Handout – Unit Conversions (Dimensional Analysis)

This section will cover conversions (1) selected units in the metric and American systems, (2) compound or derived measures, and (3) between metric and American systems. Also, (4) applications using conversions will be presented.

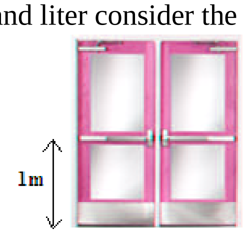
The **metric system** is based on a set of basic units and prefixes representing powers of 10.

Basic units	
length	meter (m)
mass	gram (g)
volume	liter (L)
time	second (s)
temperature	Celsius or Centigrade (°C) Kelvin (°K)

Prefixes (The units that are in bold are the ones commonly used.)		
prefix	**symbol**	**value**
yotta	Y	1,000,000,000,000,000,000,000,000 = 10^{24}
zetta	Z	1,000,000,000,000,000,000,000 = 10^{21}
exa	E	1,000,000,000,000,000,000 = 10^{18}
peta	P	1,000,000,000,000,000 = 10^{15}
tera	T	1,000,000,000,000 = 10^{12}
giga	G	1,000,000,000 = 10^{9} (a billion)
mega	M	1,000,000 = 10^{6} (a million)
kilo	**k**	**1,000 = 10^{3}**
hecto	h	100 = 10^{2}
deca	da	10
		1
deci	d	$\frac{1}{10} = 0.1 = 10^{-1}$
centi	**c**	**$\frac{1}{100} = 0.01 = 10^{-2}$**
milli	**m**	**$\frac{1}{1,000} = 0.001 = 10^{-3}$ (a thousandth)**
micro	µ (the Greek letter mu)	$\frac{1}{1,000,000} = 0.000001 = 10^{-6}$ (a millionth)
nano	n	$\frac{1}{1,000,000,000} = 0.000000001 = 10^{-9}$ (a billionth)

To get a sense of the size of the basic units of meter, gram and liter consider the following examples.

The standard height of a door handle or knob is 1 meter.



The weight of a penny is 2.5 grams.

Almost everyone is familiar with 2 liter bottles of soda.

The next set of examples illustrates the use of some of the most used prefixes.

Examples:

1. 1 milligram = $\frac{1}{1,000}$ gram = 0.001 gram, or 1 mg = $\frac{1}{1,000}$ g = 0.001 gram

2. 1000 mg=1g

3. 1 milliliter= $\frac{1}{1,000}$ liter=0.001 liter, or 1 mL= $\frac{1}{1,000}$ L=0.001 L

4. 1,000 mL = 1 L

5. 1 centimeter= $\frac{1}{100}$ meter=0.01 meter, or 1 cm = $\frac{1}{100}$ m = 0.01 m

6. 1 kilogram = 1,000 grams, or 1 kg = 1,000 g

7. 1 kilometer = 1,000 meters, or 1 km = 1000 m

8. 1 microgram = $\frac{1}{1,000,000}$ g = .000001 g, or 1 mcg = $\frac{1}{1,000,000}$ g ; 1,000,000 mcg = 1 g

9. 1 nanosecond = $\frac{1}{1,000,000,000}$ second = .000000001 seconds, or a billionth of a second

   1 ns = $\frac{1}{1,000,000,000}$ s = .000000001 s ; 1,000,000,000 ns = 1 s

10. 1 kilobyte = 1000 bytes (a byte is a unit used in computers to express the length of a “word”.)

11. 1 megabyte = 1,000,000 bytes = 1000 kilobytes

Conversion Tables

The **American system** of measurements is based on the English system.

CAPACITY (volume)
1 **gallon** = 1gal = 4 quarts = 4 qts
1 **quart** = 1 qt = 2 pints = 2 pt
1 **pint** = 1 pt = 2 cups = 2 c = 16 fluid ounces = 16 fl oz
1 **cup** = 1c = 8 fluid ounces = 8 fl. oz (Note: a fluid ounce is not the same as the weight measure ounce.)
1 **fluid ounce** = 1 fl oz = 2 tablespoons = 2 tbsp
1 **tablespoon** = 1 tbsp = 3 teaspoons = 3 tsp
1 **fluid ounce** = 1 fl oz = 480 minims (A minim is an apothecaries' measure.)

TEMPERATURE
Temperature is measured in degrees **Fahrenheit** (°F) (At sea level, water freezes at 32 °F and boils at 212 °F.) Remember: the metric system measurement for temperature are **Celsius** (°C) and **Kelvin** (°K).
The formulas used for temperature conversions are $F = \frac{9}{5}C + 32$
$C = \frac{5}{9}(F - 32)$
$K = C + 273.15$
$C = K - 273.15$

CONVERSIONS TO METRIC
1 inch = 0.0254 meters = 2.54 centimeters
1 yard = 0.9144 meters
1 mile = 1609.344 meters = 1.609344 kilometers
1 pound = 453.59237 grams
1 ounce ≈28.35 grams
1 grain ≈0.065 grams = 65 milligrams
1 gallon ≈ 3.784 liters
1 quart ≈ .9464 liters
1 fluid ounce ≈ .02957 liters = 29.57 milliliters
1 teaspoon ≈ .00493 liters = 4.93 milliliters
1 minim = .062 milliliters
1 tsp = 4.93 mL
1 tbsp = 14.8 mL
1 grain (a small unit of weight) = 65 mg = .065 g
$C = \frac{5}{9}(F - 32)$
$K = \frac{5}{9}(F - 32) + 273.15$

LENGTH
1 **foot** = 1 ft = 12 inches = 12 in
1 **yard** = 1 yd = 3 feet = 3 ft = 36 in
1 **rod** = 5.5 yd = 16.5 ft = 198 in
1 **furlong** = 220 yd
1 **mile** = 1 mi = 5280 feet = 5280 ft = 1760 yd = 8 furlongs

TIME
1 **minute** = 1 min = 60 seconds = 60 s
1 **hour** = 1 hr = 60 min
1 **day** = 24 hr

MASS
437.5 **grains** = 1 ounce = 1 oz
1 **pound** = 1 lb = 16 ounces = 16 oz
1 **ton** = 2000 pounds = 2000 lb (This is sometimes called a short ton or ton(US). A long ton or ton(UK) is equal to 2240 pounds.)

CONVERSIONS TO AMERICAN
1 meter = 1.0936 yards = 3.2808 feet = 39.37 inches
1 kilometer = .62137 miles
1 gram = .03527 ounces
1 kilogram = 35.27 ounces = 2.205 pounds
1 liter = .26417 gallons = 1.0567 quarts
$F = \frac{9}{5}C + 32$
$F= \frac{9}{5}(K - 273.15) + 32$

Milliliters are used extensively in the sciences and medicine. The abbreviation "**cc**" is often used instead of **mL**. The relation of **mL** to volume is given by

$$\mathbf{1\ mL = 1\ cc = 1\ cm^3}$$

Areas and volumes

Recall that **area** is measured in squares. One square foot or 1 ft^2 represents the area covered by a square 1 foot by 1 foot.

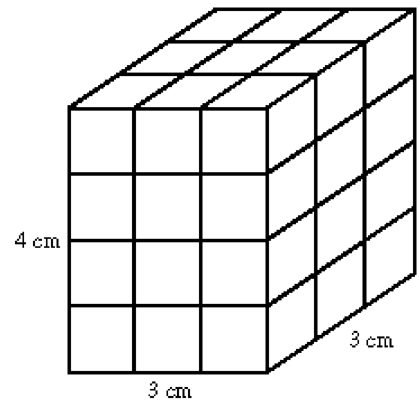
Example:
12 square feet = 12 ft^2 means 12 squares 1 foot by 1 foot. The measure of the area of a rectangle 3 ft by 4 ft is 12 ft^2 since it can be covered (tiled) with 12 squares each 1 foot by 1 foot.

1	**2**	**3**	**4**
5	**6**	**7**	**8**
9	**10**	**11**	**12**

Volume is measured in cubes. One cubic centimeter or 1 cm^3 represents the volume that can be covered by a cube 1 cm by 1 cm by 1 cm.

Example: Find the volume of a box 3 cm by 3 cm by 4 cm. The question is, how many cubes 1 cm on a side can be put into this box. 3 cm × 3 cm × 4 cm = 36 cm^3.

That is, the box will hold 36 cubes 1cm by 1 cm by 1 cm.



A table could be made for areas and another could be made for volumes. The tables would include facts like 1 ft^2 = 144 in^2, 1 yd^2 = 9 ft^2, 1 m^2 = 10000 cm^2, 1 ft^3 = 1728 in^3, etc.
Fortunately, as shown below, this is not necessary.

This handout will cover one method commonly used in the sciences to convert units. This method uses multiples of "1" in a convenient form.

Examples:

a) 4000 in = ? ft

Notice that 1 ft = 12 in. We write our "1" as $\frac{1ft}{12in}$ so that "in" in 4000 in will cancel.

$$4,000in = \frac{4,000in}{1}\cdot\frac{1ft}{12in} = \frac{4,000}{12}ft \approx 333.33ft.$$

notice that the "in" canceled

b) 18 ft = ? in

Notice that 1 ft = 12 in. This time we write our "1" as 12in / 1ft so that the "ft" cancel leaving only "in" as the unit.

$$18ft = \frac{18ft}{1}\cdot\frac{12in}{1ft} = 216in$$

c) 2.3 mi = ? in

From the conversion tables on page 3 notice that 1 mi = 5280 ft and 1 ft = 12 in. So we should write our "1" in two different ways $1=\frac{5280\,ft}{1mi}$ and as $1=\frac{12in}{1\,ft}$. Using the first fraction we can convert miles into feet, while using the second fraction we can further convert the feet into inches. Combining these two we have the following:

$$2.3mi=\frac{2.3mi}{1}\frac{5280\,ft}{1mi}\frac{12in}{1\,ft}=\frac{(2.3)(5280)(12)}{1}in=145728in$$

notice that the "mi" and the "ft" cancel.

d) 146000 cm = ? km

Just like in the previous example we don't have a direct conversion between centimeters (cm) and kilometers (km). However, both are connected through meters (m). Therefore, we will use the "1" in two different ways: $1=\frac{1m}{100cm}$ and $1=\frac{1km}{1000m}$. Using both, we get the following:

$$146000cm=\frac{146000cm}{1}\frac{1m}{100cm}\frac{1km}{1000m}=\frac{146000}{(100)(1000)}km=1.46km$$

notice that the "cm" and the "m" cancel

e) 1,000,000 fl oz = ? gal

From the conversion tables on page 3, we see that $1\,pt\ =\ 16\ fl\ oz, 1qt=2pt$
$1pt=16\,floz, 1qt=2\,pt$ and $1gal=4qt$. We have to combine all three of these conversions to go from fluid ounces to gallons:

$$1000000\,fl\ \ oz=\frac{1000000\,fl\ \ oz}{1}\frac{1pt}{16\,fl\ \ oz}\frac{1qt}{2\,pt}\frac{1gal}{4qt}=\frac{1000000}{(16)(2)(4)}gal=7812.5gal$$

notice that the "fl oz", the "pt", and the "qt" cancel.

f) 18 ft^2 = ? yd^2

The following is the standard method for handling areas and volumes. The conversion tables on page 3 say that $1yd=3\,ft$. For **square units**, we have to use this conversion **twice** so that "ft^2" cancels with "ft·ft".

$$18\,ft^2=\frac{18\,ft^2}{1}\frac{1yd}{3\,ft}\frac{1yd}{3\,ft}=\frac{18}{(3)(3)}yd^2=2\,yd^2$$

<u>Another way</u> to obtain the same result is to create a new conversion formula for our specific purpose. Since $1yd=3\,ft$ we immediately have $1yd^2=3\,ft\cdot 3\,ft=9\,ft^2$ and

$$18\,ft^2=\frac{18\,ft^2}{1}=\frac{18\,ft^2}{1}\cdot\frac{1yd^2}{9\,ft^2}=2\,yd^2$$

g) 1,000,000 mm^2 = ? km^2

This time we will use two conversions 1 m = 1000 mm and 1 km = 1000 m. Each of these two conversion will be used twice, since we are using square units:

$$1000000mm^2=\frac{1000000mm^2}{1}\cdot\frac{1m}{1000mm}\cdot\frac{1m}{1000mm}=1m^2$$

Then we continue:

$$1m^2=1m^2\cdot\frac{1km}{1000m}\cdot\frac{1km}{1000m}=0.000001km^2$$

Therefore $1000000mm^2 = 0.000001km^2$.
notice that "mm^2" cancels with "mm mm" in the first row, and "m^2" cancels with "m m" in the second row of calculations above.

h) 18 ft^3 = ? yd^3
When dealing with **cubic units**, we have to apply each conversion formula **three times**. For example, since $1yd = 3ft$, we can apply this conversion three times so that "ft^3" cancels with "ft·ft·ft".

$$18ft^3 = \frac{18ft^3}{1}\frac{1yd}{3ft}\frac{1yd}{3ft}\frac{1yd}{3ft} = \frac{18}{(3)(3)(3)}yd^3 = \frac{2}{3}yd^3$$

Or, as in the example f) above, we can create our own conversion formula $1yd^3 = 3ft \cdot 3ft \cdot 3ft = 27ft^3$ and use it directly:

$$18ft^3 = \frac{18ft^3}{1}\frac{1yd^3}{27ft^3} = \frac{18}{27}yd^3 = \frac{2}{3}yd^3$$

i) 8 mL = ? cc
This is a straight forward conversion, since $1cc = 1mL$:

$$8mL = \frac{8mL}{1}\frac{1cc}{1mL} = 8cc$$

j) 3 L = ? cc
This time we have to use two conversions in a row: 1 L = 1000 mL and 1 mL = 1 cc:

$$3L = \frac{3L}{1}\frac{1000mL}{1L}\frac{1cc}{1ml} = \frac{(3)(1000)}{1}cc = 3000cc$$

k) 1 m^3 = ? cc
For cubic units, we use conversion formulas three times:

$$1m^3 = \frac{1m^3}{1}\frac{100cm}{1m}\frac{100cm}{1m}\frac{100cm}{1m}\frac{1cc}{1cm^3} = \frac{(100)(100)(100)}{1}cc = 1000000cc$$

Alternatively, we can derive our own conversion formula for cubic units. Using $1m = 100cm$, we get $1m^3 = 100cm \cdot 100cm \cdot 100cm = 1000000cm^3$.

l) 42 °C = ? °K
Use the temperature conversion formulas from the table on page 3.

K = C + 273.15
K = (42 + 273.15) °K = 315.15 °K

m) 74 °F = ? °C

C = $\frac{5}{9}$(F – 32)
C = $\frac{5}{9}$(74 – 32) °C ≈23.3 °C

n) 29 °C = ? °F

F = $\frac{9}{5}$C + 32

F = [$\frac{9}{5}$(29) + 32] °F = 84.2 °F

Compound Measures

We now look at what is sometimes called **compound measures**:
miles per hour = mi/hr, ft/sec, lb/ft^2, g/cm^3 etc.

Examples

a) If a car is traveling 90 mi/hr, how many feet will the car travel in 1 sec? In 5 sec?

A direct way to convert these units is:

$$90 mi/hr = \frac{90mi}{1hr}\frac{5280\,ft}{1mi}\frac{1hr}{60\min}\frac{1\min}{60\sec} = \frac{(90)(5280)}{(60)(60)}\,ft/\sec = 132\,ft/\sec$$

Alternatively, we can derive our own conversion formulas separately for miles and for hours: $1mi = 5280\,ftt$ and $1hr = 60\min = 60\cdot 60\sec = 3600\sec$. We then replace miles with 5280feet and hours with 3600sec. Therefore

$$\frac{90mi}{1hr} = \frac{90\cdot 5280\,ft}{3600\sec} = 132\,ft/\sec$$

In 1 second the car will travel 132 ft. The car will travel (5 sec)(132 ft/sec) = 660 ft. in 5 seconds.

b) A 90 lb weight is applied to an area 1/4 in by 1/4 inch. This pressure is equivalent to how many tons per ft^2 ?

We have 90 pounds per (1/4)(1/4) in^2. We have [90 lb/(1/16) in^2] = 1440 lb/in^2.

$$1440lb/in^2 = \frac{1440lb}{1in^2}\frac{1ton}{2000lb}\frac{12in}{1\,ft}\frac{12in}{1\,ft} = \frac{(1440)(12)(12)}{2000}\,ton/\,ft^2 = 103.68\,ton/\,ft^2$$

c) If a machine produces 225 parts in an 8 hour day, how many minutes will it take to produce 10 parts?

We will first get minutes per part.

$$\frac{8hours}{225\,parts}\cdot\frac{60\min}{1hour} = \frac{8(60)}{225}\min/\,part = \frac{32}{15}\min/\,part$$

The time needed for 10 parts would be (10)(32/15) minutes = 64/3 minutes = 21_ minutes.

d) If a machine produces 225 parts in an 8 hour day, how many parts can it produce in 10 minutes ?

We will first get parts per minute. Notice that we have parts in the numerator since we want parts in the final answer.

$$\frac{225\,parts}{8hours}\cdot\frac{1hour}{60\min}=\frac{225}{8(60)}\,parts/\min=\frac{15}{32}\,parts/\min$$

In 10 minutes, the machine would produce $10\cdot\frac{15}{32}$ parts = $\frac{75}{16}$ parts =. $4\frac{11}{16}$

e) Water is pouring into a plastic box 1 m by 1 m by .3 m at the rate of 125 mL per minute. How long will it take in hours to fill this box?

The volume of the box is 1 m × 1 m × .3 m = .3 m^3.
In 1 minute, 125 mL will drip into the box. We will convert mL to cm^3 to m^3 and minutes to hours.

$$\frac{1\min}{125\,mL}\cdot\frac{1\,mL}{1\,cm^3}\cdot\frac{100\,cm}{1\,m}\cdot\frac{100\,cm}{1\,m}\cdot\frac{100\,cm}{1\,m}\cdot\frac{1\,hr}{60\min}=\frac{(100)(100)(100)}{(125)(60)}\,\frac{hr}{m^3}\approx 133.33\,\frac{hr}{m^3}$$

133.33 hrs for each m^3. It will take (133.33)(.3) hr = 40 hr to fill the box

Homework:

1. 1000 yd = ? in

2. 2000 in = ? ft

3. 1000 in = ? yd

4. 2000 ft = ? in

5. 1000 yd^2 = ? in^2

6. 2000 in^2 = ? ft^2

7 1000 in^2 = ? yd

8. 2000 ft^2 = ? in^2

9. 1000 yd^3 = ? in^3

10. 2000 in^3 = ? ft^3

11. 1000 in^3 = ? yd^3

12. 2000 ft^3 = ? in^3

13. 1,000,000 mm = ? cm

14. 1,000,000 mg = ? cg

15. 1,000,000 mm = ? m

16. 1,000,000 μg = ? g

17. 1,000,000 mg = ? g

18. 1,000,000 cm = ? m

19. 1,000,000 mL = ? L

20. 1,000,000 μm = ? cm

21. 1,000,000 mm = ? km

22. 1,000,000 cm = ? km

23. 1,000,000 mg = ? kg

24. 1,000,000 μg = ? mg

25. 1,000,000 km = ? m

26. 1,000,000 kg = ? g

27. 1,000,000 km = ? cm

28. 1,000,000 mL = ? L

29. 1,000,000 kg = ? mg

30. 1,000,000 cg = ? g

31. 50 mi = ? yd

32. 50 mi = ? in

33. 1,000,000 tons = ? oz.

34. 1,000,000 oz = ? tons

35. 1,000,000 fl. oz. = ? gal

36. 1,000,000 fl. oz. = ? quarts

37. 42 °F = ? °C

38. 73 °F = ? ° C

39. 12 °C = ? °F

40. 70 °C = ? °F

41. 25 °C = ? °K

42. 300 °K = ? °C

43. 100 ft/sec = ? mi/hr

44. 100 mi / hr = ? ft / sec.

45. 5 gal / min = ? gal/hr

46. 5 pints / min = ? gal / hr

47. 3 g/cm^3 = ? kg/m^3

48. 180 kg / m^3 = ? g / mm^3

49. 200 lb/in^2 = ? tons/ft^2

50. 2.5 tons / ft^2 = ? lb / in^2

51. 100 km/hr = ? m/sec

52. 250 m/min = ? km / hr

53. 100 m/sec = ? km/hr

54. 250 km / hr = ? m / min

55. 2 cc/sec = ? L/hr

56. 2 L / hr = ? cc / min

57. 2 m^3 = ? L

58. 18 L = ? m^3

59. 4 m^2 = ? ft^2

60. 4 ft^2 = ? m^2

61. 9 qt = ? m^3

62. 2 m^3 = ? qt

63. 1,000,000 grains = ? lbs

64. 10 lbs = ? grains

65. 3.2 mg / mm^3 = ? oz / in^3

66. 5 oz / in^3 = ? mg / mm

67. A car traveling at a constant speed travels 175 miles in 4 hours. How many minutes will it take for the car to travel 1000 feet ?

68. A car traveling at a constant speed travels 1000 ft in 12 seconds. In miles, how far will this car travel in 4 hours?

69. A car traveling at a constant speed travels 175 miles in 4 hours. How many feet will the car travel in 10 minutes ?

70. A car traveling at a constant speed travels 1000 ft in 12 seconds. How long in hours will it take to travel 175 miles?

71. If a car is traveling 75 miles per hour, how many feet will it travel in 10 seconds ?

72. If a car is traveling 75 kilometers per hour, how many meters will it travel in 10 seconds?

73. A leaky faucet drips at the rate of 1 pint per hour. How many gallons will drip in a 24 hour day?

74. A leaky faucet drips at the rate of 300 mL per hour. How many liters will drip in a 24 hour day?

75. A leaky faucet drips at the rate of 1 pint per hour. How long will it take to fill a 10 gallon container?

76. A leaky faucet drips at the rate of 300 mL per hour. How long will it take to fill a 10 liter container?

77. You wish to give a patient 5 liters of fluid intravenously in 24 hours. If this is done at a constant rate, how many cc must be given per minute?

78. You wish to give a patient 4 liters of fluid in 8 hours. If this is done at a constant rate, how many cc must be given per minute?

79. You are giving a patient 2.5 cc / min of a given solution intravenously. If this continues for 8 hours, how many liters of this solution will you need ?

80. You are giving a patient 3 cc / min of a given solution intravenously. If this is done for 24 hours, how many liters of this solution will you need?

81. A recipe calls for 300 mL water. In the English system, how much water is this?

82. A recipe calls for 3 cups water. In the metric system, how much water is this?

83. A car is traveling 100 km / hr, How many feet does this car travel every second?

84. A car is traveling 100 miles / hour. How many meters does this car travel every second?

85. John has a bicycle whose tires are 27 inches in diameter. If John rides his bike 1 mile, how many revolutions does each tire make?

86. A vehicle has wheel 15 inches in diameter. If the vehicle travels 2 miles, how many revolutions does the wheel make?

87. 1000 inches is how many meters?

88. 450 millimeters is how many inches?

89. A large block of butter measures 2.3 meters by 3.4 meters by 5 meters. How many tablespoons of butter are in this block?

90. You wish to form a cube formed from 1,000,000 tablespoons of butter. What is the length of a side in meters? feet? inches? (Recall: a cube has length = width = height.)

91. An automatic machine produces 1 part every 2.3 minutes. How many parts are produced in 8 hours if the machine runs constantly?

92. A machine produces 4500 parts in an 8 hour day. In minutes, how long will it take to produce 100 parts?

93. An automatic machine produces 1 part every 2.3 minutes. How long in hours will it take to produce 5000 parts?

94. If a machine produces 435 parts per hour. how many minutes will it take to produce each part?

95. A certain medication recommends that each day a person be given 8 mg for every 100 lbs of weight. John weighs 238 lbs. If his measurements are exact, How many kg of this medication will he take in 365 days?

96. A certain medication recommends that each day a person be given 8 mg for every 100 lbs of weight. If 10,000 people take this medication each day and their average weight is 180 lbs, how many kilograms of this drug are used daily?

Solutions:

1. $1000yd = \frac{1000yd}{1}\frac{3ft}{1yd}\frac{12in}{1ft} = (1000)(3)(12)in = 36000in$

3. $1000in = \frac{1000in}{1}\frac{1ft}{12in}\frac{1yd}{3ft} = \frac{1000}{(12)(3)}yd = 27\frac{7}{9}yd$

5. $\frac{1000yd^2}{1}\frac{3ft}{1yd}\frac{3ft}{1yd}\frac{12in}{1ft}\frac{12in}{1ft} = (1000)(3)(3)(12)(12)in^2 = 1296000in^2$

7. $\frac{1000in^2}{1}\frac{1ft}{12in}\frac{1ft}{12in}\frac{1yd}{3ft}\frac{1yd}{3ft} = \frac{1000}{(12)(12)(3)(3)}yd^2 = .77yd^2$

9. $\frac{1000yd^3}{1}\frac{3ft}{1yd}\frac{3ft}{1yd}\frac{3ft}{1yd}\frac{12in}{1ft}\frac{12in}{1ft}\frac{12in}{1ft} = (1000)(3)(3)(3)(12)(12)(12)in^3 = 46656000in^3$

11. $\frac{1000in^3}{1}\frac{1ft}{12in}\frac{1ft}{12in}\frac{1ft}{12in}\frac{1yd}{3ft}\frac{1yd}{3ft}\frac{1yd}{3ft} = \frac{1000}{(12)(12)(12)(3)(3)(3)}yd^3 = .021yd^3$

13. $\frac{1000000mm}{1}\frac{1m}{1000mm}\frac{100cm}{1m} = \frac{(1000000)(100)}{1000}cm = 100000cm$

15. $\frac{1000000mm}{1}\frac{1m}{1000mm} = \frac{1000000}{1000}m = 1000m$

17. $\frac{1000000mg}{1}\frac{1g}{1000mg} = \frac{1000000}{1000}g = 1000g$

19. $\frac{1000000mL}{1}\frac{1L}{1000mL} = \frac{1000000}{1000}L = 1000L$

21. $\frac{1000000\ mm}{1}\cdot\frac{1\ m}{1000\ mm}\cdot\frac{1\ km}{1000\ m} = \frac{1000000}{(1000)(1000)}km = 1\ km$

23. $\frac{1000000mg}{1}\frac{1g}{1000mg}\frac{1kg}{1000g} = \frac{1000000}{(1000)(1000)}kg = 1kg$

25. $\frac{1000000km}{1}\frac{1000m}{1km} = (1000000)(1000)m = 1000000000m$

27. $\frac{1000000km}{1}\frac{1000m}{1km}\frac{100cm}{1m} = (1000000)(1000)(100)cm = 100000000000cm = 1\times10^{11}cm$

29. $\frac{1000000kg}{1}\frac{1000g}{1kg}=(1000000)(1000)g=1000000000g$

31. $\frac{50mi}{1}\frac{5280\,ft}{1mi}\frac{1yd}{3\,ft}=\frac{(50)(5280)}{3}yd=88000yd$

33. $\frac{1000000tons}{1}\frac{2000lb}{1ton}\frac{16oz}{1lb}=(1000000)(2000)(16)oz=32000000000oz=3.2\times10^{10}oz$

35. $\frac{1000000\,fl\ \ oz}{1}\frac{1pt}{16\,fl\ \ oz}\frac{1qt}{2\,pt}\frac{1gal}{4qt}=\frac{1000000}{(16)(2)(4)}gal=7812.5gal$

37. C = $\frac{5}{9}$(F – 32) ; C = $\frac{5}{9}$(42 – 32) °C ≈ 5.6 °C

39. F = $\frac{9}{5}$C + 32; F = $\frac{9}{5}$(12) + 32 °F = 53.6 °F

41. K = C + 273.15; K = 25 + 273.15 °K = 298.15 °K

43. $\frac{100\,ft}{1\sec}\frac{1mi}{5280\,ft}\frac{60\sec}{1\min}\frac{60\min}{1hr}=\frac{(100)(60)(60)mi}{5280hr}=68.18mi/hr$

45. $\frac{5gal}{1\min}\frac{60\min}{1hr}=(5)(60)gal/hr=300gal/hr$

47. $\frac{3g}{1cm^3}\frac{1kg}{1000g}\frac{100cm}{1m}\frac{100cm}{1m}\frac{100cm}{1m}=\frac{(3)(100)(100)(100)}{1000}kg/m^3=3000kg/m^3$

49. $\frac{200lb}{1in^2}\frac{1ton}{2000lb}\frac{12in}{1\,ft}\frac{12in}{1\,ft}=\frac{(200)(12)(12)}{2000}tons/\ ft^2=14.4tons/\ ft^2$

51. $\frac{100km}{1hr}\frac{1000m}{1km}\frac{1hr}{60\min}\frac{1\min}{60\sec}=\frac{(100)(1000)}{(60)(60)}m/\sec=27.78m/\sec$

53. $\frac{100m}{1\sec}\frac{1km}{1000m}\frac{60\sec}{1\min}\frac{60\min}{1hr}=\frac{(100)(60)(60)}{1000}km/hr=360km/hr$

55. $\frac{2cc}{1\sec}\frac{1ml}{1cc}\frac{1L}{1000ml}\frac{60\sec}{1\min}\frac{60\min}{1hr}=\frac{(2)(60)(60)}{1000}L/hr=7.2L/hr$

57. $\frac{2\,m^3}{1}\cdot\frac{100\,cm}{1\,m}\cdot\frac{100\,cm}{1\,m}\cdot\frac{100\,cm}{1\,m}\cdot\frac{1\,mL}{1\,cm^3}\cdot\frac{1\,L}{1000\,mL}=\frac{(2)(100)(100)(100)}{1000}L=2000\,L$

59. $\frac{4\,m^2}{1}\cdot\frac{39.37\,in}{1\,m}\cdot\frac{39.37\,in}{1\,m}\cdot\frac{1\,ft}{12\,in}\cdot\frac{1\,ft}{12\,in}=\frac{4(39.37)(39.37)}{(12)(12)}\;ft^2\approx 43.05\,ft^2$

61. $\frac{9\,qt}{1}\cdot\frac{1\,L}{1.0567\,qt}\cdot\frac{1000\,mL}{1\,L}\cdot\frac{1\,cm^3}{1\,mL}\cdot\frac{1\,m}{100\,cm}\cdot\frac{1\,m}{100\,cm}\cdot\frac{1\,m}{100\,cm}=\frac{9(1000)}{(1.0567)(100)(100)(100)}\,m^3\approx .0085$

63. $\frac{1,000,000\,grains}{1}\cdot\frac{.065\,g}{1\,grain}\cdot\frac{1\,kg}{1000\,g}\cdot\frac{2.2\,lbs}{1\,kg}=\frac{(1,000,000)(.065)(2.2)}{1000}\,lbs=143\,lbs$

65. $\frac{3.2\,mg}{1\,mm^3}\cdot\frac{1\,g}{1000\,mg}\cdot\frac{1\,kg}{1000\,g}\cdot\frac{2.2\,lbs}{1\,kg}\cdot\frac{16\,oz}{1\,lb}\cdot\frac{1000\,mm}{1\,m}\cdot\frac{1000\,mm}{1\,m}\cdot\frac{1000\,mm}{1\,m}\cdot\frac{1\,m}{39.37\,in}\cdot\frac{1\,m}{39.37\,in}\cdot\frac{1\,m}{39.37\,in}=$
$\frac{(3.2)(2.2)(16)(1000)(1000)(1000)}{(1000)(1000)(39.37)(39.37)(39.37)}\,\frac{oz}{in^3}\approx 1.85\,\frac{oz}{in^3}$

67. $\frac{4hours}{175miles}\cdot\frac{1mile}{5280\,ft}\cdot\frac{60\min}{1hour}=\frac{(4)(60)}{(175)(5280)}\min/\,ft=.0002597\min/\,ft$;
The car will take approximately .26 minutes to travel 1000 feet.

69. $\frac{175miles}{4hours}\cdot\frac{5280\,ft}{1mile}\cdot\frac{1hour}{60\min}=\frac{(175)(5280)}{(4)(60)}\,ft/\min=3850\,ft/\min$;
In 10 minutes the car would travel (10)(3850) ft = 38500 ft.

71. $\frac{75\,mi}{1\,hr}\cdot\frac{5280\;ft}{1\,mi}\cdot\frac{1\,hr}{60\min}\cdot\frac{1\min}{60\sec}=\frac{(75)(5280)}{(60)(60)}\,ft/\sec=110\,ft/\sec$
In 10 seconds the car will travel (10)(110) ft. = 1100 ft.

73. $\frac{1pt}{1hour}\cdot\frac{1qt}{2\,pt}\cdot\frac{1gal}{4qt}\cdot\frac{24\,hours}{1\,day}=\frac{24}{(2)(4)}\,gal/day=3\,gal/day$

75. $\frac{1hour}{1pt}\cdot\frac{2\,pt}{1qt}\cdot\frac{4qt}{1gal}=8\,hours/gal$;
It would take (10)(8) hours = 80 hours to fill a 10 gallon container.

77. $\frac{5L}{24hours}\cdot\frac{1hour}{60\min}\cdot\frac{1000mL}{1L}\cdot\frac{1cc}{1mL}=\frac{(5)(1000)}{(24)(60)}\,cc/\min=3.47cc/\min$

79. $\frac{2.5cc}{1\min}\cdot\frac{60\min}{1hour}\cdot\frac{1mL}{1cc}\cdot\frac{1L}{1000mL}=\frac{(2.5)(60)}{1000}\,L/hour=.15L/hour$;
You would need (8)(.15) L = 1.2 L in 8 hours.

81. $\frac{300\,mL}{1}\cdot\frac{1\,pt}{480\,mL}=\frac{300}{480}\,pt=\frac{5}{8}\,pt$, also $\frac{5}{8}\,pt\cdot\frac{2\,cups}{1\,pt}=1\tfrac{1}{4}\,cups$ and $\frac{300\,mL}{1}\cdot\frac{1Tbs}{30\,mL}=10\,Tbs$

83. $\frac{100\,km}{1\,hr}\cdot\frac{.6214\,miles}{1\,km}\cdot\frac{5280\ ft}{1\,mile}\cdot\frac{1\,hr}{60\min}\cdot\frac{1\min}{60\sec}=\frac{(100)(.6214)(5280)\ ft}{(60)(60)\sec}\approx 91.14\ {}^{ft}\!/_{\sec}$

85. C = π d = 2 π r ; C = π 27 in. ; 1 revolution = 1 rev = 1 circumference = 27 π in. ;

$$\frac{1\,mile}{1}\cdot\frac{5280\ ft}{1\,mile}\cdot\frac{12\,in}{1\ ft}\cdot\frac{1\,rev}{27\pi\,in}=\frac{(5280)(12)}{27\pi}rev\approx 747\,rev$$

87. $\frac{1000\,in}{1}\cdot\frac{1\,m}{39.37\,in}=\frac{1000}{39.37}m\approx 25.4\,in$

89. Volume = 2.3 m x 3.4 m x 5 m = 39.1 m^3 ;

$$\frac{39.1\,m^3}{1}\cdot\frac{100\,cm}{1\,m}\cdot\frac{100\,cm}{1\,m}\cdot\frac{100\,cm}{1\,m}\cdot\frac{1\,mL}{1\,cm^3}\cdot\frac{1\,tbsp}{15\,mL}=\frac{(39.1)(100)(100)(100)}{15}tbsp\approx 2,600,000\,tbsp$$

91. $\frac{1\,part}{2.3\min}\cdot\frac{60\min}{1\,hr}=\frac{60}{2.3}\frac{parts}{hr}\approx\frac{26.1\,parts}{1\,hour}=\frac{(8)(26.1)\ parts}{8\,hours}$ **;** 208.8 parts in 8 hours

93. $\frac{2.3\min}{1\ part}\cdot\frac{1\,hr}{60\min}=\frac{2.3}{60}\frac{hr}{part}\approx .0383\frac{hr}{part}=\frac{(.0383)(5000)\,hrs}{5000\ parts}$ **;**

It will take approximately 192 hours to produce 5000 parts.

95. $\frac{8\,mg}{100\,lbs}\cdot\frac{238\,lbs}{1}=19.04\,mg$ each day; 19.04mg each day x 365 days = 6949.6 mg

$$\frac{6949.6\,mg}{1}\cdot\frac{1\,g}{1000\,mg}\cdot\frac{1\,kg}{1000\,g}=\frac{6949.6}{(1000)(1000)}kg=.0069496\,kg$$

In one year, John would take approximately .007 kg.