b) * * $\rightarrow$ $1\text{ m} = \frac{1}{20{,}117}$ chain

1 furlong = 201,168 (m) $= \frac{201{,}168}{20{,}117}$ chain $\Rightarrow d = 4$ furlong $= 4 \times \frac{201{,}168}{20{,}117} \simeq 40$ rod

6 E You can easily convert common units and measures electronically, but you still should be able to use a conversion table, such as those in Appendix D. Table 1.1 is part of a conversion table for a system of volume measures once common in Spain; a volume of 1 fanega is equivalent to 55.501 dm^3 (cubic decimeters). To complete the table, what numbers (to three significant figures) should be entered in (a) the cahiz column, (b) the fanega column, (c) the cuartilla column, and (d) the almude column, starting with the top blank? Express 7.00 almudes in (e) medios, (f) cahizes, and (g) cubic centimeters (cm^3).

Table 1.1 Problem 6

	cahiz	fanega	cuartilla	almude	medio
1 cahiz =	1	12	48	144	288
1 fanega =	$\frac{1}{12}$	1	4	12	24
1 cuartilla =	$\frac{1}{48}$	$\frac{1}{4}$	1	3	6
1 almude =	$\frac{1}{144}$	$\frac{1}{12}$	$\frac{1}{3}$	1	2
1 medio =	$\frac{1}{288}$	$\frac{1}{24}$	$\frac{1}{6}$	$\frac{1}{2}$	1

$8{,}33 \times 10^{-2}$ $\quad 2{,}08 \times 10^{-2}$ $\quad 6{,}94 \times 10^{-3}$ $\quad 3{,}47 \times 10^{-3}$ $\quad 4{,}17 \times 10^{-2}$ $\quad 0{,}250$ $\quad 0{,}333$ $\quad 0{,}167$ $\quad 0{,}500$

e) 7 almude = ? medio

1 almude = 2 medio $\longrightarrow$ **7 almude = 14 medio**

f) 7 almude = ? cahiz

1 almude = $\frac{1}{144}$ cahiz $\Rightarrow$ **7 almude = $\frac{7}{144}$ cahiz = $4{,}86 \times 10^{-2}$ cahiz**

g) 7 almude = ? cm^3

1 fanega = $55{,}501\ dm^3 = 55{,}501\ (10\ cm)^3 = 55{,}501 \times 10^3\ cm^3$

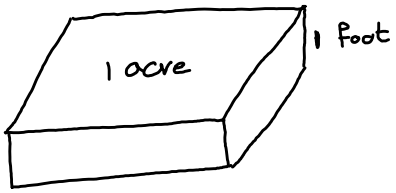
12 almude

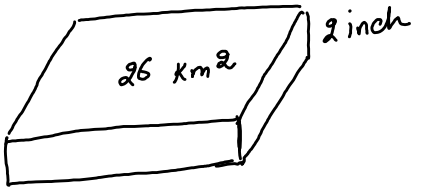
$\longrightarrow$ 1 almude = $\frac{55{,}501 \times 10^3}{12}\ cm^3$ $\Rightarrow$ 7 almude = $\frac{55{,}501 \times 10^3}{12} \times 7\ cm^3$

$\Rightarrow$ **7 almude $\simeq 3{,}24 \times 10^4\ cm^3$**

7 M Hydraulic engineers in the United States often use, as a unit of volume of water, the *acre-foot*, defined as the volume of water that will cover 1 acre of land to a depth of 1 ft. A severe thunderstorm dumped 2.0 in. of rain in 30 min on a town of area 26 km^2. What volume of water, in acre-feet, fell on the town?

$V = 26 \times 2 = 52\ km^2 \cdot inch$





$km^2 \longrightarrow$ acre

inch $\longrightarrow$ foot

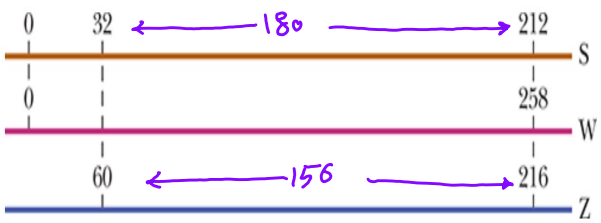
$km^2 \cdot$ inch $\longrightarrow$ acre-foot

1 km^2 = 247,105 acre
1 inch = 0,0833 foot
$\Rightarrow$ 1 km^2 - inch = 247,105 x 0,0833 acre-foot

20,58

$\longrightarrow V = 52 \times 20{,}58$ acre-foot $= 1070{,}36 \simeq 1{,}1 \times 10^3$ acre-foot

8 M GO Harvard Bridge, which connects MIT with its fraternities across the Charles River, has a length of 364.4 Smoots plus one ear. The unit of one Smoot is based on the length of Oliver Reed Smoot, Jr., class of 1962, who was carried or dragged length by length across the bridge so that other pledge members of the Lambda Chi Alpha fraternity could mark off (with paint) 1-Smoot lengths along the bridge. The marks have been repainted biannually by fraternity pledges since the initial measurement, usually during times of traffic congestion so that the police cannot easily interfere. (Presumably, the police were originally upset because the Smoot is not an SI base unit, but these days they seem to have accepted the unit.) Figure 1.1 shows three parallel paths, measured in Smoots (S), Willies (W), and Zeldas (Z). What is the length of 50.0 Smoots in (a) Willies and (b) Zeldas?



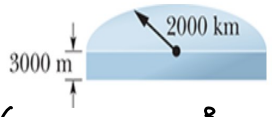
a) 212 smoot = 258 willie $\Rightarrow$ 1 smoot = $\frac{258}{212}$ willie

$\Rightarrow$ 50 smoot = $50 \times \frac{258}{212} \simeq 60{,}8$ willie $\Rightarrow$ 50 S $\simeq$ 60,8 W

b) 180 smoot = 156 zelda $\Rightarrow$ 1 smoot = $\frac{156}{180}$ zelda

$\Rightarrow$ 50 smoot = $50 \times \frac{156}{180} \simeq 43{,}3$ zelda $\Rightarrow$ 50 S = 43,3 Z

9 M Antarctica is roughly semicircular, with a radius of 2000 km (Fig. 1.2). The average thickness of its ice cover is 3000 m. How many cubic centimeters of ice does Antarctica contain? (Ignore the curvature of Earth.)



$V = ?\ cm^3$

$R = 2000\ km = 2 \times 10^3 \times 10^3\ m = 2 \times 10^6\ m = 2 \times 10^8\ cm$ ($1\ m = 10^2\ cm$)

$h = 3000\ m = 3 \times 10^3 \times 10^2\ cm = 3 \times 10^5\ cm$

$V_{\text{hemisphere}} = \pi R^2 \times h \longrightarrow V = \frac{1}{2}\pi R^2 h = \frac{1}{2} \times 3{,}14 \times (2 \times 10^8)^2 \times 3 \times 10^5 = 18{,}84 \times 10^{21}$ ($2 \times 2 = 4 \times 10^{16}$; $1{,}88 \times 10$)

$\Rightarrow V = 1{,}88 \times 10^{22}\ cm^3$