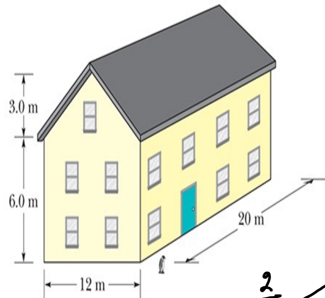
32 In the United States, a doll house has the scale of 1:12 of a real house (that is, each length of the doll house is $\frac{1}{12}$ that of the real house) and a miniature house (a doll house to fit within a doll house) has the scale of 1:144 of a real house. Suppose a real house (Fig. 1.4) has a front length of 20 m, a depth of 12 m, a height of 6.0 m, and a standard sloped roof (vertical triangular faces on the ends) of height 3.0 m. In cubic meters, what are the volumes of the corresponding (a) doll house and (b) miniature house?

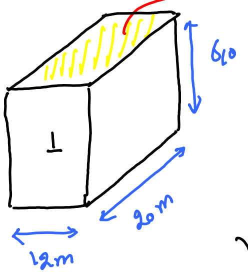


h : real house

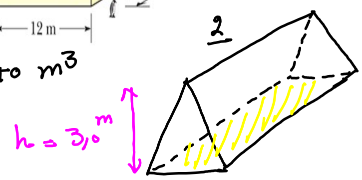
h' : doll "

h'' : miniature "

$A = 12 \times 20 = 240 \text{ m}^2$



$V_1 = 12 \times 20 \times 6{,}0 = 1440 \text{ m}^3$



$V_2 = \dfrac{A \cdot h}{2} = \dfrac{240 \times 3{,}0}{2}$

$V_2 = 360 \text{ m}^3$

$V_h = 1440 + 360 = 1{,}8 \times 10^3 \text{ m}^3$

a) $\dfrac{h'}{h} = \dfrac{1}{12} \rightarrow \dfrac{V_{h'}}{V_h} = \left(\dfrac{1}{12}\right)^3 \rightarrow V_{h'} = 1{,}8 \times 10^3 \times \left(\dfrac{1}{12}\right)^3 \simeq 0{,}001 \times 10^3 = \boxed{1{,}0 \text{ m}^3}$

V_h: $1{,}8 \times 10^3$

b) $\dfrac{h''}{h} = \dfrac{1}{144} \Rightarrow \dfrac{V_{h''}}{V_h} = \left(\dfrac{1}{144}\right)^3 \Rightarrow V_{h''} = 1{,}8 \times 10^3 \times \left(\dfrac{1}{144}\right)^3 \simeq \boxed{6{,}0 \times 10^{-4} \text{ m}^3}$

33 SSM A ton is a measure of volume frequently used in shipping, but that use requires some care because there are at least three types of tons: A *displacement ton* is equal to 7 barrels bulk, a *freight ton* is equal to 8 barrels bulk, and a *register ton* is equal to 20 barrels bulk. A *barrel bulk* is another measure of volume: 1 barrel bulk = 0.1415 m^3. Suppose you spot a shipping order for "73 tons" of M&M candies, and you are certain that the client who sent the order intended "ton" to refer to volume (instead of weight or mass, as discussed in Chapter 5). If the client actually meant displacement tons, how many extra U.S. bushels of the candies will you erroneously ship if you interpret the order as (a) 73 freight tons and (b) 73 register tons? (1 m^3 = 28.378 U.S. bushels.)

1 displacement ton = 7 barrel bulk

1 freight " = 8 " "

1 register " = 20 " "

1 barrel bulk = 0,1415 m^3

1 m^3 = 28,378 bushel

$M_{real} = 73$ displacement ton

a) $M = 73$ freight ton $\Rightarrow M - M_{real} = 73 \times 8 - 73 \times 7 = 73 \times (8-7) = 73 \underbrace{\text{barrel}}_{0{,}1415 \text{ m}^3}$

$\Rightarrow \Delta M = 73 \times 0{,}1415 \simeq 10{,}33 \underbrace{\text{m}^3}_{28{,}378} \Rightarrow \boxed{\Delta M \simeq 293 \text{ bushel}}$

b) $M = 73$ register ton $\Rightarrow M - M_{real} = 73 \times 20 - 73 \times 7 = 73 \times \overbrace{(20-7)}^{13} \underbrace{\text{barrel}}_{0{,}1415 \times 28{,}378}$

$\Rightarrow \boxed{\Delta M \simeq 3{,}8 \times 10^3 \text{ bushel}}$

34 Two types of *barrel* units were in use in the 1920s in the United States. The apple barrel had a legally set volume of 7056 cubic inches; the cranberry barrel, 5826 cubic inches. If a merchant sells 20 cranberry barrels of goods to a customer who thinks he is receiving apple barrels, what is the discrepancy in the shipment volume in liters?

apple barrel = 7056 in^3 $\qquad N = 20$

cranberry " = 5826 in^3

$V_1 = 20$ apple barrel $= 20 \times 7056$ in^3

$V_2 = 20$ cranberry " $= 20 \times 5826$ in^3

$\Longrightarrow \Delta V = V_1 - V_2 = 20 \times \overbrace{(7056 - 5826)}^{1230}$

$\Longrightarrow \Delta V = 24600 \ \underbrace{in^3}_{1{,}639 \times 10^{-2}}$

Appendix : $1 \ in^3 = 1{,}639 \times 10^{-2}$ liter

$\rightarrow \boxed{\Delta V \simeq 403 \text{ liter}}$

35 An old English children's rhyme states, "Little Miss Muffet sat on a tuffet, eating her curds and whey, when along came a spider who sat down beside her...." The spider sat down not because of the curds and whey but because Miss Muffet had a stash of 11 tuffets of dried flies. The volume measure of a tuffet is given by 1 tuffet = 2 pecks = 0.50 Imperial bushel, where 1 Imperial bushel = 36.3687 liters (L). What was Miss Muffet's stash in (a) pecks, (b) Imperial bushels, and (c) liters?

1 tuffet = 2 peck = 0,50 imperial bushel $\qquad V = 11$ tuffet

1 imperial bushel = 36,3687 liter

a) $V = 11 \ \underbrace{\text{tuffet}}_{2 \text{ pecks}} = \boxed{22 \text{ peck}}$

b) $V = 11 \ \underbrace{\text{tuffet}}_{0{,}5 \text{ bushel}} = \boxed{5{,}5 \text{ imperial bushel}}$

c) $V = 5{,}5 \ \underbrace{\text{bushel}}_{36{,}3687 \text{ liter}} \simeq \boxed{200 \text{ liter}}$

36 Table 1.2 shows some old measures of liquid volume. To complete the table, what numbers (to three significant figures) should be entered in (a) the wey column, (b) the chaldron column, (c) the bag column, (d) the pottle column, and (e) the gill column, starting from the top down? (f) The volume of 1 bag is equal to 0.1091 m^3. If an old story has a witch cooking up some vile liquid in a cauldron of volume 1.5 chaldrons, what is the volume in cubic meters?

	wey	chaldron	bag	pottle	gill
wey	1	$\frac{10}{9}$	$\frac{40}{3}$	640	120240
chaldron	$\frac{9}{10} = 0{,}900$	1	12	576	$108216 = 1{,}08 \times 10^5$
bag	$\frac{3}{40} = 7{,}50 \times 10^{-2}$	$\frac{1}{12} = 8{,}37 \times 10^{-2}$	1	48	$9018 = 9{,}02 \times 10^3$
pottle	$\frac{1}{640} = 1{,}56 \times 10^{-3}$	$\frac{1}{576} = 1{,}74 \times 10^{-3}$	$\frac{1}{48} = 2{,}08 \times 10^{-2}$	1	188
gill	$\frac{1}{120240} = 8{,}32 \times 10^{-6}$	$\frac{1}{108216} = 9{,}24 \times 10^{-6}$	$\frac{1}{9018} = 1{,}11 \times 10^{-4}$	$\frac{8}{1503} = 5{,}32 \times 10^{-3}$	1

1 wey $= \frac{10}{9}$ chaldron $= \frac{40}{3}$ bag $= 640$ pottle $= 120240$ gill *

b) $\frac{10}{9}$ chaldron $= \frac{40}{3}$ bag $\Rightarrow$ 1 chaldron $= \frac{\cancel{9}^{3}}{\cancel{10}} \times \frac{\cancel{40}^{4}}{\cancel{3}}$ bag $= 12$ bag

* : $\frac{10}{9}$ chaldron = 640 pottle → 1 chaldron = $\frac{9}{10} \times 640 = 576$ pottle

* : $\frac{10}{9}$ chaldron = 120240 gill → 1 chaldron = $\frac{9}{10} \times 120240 = 108216$ gill

c) * : $\frac{40}{3}$ bag = 640 pottle → 1 bag = $\frac{3}{40} \times 640 = 48$ pottle

* : $\frac{40}{3}$ bag = 120240 gill → 1 bag = $\frac{3}{40} \times 120240 = 9018$ gill

d) * : 640 pottle = 120240 gill → 1 pottle = $\frac{120240}{640} = \frac{1503}{8} = 187{,}87 = 188$ gill

f) 1 bag = 0,1091 m^3 $\quad V = 1{,}5 \underbrace{\text{chaldon}}_{12\ \text{bag}} = 16 \underbrace{\text{bag}}_{0{,}1091\ m^3} \rightarrow \boxed{V \simeq 1{,}96\ m^3}$

37 A typical sugar cube has an edge length of 1 cm. If you had a cubical box that contained a mole of sugar cubes, what would its edge length be? (One mole = 6.02×10^{23} units.)

$v = 1\ cm^3$

$N = 6{,}02 \times 10^{23}$ → $V_{box} = N.v = 6{,}02 \times 10^{23} \times 1 = 6{,}02 \times 10^{23}\ cm^3 = a^3$

→ $a = \sqrt[3]{V_{box}} = \sqrt[3]{\underbrace{6{,}02 \times 10^2}_{602} \times 10^{21}} = \sqrt[3]{602} \times 10^7 \simeq 8{,}44 \times 10^7\ \underbrace{cm}_{10^{-5}\ km}$

→ $a \simeq 8{,}44 \times 10^2$ $\boxed{\simeq 844\ km}$

38 An old manuscript reveals that a landowner in the time of King Arthur held 3.00 acres of plowed land plus a livestock area of 25.0 perches by 4.00 perches. What was the total area in (a) the old unit of roods and (b) the more modern unit of square meters? Here, 1 acre is an area of 40 perches by 4 perches, 1 rood is an area of 40 perches by 1 perch, and 1 perch is the length 16.5 ft.

$A_1 = 3{,}00$ acre

$A_2 = 25{,}0 \times 4{,}00$ perch^2 = 100 perch^2

1 acre = $40 \times 4 = 160$ perch^2

1 rood = $40 \times 1 = 40$ perch^2

↓

1 perch^2 = $\frac{1}{40}$ rood

a) $A_1 = 3{,}00 \underbrace{\text{acre}}_{160\ \text{perch}^2} = 480$ perch^2

→ $A = A_1 + A_2 = 480 + 100 = 580 \underbrace{\text{perch}^2}_{\frac{1}{40}\ \text{rood}} = \frac{580}{40}$ rood → $\boxed{A = 14{,}5\ \text{rood}}$

b) 1 perch = 16,5 ft

$A = 580$ perch^2 $= 580 \times (16{,}5\ ft)^2 = 580 \times (16{,}5)\ ft^2 = 157905\ ft^2$

Appendix D: 1 $ft^2 = 9{,}290 \times 10^{-2}\ m^2$

→ $A = 157905 \times 9{,}290 \times 10^{-2}$ $\boxed{\simeq 1{,}47 \times 10^4\ m^2}$

39 SSM A tourist purchases a car in England and ships it home to the United States. The car sticker advertised that the car's fuel consumption was at the rate of 40 miles per gallon on the open road. The tourist does not realize that the U.K. gallon differs from the U.S. gallon:

1 U.K. gallon = 4.546 090 0 liters ←
1 U.S. gallon = 3.785 411 8 liters.

For a trip of 750 miles (in the United States), how many gallons of fuel does (a) the mistaken tourist believe she needs and (b) the car actually require?

$R = 40$ mile/gallon

mile	gallon
40	1
750	$x = \frac{750}{40} \simeq 18{,}75 = 18{,}8$ gallon

$$\frac{\text{Uk gallon}}{\text{Us gallon}} = \frac{4{,}5460900}{3{,}7854118} \simeq 1{,}20095 = 1{,}2$$

a) $V_{fake} = 18{,}8$ U.S. gallon

b) $V_{real} = 18{,}75 \times 1{,}20095 \simeq 22{,}5$ U.S. gallon

40 Using conversions and data in the chapter, determine the number of hydrogen atoms required to obtain 1.0 kg of hydrogen. A hydrogen atom has a mass of 1.0 u.

$m_H = 1$ u

Appendix D: $1\,u = 1{,}661 \times 10^{-27}$

atom	kg
1	$1{,}661 \times 10^{-27}$
N	1

$\Rightarrow N = \frac{1}{1{,}661 \times 10^{-27}}$

$\rightarrow N \simeq \underbrace{0{,}60}_{6{,}0 \times 10^{-1}} \times 10^{+27} = 6{,}0 \times 10^{26}$

41 SSM A *cord* is a volume of cut wood equal to a stack 8 ft long, 4 ft wide, and 4 ft high. How many cords are in 1.0 m^3?

$V = 8 \times 4 \times 4 = 128\ ft^3 \rightarrow 1$ Cord $= 128\ ft^3$

Appendix D: $1\ (ft)^3 = 2{,}832 \times 10^{-2}\ m^3$

$\rightarrow 1$ Cord $= 128 \times 2{,}832 \times 10^{-2} = 3{,}62496\ m^3 \Rightarrow 1\ m^3 = \frac{1}{3{,}62496} \simeq 0{,}28 = 0{,}3$ Cord

42 One molecule of water (H_2O) contains two atoms of hydrogen and one atom of oxygen. A hydrogen atom has a mass of 1.0 u and an atom of oxygen has a mass of 16 u, approximately. (a) What is the mass in kilograms of one molecule of water? (b) How many molecules of water are in the world's oceans, which have an estimated total mass of 1.4×10^{21} kg?

a)

$\left.\begin{array}{l} m_H = 1\ u \\ m_O = 16\ u \end{array}\right\} \Rightarrow m_{H_2O} = 2 \times 1 + 16 = 18\,u = \underbrace{18 \times 1{,}661}_{29{,}898 = 2{,}9898 \times 10 \simeq 3{,}0} \times 10^{-27} \rightarrow m_{H_2O} = 3{,}0 \times 10^{-26}$ kg

Appendix D: $1\ u = 1{,}661 \times 10^{-27}$ kg

b)

molecule	kg
1	$3{,}0 \times 10^{-26}$
N	$1{,}4 \times 10^{21}$

$\Rightarrow N = \frac{1{,}4 \times 10^{21}}{3{,}0 \times 10^{-26}} \simeq \underbrace{0{,}47}_{4{,}7 \times 10^{-1}} \times 10^{21} \times 10^{26} \rightarrow N \simeq 4{,}7 \times 10^{46}$

43 A person on a diet might lose 2.3 kg per week. Express the mass loss rate in milligrams per second, as if the dieter could sense the second-by-second loss.

$$R = 2{,}3\ \frac{kg}{week} = ?\ \frac{mg}{s} \Longrightarrow R = 2{,}3 \times \frac{10^6\ mg}{604800\ s} = \frac{2{,}3 \times 10^6}{604800} \simeq \boxed{3{,}8\ mg/s}$$

$$1\ kg = 10^3\ g = 10^3 \times 10^3\ mg = 10^6\ mg$$

$$1\ week = 24\ day = 24 \times 7 \times 3600 = 604800\ s$$

44 What mass of water fell on the town in Problem 7? Water has a density of $1.0 \times 10^3\ kg/m^3$.

Problem 7: $A = 26\ km^2 = 26 \times (10^3)^2\ m^2 = 26 \times 10^6\ m^2$

$h = 2{,}0\ in = 2{,}0 \times 2{,}54 \times 10^{-2}\ m$

Appendix D: $1\ in = 2{,}54 \times 10^{-2}\ m$

$$\Longrightarrow V = A.h = 26 \times 10^6 \times 2{,}0 \times 2{,}54 \times 10^{-2} = \underbrace{132{,}08}_{\simeq 1{,}32 \times 10^2} \times 10^4\ m^3$$

$$\rho = \frac{m}{V} \Longrightarrow m = \rho . V = 1{,}0 \times 10^3 \times 1{,}32 \times 10^6 \Longrightarrow \boxed{m \simeq 1{,}3 \times 10^9\ kg}$$

45 (a) A unit of time sometimes used in microscopic physics is the *shake*. One shake equals 10^{-8} s. Are there more shakes in a second than there are seconds in a year? (b) Humans have existed for about 10^6 years, whereas the universe is about 10^{10} years old. If the age of the universe is defined as 1 "universe day," where a universe day consists of "universe seconds" as a normal day consists of normal seconds, how many universe seconds have humans existed?

a)

$1\ shake = 10^{-8}\ s \Longrightarrow 1\,s = 10^8\ shake$ ✓

$1\ year = 365{,}25 \times 3600 \simeq 3{,}2 \times 10^7\ s$

b) $t = 10^6\ year$

$T = 10^{10}\ year = 1\ universe\ day$

$$\Longrightarrow \frac{t}{T} = \frac{10^6}{10^{10}} = 10^{-4} \longrightarrow t = 10^{-4}\ \underbrace{universe\ day}_{24 \times 3600\ s}$$

T: 1 universe day

$$\longrightarrow \boxed{t \simeq 8{,}64\ universe\ second}$$

46 A unit of area often used in measuring land areas is the *hectare*, defined as $10^4\ m^2$. An open-pit coal mine consumes 75 hectares of land, down to a depth of 26 m, each year. What volume of earth, in cubic kilometers, is removed in this time?

$1\ hectare = 10^4\ m^2$

$A = 75\ hectare = 75 \times 10^4\ m^2$

$h = 26\ m$

$$V = A.h = 75 \times 10^4 \times 26 \simeq 2 \times 10^7\ \underbrace{m^3}_{(10^{-3}\ km)^3} = 2 \times 10^7 \times 10^{-9} \simeq 2 \times 10^{-2} = \boxed{0{,}02\ km^3}$$