

Sect 5.2 – US System of Measurement

Objective 1: The Unit Conversion Factor

In this section, we will be working with the U.S. system of measurement and converting between various units. To convert from one unit to another unit, we will use unit conversion factors. To form a unit conversion factor, we start with a conversion fact (i.e., 1 ft = 12 in) and divide both sides by the value on one side of the conversion fact. If we use 1 ft = 12 in, we can divide both sides by 12 in to get:

$$\frac{1 \text{ ft} = 12 \text{ in}}{12 \text{ in} \quad 12 \text{ in}}$$

$$\frac{1 \text{ ft}}{12 \text{ in}} = 1$$

Notice that $\frac{1 \text{ ft}}{12 \text{ in}}$ is the same as one, so if we needed to convert 48 in into ft, we can multiply 48 in by this unit conversion factor. It does not change the value of 48 in since we are multiply by a form of one:

$$48 \text{ in} = 48 \text{ in} \cdot 1 = \frac{48 \text{ in}}{1} \cdot \frac{1 \text{ ft}}{12 \text{ in}} = \frac{48 \cancel{\text{in}}}{1} \cdot \frac{1 \text{ ft}}{12 \cancel{\text{in}}} = \frac{48}{12} \text{ ft} = 4 \text{ ft}.$$

Notice that the inches divide out. We always set-up our unit conversion factors so that the units we are converting from divide out. So, if we had to convert from ft to in, we would use $\frac{12 \text{ in}}{1 \text{ ft}}$ so that the ft would divide out, leaving our answer in inches. Here are some common conversions within the U.S. system of measurement:

US System of Measurement

(fur – furlong, bu – bushel, psi – pounds per in², atm – Earth's atmosphere)

Length	Time
1 ft = 12 in	1 min = 60 sec
1 yd = 3 ft = 36 in	1 h = 60 min = 3600 sec
1 mi = 5280 ft = 1760 yd = 8 fur	1 day = 24 hr
1 rod = $16\frac{1}{2}$ ft = $5\frac{1}{2}$ yd	1 year = 365 days

Area	Volume
$1 \text{ ft}^2 = 144 \text{ in}^2$ $1 \text{ yd}^2 = 9 \text{ ft}^2 = 1296 \text{ in}^2$ $1 \text{ rod}^2 = 30.25 \text{ yd}^2$ $1 \text{ acre} = 160 \text{ rod}^2 = 4840 \text{ yd}^2$ $1 \text{ acre} = 43,560 \text{ ft}^2$ $1 \text{ mi}^2 = 640 \text{ acres}$	$1 \text{ ft}^3 = 1728 \text{ in}^3$ $1 \text{ gal} = 231 \text{ in}^3$ $1 \text{ bu} \approx 2150.42 \text{ in}^3 \approx 1.24446 \text{ ft}^3$ $1 \text{ pt} = 28.875 \text{ in}^3$ $1 \text{ yd}^3 = 27 \text{ ft}^3 = 46,656 \text{ in}^3$ $1 \text{ fl oz} \approx 1.805 \text{ in}^3$ $1 \text{ ft}^3 \approx 7.48052 \text{ gal}$
Liquid Capacity	Weight and Other
$1 \text{ c} = 8 \text{ fl oz}$ $1 \text{ pt} = 2 \text{ c}$ $1 \text{ qt} = 2 \text{ pt} = 4 \text{ c}$ $1 \text{ gal} = 4 \text{ qt}$	$1 \text{ lb} = 16 \text{ oz}$ $1 \text{ ton} = 2000 \text{ lb}$ $1 \text{ atm} = 14.7 \text{ psi}$

Convert each unit as indicated:

Ex. 1 Convert 10.5 yd to ____ ft.

Solution:

Since $1 \text{ yd} = 3 \text{ ft}$, we want to write our unit conversion factor with 1 yd on the bottom:

$$10.5 \text{ yd} = \frac{10.5 \text{ yd}}{1} \cdot \frac{3 \text{ ft}}{1 \text{ yd}} = \frac{10.5 \text{ yd}}{1} \cdot \frac{3 \text{ ft}}{1 \text{ yd}} = \frac{31.5}{1} \text{ ft} = 31.5 \text{ ft}$$

Ex. 2 Convert 177408 in to ____ mi.

Solution:

First use $12 \text{ in} = 1 \text{ ft}$ to convert the inches to feet:

$$177408 \text{ in} = \frac{177408 \text{ in}}{1} \cdot \frac{1 \text{ ft}}{12 \text{ in}} = \frac{177408 \text{ ft}}{12} = 14,784 \text{ ft}$$

Now, use $5280 \text{ ft} = 1 \text{ mi}$ to convert 14,784 ft into mi:

$$14,784 \text{ ft} = \frac{14784 \text{ ft}}{1} \cdot \frac{1 \text{ mi}}{5280 \text{ ft}} = \frac{14784}{5280} \text{ mi} = 2.8 \text{ mi.}$$

Ex. 3 Convert 4.8 ton to ____ lb.

Solution:

Use $1 \text{ ton} = 2000 \text{ lb}$ to convert the tons to lbs:

$$4.8 \text{ ton} = \frac{4.8 \text{ ton}}{1} \cdot \frac{2000 \text{ lb}}{1 \text{ ton}} = 9600 \text{ lb.}$$

Ex. 4 Convert $\frac{\$9.12}{\text{lb}}$ to $\frac{\$}{\text{oz}}$

Solution:

Use 1 lb = 16 oz to convert the lb to oz. When writing the unit conversion factor, the 1 lb goes on top so that the lbs divide out:

$$\frac{\$9.12}{\text{lb}} = \frac{\$9.12}{\text{lb}} \cdot \frac{1\text{lb}}{16\text{oz}} = \frac{\$9.12}{16\text{oz}} = \frac{\$0.57}{\text{oz}}$$

Ex. 5 Convert 85 qt to ____ gal

Solution:

Use 4 qt = 1 gal to convert the qt to gal:

$$85 \text{ qt} = \frac{85\text{qt}}{1} \cdot \frac{1\text{gal}}{4\text{qt}} = \frac{85}{4} \text{ gal} = 21.25 \text{ gal} \approx 21 \text{ gal}.$$

Objective 2: Converting Compound Units

Compound units are made of two or more simple units. Example #4, is example of a compound unit since we are converting from \$ per lb to \$ per oz. Let's try some conversions with compound units

Ex. 6 Convert $\frac{\$2.45}{\text{pt}}$ to $\frac{\$}{\text{fl oz}}$.

Solution:

First, use 1 pt = 2 c to convert pt to c:

$$\frac{\$2.45}{\text{pt}} = \frac{\$2.45}{\text{pt}} \cdot \frac{1\text{pt}}{2\text{c}} = \frac{\$2.45}{2\text{c}} = \frac{\$1.225}{\text{c}}$$

Now, use 1 c = 8 fl oz to convert c to fl oz.

$$\frac{\$1.225}{\text{c}} = \frac{\$1.225}{\text{c}} \cdot \frac{1\text{c}}{8\text{fl oz}} = \frac{\$1.225}{8\text{fl oz}} = \frac{\$0.153125}{\text{fl oz}} \approx \frac{\$0.15}{\text{fl oz}}$$

Ex. 7 Convert $\frac{\$9.27}{\text{yd}^2}$ to $\frac{\$}{\text{ft}^2}$.

Solution:

Use 9 ft² = 1 yd² to convert ft² to yd²: $\frac{\$9.27}{\text{yd}^2} \cdot \frac{\text{yd}^2}{9\text{ft}^2} = \frac{\$9.27}{9\text{ft}^2} = \frac{\$1.03}{\text{ft}^2}$.

Ex. 8 Convert $\frac{3.0\text{bu}}{\text{acre}}$ to $\frac{\text{in}^3}{\text{ft}^2}$

Solution:

First, use 1 bu = 2150.42 in³ to convert bu to in³:

$$\frac{3.0\text{bu}}{\text{acre}} = \frac{3.0\text{bu}}{\text{acre}} \cdot \frac{2150.42\text{in}^3}{\text{bu}} = \frac{6451.26\text{in}^3}{\text{acre}}$$

Now, use 1 acre = 43,560 ft² to convert acre to ft²:

$$\frac{6451.26 \text{ in}^3}{\text{acre}} \cdot \frac{1 \text{ acre}}{43,560 \text{ ft}^2} = 0.14810... \frac{\text{in}^3}{\text{ft}^2} \approx \frac{0.15 \text{ in}^3}{\text{ft}^2}.$$

We always wait until the end to round to the appropriate significant digits.

Ex. 9 Convert $\frac{6.6 \text{ ft}}{\text{sec}}$ into $\frac{\text{mi}}{\text{hr}}$.

Solution:

First, use 1 hr = 3600 sec to convert the sec to hr:

$$\frac{6.6 \text{ ft}}{\text{sec}} \cdot \frac{3600 \text{ sec}}{\text{hr}} = \frac{23760 \text{ ft}}{\text{hr}}$$

Now, use 1 mi = 5280 ft to convert the ft to mi:

$$\frac{23760 \text{ ft}}{\text{hr}} \cdot \frac{1 \text{ mi}}{5280 \text{ ft}} = \frac{4.5 \text{ mi}}{\text{hr}} = 4.5 \text{ mph}.$$

Solve the following:

Ex. 10 The pressure in a sealed chamber is 1.323 ton per sq ft. How does that compare to the Earth's atmosphere?

Solution:

We want to convert $\frac{\text{ton}}{\text{ft}^2}$ to atm. In examining our chart, we see that

1 atm = 14.7 psi $\left(\frac{\text{lb}}{\text{in}^2}\right)$ so we will need to first convert from $\frac{\text{ton}}{\text{ft}^2}$ to $\frac{\text{lb}}{\text{in}^2}$.

Since 1 ton = 2000 lb, then:

$$\frac{1.323 \text{ ton}}{\text{ft}^2} = \frac{1.323 \text{ ton}}{\text{ft}^2} \cdot \frac{2000 \text{ lb}}{\text{ton}} = \frac{2646 \text{ lb}}{\text{ft}^2}$$

But, 1 ft² = 144 in², so

$$\frac{2646 \text{ lb}}{\text{ft}^2} = \frac{2646 \text{ lb}}{\text{ft}^2} \cdot \frac{1 \text{ ft}^2}{144 \text{ in}^2} = \frac{18.375 \text{ lb}}{\text{in}^2} \text{ or } 18.375 \text{ psi}$$

Now, we can use 1 atm = 14.7 psi to convert:

$$18.375 \text{ psi} = \frac{18.375 \text{ psi}}{1} \cdot \frac{1 \text{ atm}}{14.7 \text{ psi}} = 1.25 \text{ atm}.$$

Thus, the pressure in the chamber is 1.25 times the Earth's atmosphere.

Objective 3 Understanding Lumber Measurement

The amount of volume of lumber is measured in board feet. One board foot (bf) is a piece of wood that has an area of 1 square foot and a thickness of 1 inch. If a board is less than 1 inch thick, we round the thickness to 1 inch.

1 bf = thickness in inches × length in feet × width in feet

Solve the following:

Ex. 11 A carpenter purchases 28 boards of lumber measuring $\frac{7}{8}$ in by 12 ft by 4 in. How many board feet did she buy?

Solution:

Before we calculate the board feet, the width needs to be converted into feet:

$$4 \text{ in} = \frac{4 \text{ in}}{1} \cdot \frac{1 \text{ ft}}{12 \text{ in}} = \frac{1}{3} \text{ ft}$$

Since the thickness is less than an inch, we will round it to 1 inch.

Thus, the number of board feet for each piece is:

$$1 \text{ in} \cdot \frac{1}{3} \text{ ft} \cdot 12 \text{ ft} = 4 \text{ bf}$$

Since there were 28 boards, then the total board feet is

$$28 \cdot 4 \text{ bf} = 112 \text{ bf}$$

So, the carpenter bought 112 bf.