1.1: U.S. Customary Measurement System

Learning Objectives

1. Define units of length, weight and capacity.
2. Convert from one unit to another.
3. Perform arithmetic calculations on units of length, weight and capacity.
4. Solve application problems involving units of length, weight and capacity.

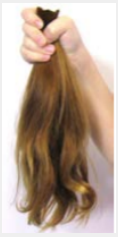
Introduction

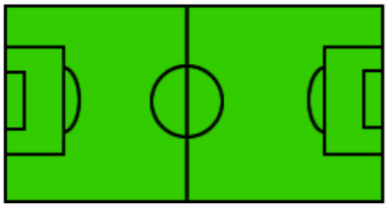
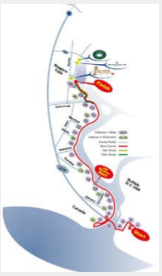
Measurement is a number that describes the size or amount of something. You can measure many things like length, area, capacity, weight, temperature and time. In the United States, two main systems of measurement are used: the **metric system** and the **U.S. customary measurement system**. This section addresses the measurements of length, weight and capacity using the U.S. customary measurement system.

Suppose you want to purchase tubing for a project, and you see two signs in a hardware store: *$1.88 for 2 feet* of tubing and *$5.49 for 3 yards* of tubing. If both types of tubing will work equally well for your project, which is the better price? You need to know about two **units of measurement**, yards and feet, in order to determine the answer.

Units of Length

Length is the distance from one end of an object to the other end, or from one object to another. For example, the length of a letter-sized piece of paper is 11 inches. The system for measuring length in the United States is based on the four customary units of length: **inch, foot, yard,** and **mile**. Below are examples to show measurement in each of these units.

Unit	Description	Image
Inch/Inches	Some people donate their hair to be made into wigs for cancer patients who have lost hair as a result of treatment. One company requires hair donations to be at least 8 inches long.	
	Frame size of a bike: the distance from the center of the crank to the top of the seat tube. Frame size is usually measured in inches. This frame is 16 inches.	
Foot/Feet	Rugs are typically sold in standard lengths. One typical size is a rug that is 8 feet wide and 11 feet long. This is often described as an 8 by 11 rug.	

Yard/Yards	Soccer fields vary some in their size. An official field can be any length between 100 and 130 yards.	
Mile/Miles	A marathon is 26.2 miles long. One marathon route is shown in the map to the right.	

You can use any of these four U.S. customary measurement units to describe the length of something, but it makes more sense to use certain units for certain objects depending on their general size. For example, it makes more sense to describe the length of a rug in feet rather than miles, and to describe a marathon in miles rather than inches.

You may need to convert between units of measurement. For example, you might want to express your height using feet and inches (5 feet 4 inches) or using only inches (64 inches). You need to know the unit equivalents in order to make these conversions between units.

The table below shows equivalents and conversion factors for the four customary units of measurement of length.

Unit Equivalents	Conversion Factors (longer to shorter units of measurement)	Conversion Factors (shorter to longer units of measurement)
1 foot = 12 inches	$\frac{12 \text{ inches}}{1 \text{ foot}}$	$\frac{1 \text{ foot}}{12 \text{ inches}}$
1 yard = 3 feet	$\frac{3 \text{ feet}}{1 \text{ yard}}$	$\frac{1 \text{ yard}}{3 \text{ feet}}$
1 mile = 5280 feet	$\frac{5280 \text{ feet}}{1 \text{ mile}}$	$\frac{1 \text{ mile}}{5280 \text{ feet}}$

Note that each of these conversion factors is a ratio of equal values, also called a unit fraction, so each conversion factor equals 1. Recall that multiplying a number by 1 does not change the number. Multiplying a measurement by a conversion factor does not change the size of the measurement at all since it is the same as multiplying by 1; it just changes the units that you are using to measure.

Converting Between Units of Length

You can use the conversion factors to convert a measurement, such as feet, to another type of measurement, such as inches.

Note that there are many more inches for a measurement than there are feet for the same measurement, as feet is a longer unit of measurement. You could use the conversion factor $\frac{12 \text{ inches}}{1 \text{ foot}}$.

If a length is measured in feet, and you'd like to convert the length to yards, you can think, "I am converting from a shorter unit to a longer one, so the length in yards will be less than the length in feet." You could use the conversion factor $\frac{1 \text{ yard}}{3 \text{ feet}}$.

If a distance is measured in miles, and you want to know how many feet it is, you can think, "I am converting from a longer unit of measurement to a shorter one, so the number of feet would be greater than the number of miles." You could use the conversion factor $\frac{5280 \text{ feet}}{1 \text{ mile}}$.

Another way to determine which conversion factor, or unit fraction to use, is to check which unit will need to be cancelled. I.e. Converting inches to feet, you want the denominator of the unit fraction to cancel out the original units of inches. Hence the appropriate conversion factors has to be in $\frac{\_\_\_\_\_ \text{ feet}}{\_\_\_\_\_ \text{ inches}}$. Then you just need to fill in the appropriate numbers. Since 1 foot = 12 inches, the conversion factor is $\frac{1 \text{ feet}}{12 \text{ inches}}$.

You can use the **factor label method (dimensional analysis)** to convert a length from one unit of measure to another using the conversion factors. In the factor label method, you multiply by **unit fractions** to convert a measurement from one unit to another. Study the example below to see how the factor label method can be used to convert $3\frac{1}{2}$ feet into an equivalent number of inches.

Example 1.1.1

How many inches are in $3\frac{1}{2}$ feet?

Solution

Begin by reasoning about your answer. Since a foot is longer than an inch, this means the answer would be greater than $3\frac{1}{2}$.

$$3\frac{1}{2} \text{ feet} = \_\_\_\_\_ \text{ inches}$$

Find the conversion factor that compares inches and feet, with “inches” in the numerator, and "feet" in the denominator. Then multiply

$$3\frac{1}{2} \text{ feet} \cdot \frac{12 \text{ inches}}{1 \text{ foot}} = \_\_\_\_\_ \text{ inches}$$

Rewrite the mixed number as an improper fraction before multiplying.

$$\frac{7 \text{ feet}}{2} \cdot \frac{12 \text{ inches}}{1 \text{ foot}} = \_\_\_\_\_ \text{ inches}$$

You can cancel the same units when they appear in the numerator *and* the denominator. Here “feet” and “foot” describe the same unit just in the singular and plural form. This eliminates the unit of "feet" from the problem and leaves the unit of "inches".

$$\frac{7 \text{ } \cancel{\text{feet}}}{2} \cdot \frac{12 \text{ inches}}{1 \text{ } \cancel{\text{foot}}} = \_\_\_\_\_ \text{ inches}$$

$$\frac{7}{2} \cdot \frac{12 \text{ inches}}{1} = \_\_\_\_\_ \text{ inches}$$

Rewrite as multiplication of numerators and denominators.

$$\frac{7 \cdot 12 \text{ inches}}{2 \cdot 1} = \_\_\_\_\_ \text{ inches}$$

Multiply.

$$\frac{84 \text{ inches}}{2} = \_\_\_\_\_ \text{ inches}$$

Divide.

$$\frac{84 \text{ inches}}{2} = 42 \text{ inches}$$

Answer: There are 42 inches in $3\frac{1}{2}$ feet.

Notice that by using the factor label method you can cancel the units out of the problem, just as if they were numbers. You can only cancel if the unit being canceled is in both the numerator and denominator of the fractions you are multiplying.

In the problem above, you canceled feet and foot leaving you with inches, which is what you were trying to find.

$$\frac{7 \cancel{\text{ feet}}}{2} \cdot \frac{12 \text{ inches}}{1 \cancel{\text{ foot}}} = \_\_\_\_\_ \text{ inches}$$

What if you had used the wrong conversion factor?

$$\frac{7 \text{ feet}}{2} \cdot \frac{1 \text{ foot}}{12 \text{ inches}} = \_\_\_\_\_ \text{ inches}$$

You could not cancel the feet because the unit is not the same in both the numerator and the denominator. So if you complete the computation, you would still have both feet and inches in the answer and no conversion would take place.

Here is another example of a length conversion using the factor label method.

Example 1.1.2

How many yards is 7 feet?

Solution

Start by reasoning about the size of your answer. Since a yard is longer than a foot, there will be fewer yards. So your answer will be less than 7.

$$7 \text{ feet} = \_\_\_\_\_ \text{ yards}$$

Find the conversion factor that compares feet and yards, with yards in the numerator.

$$7 \text{ feet} \cdot \frac{1 \text{ yard}}{3 \text{ feet}} = \_\_\_\_\_ \text{ yards}$$

Rewrite the whole number as a fraction in order to multiply.

$$\frac{7 \text{ feet}}{1} \cdot \frac{1 \text{ yard}}{3 \text{ feet}} = \_\_\_\_\_ \text{ yards}$$

Cancel the similar units “feet” and “feet” leaving only yards.

$$\frac{7 \text{ feet}}{1} \cdot \frac{1 \text{ yard}}{3 \text{ feet}} = \_\_\_\_\_ \text{ yards}$$

$$\frac{7}{1} \cdot \frac{1 \text{ yard}}{3} = \_\_\_\_\_ \text{ yards}$$

Multiply.

$$\frac{7 \cdot 1 \text{ yard}}{1 \cdot 3} = \_\_\_\_\_ \text{ yards}$$

Divide.

$$\frac{7 \text{ yards}}{3} = 2\frac{1}{3} \text{ yards}$$

Answer: 7 feet equals $2\frac{1}{3}$ yards.

Note that if the units do not cancel to give you the answer you are trying to find, you may not have used the correct conversion factor.

Try It 1.1.1

How many feet are in $2\frac{1}{2}$ miles?

Answer

There are 5280 feet in a mile, so multiply $2\frac{1}{2}$ by $\frac{5280\text{feet}}{1\text{mile}}$ to get 13,200 feet.

Applying Unit Conversions

There are times when you will need to perform computations on measurements that are given in different units. For example, consider the tubing problem given earlier. You must decide which of the two options is a better price, and you have to compare prices given in different unit measurements.

In order to compare, you need to convert the measurements into one single, common unit of measurement. To be sure you have made the computation accurately, think about whether the unit you are converting to is smaller or larger than the number you have. Its relative size will tell you whether the number you are trying to find is greater or lesser than the given number.

Example 1.1.3

An interior decorator needs border trim for a home she is wallpapering. She needs 15 feet of border trim for the living room, 30 feet of border trim for the bedroom, and 26 feet of border trim for the dining room. How many yards of border trim does she need?

Solution

You need to find the total length of border trim that is needed for all three rooms in the house. You can only add or subtract numbers with the same units. Since the measurements for each room are given in feet, you can add the numbers.

$$15 \text{ feet} + 30 \text{ feet} + 26 \text{ feet} = 71 \text{ feet}$$

How many yards is 71 feet? Reason about the size of your answer. Since a yard is longer than a foot, there will be fewer yards. Expect your answer to be less than 71.

$$71 \text{ feet} = \_\_\_\_\_ \text{ yards}$$

Use the conversion factor $\frac{1 \text{ yard}}{3 \text{ feet}}$.

$$\frac{71 \text{ feet}}{1} \cdot \frac{1 \text{ yard}}{3 \text{ feet}} = \_\_\_\_\_ \text{ yards}$$

Since “feet” is in the numerator and denominator, you can cancel this unit.

$$\frac{71 \text{ feet}}{1} \cdot \frac{1 \text{ yard}}{3 \text{ feet}} = \_\_\_\_\_ \text{ yards}$$

$$\frac{71}{1} \cdot \frac{1 \text{ yard}}{3} = \_\_\_\_\_ \text{ yards}$$

Multiply.

$$\frac{71 \cdot 1 \text{ yards}}{1 \cdot 3} \_\_\_\_\_ \text{ yards}$$

$$\frac{71 \text{ yards}}{3} = \_\_\_\_\_ \text{ yards}$$

Divide, and write as a mixed number.

$$\frac{71 \text{ yards}}{3} = 23\frac{2}{3} \text{ yards}$$

Answer: The interior decorator needs $23\frac{2}{3}$ yards of border trim.

The next example uses the factor label method to solve a problem that requires converting from miles to feet.

Example 1.1.4

Two runners were comparing how much they had trained earlier that day. Jo said, “According to my pedometer, I ran 8.3 miles.” Alex said, “That’s a little more than what I ran. I ran 8.1 miles.” How many more feet did Jo run than Alex?

Solution

You need to find the difference between the distance Jo ran and the distance Alex ran. Since both distances are given in the same unit, you can subtract and keep the unit the same.

$$8.3 \text{ miles} - 8.1 \text{ miles} = 0.2 \text{ mile}$$

$$0.2 \text{ mile} = \frac{2}{10} \text{ miles}$$

Since the problem asks for the difference in *feet*, you must convert from miles to feet. How many feet is 0.2 mile? Reason about the size of your answer. Since a mile is longer than a foot, the distance when expressed as feet will be a number greater than 0.2.

$$\frac{2}{10} \text{ miles} = \_\_\_\_\_ \text{feet}$$

Use the conversion factor $\frac{5280 \text{ feet}}{1 \text{ mile}}$.

$$\frac{2 \text{ miles}}{10} \cdot \frac{5280 \text{ feet}}{1 \text{ mile}} = \_\_\_\_\_ \text{feet}$$

$$\frac{2}{10} \cdot \frac{5280 \text{ feet}}{1} = \_\_\_\_\_ \text{feet}$$

Multiply.

$$\frac{2 \cdot 5280 \text{ feet}}{10 \cdot 1} = \_\_\_\_\_ \text{feet}$$

$$\frac{10,560 \text{ feet}}{10} = \_\_\_\_\_ \text{feet}$$

Divide.

$$\frac{10,560 \text{ feet}}{10} = 1056 \text{ feet}$$

Answer: Jo ran 1056 feet more than Alex.

Now let's revisit the question from earlier.

Example 1.1.5

You are walking through a hardware store and notice two sales on tubing.

- 3 yards of Tubing A costs $5.49.
- Tubing B sells for $1.88 for 2 feet.

Either tubing is acceptable for your project. Which tubing is less expensive?

Solution

Find the unit price for each tubing. This will make it easier to compare.

Tubing A: 3 yards = $5.49

Find the cost per yard of Tubing A by dividing the cost of 3 yards of the tubing by 3.

$$\frac{\$5.49 \div 3}{3 \text{ yards} \div 3} = \frac{\$1.83}{1 \text{ yard}}$$

Tubing B is sold by the foot. Find the cost per foot by dividing $1.88 by 2 feet.

Tubing B: 2 feet = $1.88

$$\frac{\$1.88 \div 2}{2 \text{ feet} \div 2} = \frac{\$0.94}{1 \text{ foot}}$$

To compare the prices, you need to have the same unit of measure.

$$\frac{\$0.94}{1 \text{ foot}} \cdot \frac{3 \text{ feet}}{1 \text{ yard}} = \frac{\$\_\_\_\_\_}{\_\_\_\_\_ \text{ yard}}$$

Use the conversion factor $\frac{3 \text{ feet}}{1 \text{ yard}}$, cancel and multiply

$$\frac{\$0.94}{1} \cdot \frac{3}{1 \text{ yard}} = \frac{\$2.82}{1 \text{ yard}}$$

$$\therefore \$2.82 \text{ per yard}$$

Compare prices for 1 yard of each tubing.

Tubing A: $1.83 per yard

Tubing B: $2.82 per yard

Answer: Tubing A is less expensive than Tubing B.

In the problem above, you could also have found the price per foot for each kind of tubing and compared the unit prices of each per foot.

Try It 1.1.2

A fence company is measuring a rectangular area in order to install a fence around its perimeter. If the length of the rectangular area is 130 yards and the width is 75 feet, what is the total length of the distance to be fenced?

Answer

130 yards is equivalent to 390 feet. To find the perimeter, add length + length + width + width: 390 feet + 390 feet + 75 feet + 75 feet = 930 feet.

Summary

The four basic units of measurement that are used in the U.S. customary measurement system are: inch, foot, yard, and mile. Typically, people use yards, miles, and sometimes feet to describe long distances. Measurement in inches is common for shorter objects or lengths.

You need to convert from one unit of measure to another if you are solving problems that include measurements involving more than one type of measurement. Each of the units can be converted to one of the other units using the table of equivalents, the conversion factors, and/or the factor label method shown in this topic.

Weight

Introduction

When you mention how heavy or light an object is, you are referring to its weight. In the U.S. customary system of measurement, weight is measured in ounces, pounds, and tons. Like other units of measurement that describe the same kind of quantity, you can convert between these units and you sometimes need to do this to solve problems.

In 2010, the post office charged $0.44 to mail an item that weighed an ounce or less. The post office charged $0.17 for each additional ounce, or fraction of an ounce, of weight. How much did it cost to mail a package that weighed two pounds three ounces? To answer this question, you need to understand the relationship between ounces and pounds.

Units of Weight

You often use the word **weight** to describe how heavy or light an object or person is. Weight is measured in the U.S. customary system using three units: ounces, pounds, and tons. An **ounce** is the smallest unit for measuring weight, a **pound** is a larger unit, and a **ton** is the largest unit.

Whales are some of the largest animals in the world. Some species can reach weights of up to 200 tons- that's equal to 400,000 pounds	
Meat is a product that is typically sold by the pound. One pound of ground beef makes about four hamburger patties.	
Ounces are used to measure lighter objects. A stack of 11 pennies is equal to about one ounce.	

You can use any of the customary measurement units to describe the weight of something, but it makes more sense to use certain units depending on how heavy an object is. For example, it makes more sense to describe the weight of a human being in pounds rather than tons. It makes more sense to describe the weight of a car in tons rather than ounces.

$$1 \text{ pound} = 16 \text{ ounces}$$

$$1 \text{ ton} = 2000 \text{ pounds}$$

Converting Between Units of Weight

Four ounces is a typical serving size of meat. Since meat is sold by the pound, you might want to convert the weight of a package of meat from pounds to ounces in order to determine how many servings are contained in a package of meat.

The weight capacity of a truck is often provided in tons. You might need to convert pounds into tons if you are trying to determine whether a truck can safely transport a big shipment of heavy materials.

The table below shows the unit conversions and conversion factors that are used to make conversions between customary units of weight.

Unit Equivalents	Conversion Factors (heavier to lighter units of measurement)	Conversion Factors (lighter to heavier units of measurement)
1 pound = 16 ounces	$\frac{16 \text{ ounces}}{1 \text{ pound}}$	$\frac{1 \text{ pound}}{16 \text{ ounces}}$
1 ton = 2000 pounds	$\frac{2000 \text{ pounds}}{1 \text{ ton}}$	$\frac{1 \text{ ton}}{2000 \text{ pounds}}$

You can use the *factor label method* to convert one customary unit of weight to another customary unit of weight. This method uses unit fractions conversion factor, which allow you to "cancel" units to end up with your desired unit of measurement.

Two examples illustrating the factor label method are shown below.

Example 1.1.6

How many ounces are in $2\frac{1}{4}$ pounds?

Solution

Begin by reasoning about your answer. Since a pound is heavier than an ounce, expect your answer to be a number greater than $2\frac{1}{4}$.

$$2\frac{1}{4} \text{ pounds} = \_\_\_\_\_ \text{ounces}$$

Multiply by the conversion factor that relates ounces and pounds: $\frac{16 \text{ ounces}}{1 \text{ pound}}$.

$$2\frac{1}{4} \text{ pounds} \cdot \frac{16 \text{ ounces}}{1 \text{ pound}} = \_\_\_\_\_ \text{ounces}$$

Write the mixed number as an improper fraction.

$$\frac{9 \text{ pounds}}{4} \cdot \frac{16 \text{ ounces}}{1 \text{ pound}} = \_\_\_\_\_ \text{ounces}$$

The common unit "pound" can be canceled because it appears in both the numerator and denominator.

$$\frac{9}{4} \cdot \frac{16 \text{ ounces}}{1} = \_\_\_\_\_ \text{ounces}$$

Multiply and simplify.

$$\frac{9 \cdot 16 \text{ ounces}}{4 \cdot 1} = \_\_\_\_\_ \text{ounces}$$

$$\frac{144 \text{ ounces}}{4} = \_\_\_\_\_ \text{ounces}$$

$$\frac{144 \text{ ounces}}{4} = 36 \text{ ounces}$$

Answer: There are 36 ounces in $2\frac{1}{4}$ pounds.

Example 1.1.7

How many tons is 6500 pounds?

Solution

Begin by reasoning about your answer. Since a ton is heavier than a pound, expect your answer to be a number less than 6500.

$$6500 \text{ pounds} = \_\_\_\_\_ \text{tons}$$

Multiply by the conversion factor that relates tons to pounds: $\frac{1 \text{ ton}}{2000 \text{ pounds}}$.

$$6500 \text{ pounds} \cdot \frac{1 \text{ ton}}{2000 \text{ pounds}} = \_\_\_\_\_ \text{tons}$$

$$\frac{6500 \text{ pounds}}{1} \cdot \frac{1 \text{ ton}}{2000 \text{ pounds}} = \_\_\_\_\_ \text{tons}$$

Apply the Factor Label method.

$$\frac{6500}{1} \cdot \frac{1 \text{ ton}}{2000} = \_\_\_\_\_ \text{tons}$$

Multiply and simplify.

$$\frac{6500 \text{ tons}}{2000} = \_\_\_\_\_ \text{tons}$$

$$\frac{6500 \text{ tons}}{2000} = 3\frac{1}{4} \text{ tons}$$

Answer: There are 6500 pounds in $3\frac{1}{4}$ tons.

Try It 1.1.3

How many pounds is 72 ounces?

Answer

There are 16 ounces in one pound, so $72 \text{ ounces} \cdot \frac{1 \text{ pound}}{16 \text{ ounces}} = 4\frac{1}{2} \text{ pounds}$.

Applying Unit Conversions

There are times when you need to perform calculations on measurements that are given in different units. To solve these problems, you need to convert one of the measurements to the same unit of measurement as the other measurement.

Think about whether the unit you are converting to is smaller or larger than the unit you are converting from. This will help you be sure that you are making the right computation. You can use the factor label method to make the conversion from one unit to another.

Here is an example of a problem that requires converting between units.

Example 1.1.8

A municipal trash facility allows a person to throw away a maximum of 30 pounds of trash per week. Last week, 140 people threw away the maximum allowable trash. How many tons of trash did this equal?

Solution

Determine the total trash for the week expressed in pounds. If 140 people each throw away 30 pounds, you can find the total by multiplying.

$$140 \cdot 30 \text{ pounds} = 4200 \text{ pounds}$$

Then convert 4200 pounds to tons. Reason about your answer. Since a ton is heavier than a pound, expect your answer to be a number less than 4200.

$$4200 \text{ pounds} = \_\_\_\_\_ \text{ tons}$$

Find the conversion factor appropriate for the situation: $\frac{1 \text{ ton}}{2000 \text{ pounds}}$.

$$\frac{4200 \text{ pounds}}{1} \cdot \frac{1 \text{ ton}}{2000 \text{ pounds}} = \_\_\_\_\_ \text{tons}$$

$$\frac{4200}{1} \cdot \frac{1 \text{ ton}}{2000} = \_\_\_\_\_ \text{tons}$$

Multiply and simplify.

$$\frac{4200 \cdot 1 \text{ ton}}{1 \cdot 2000} = \_\_\_\_\_ \text{tons}$$

$$\frac{4200 \text{ tons}}{2000} = \_\_\_\_\_ \text{tons}$$

$$\frac{4200 \text{ tons}}{2000} = 2\frac{1}{10} \text{ tons}$$

Answer: The total amount of trash generated is $2\frac{1}{10}$ tons.

Let's revisit the post office problem that was posed earlier. We can use unit conversion to solve this problem.

Example 1.1.9

The post office charges \$0.44 to mail something that weighs an ounce or less. The charge for each additional ounce, or fraction of an ounce, of weight is \$0.17. At this rate, how much will it cost to mail a package that weighs 2 pounds 3 ounces?

Solution

Since the pricing is for ounces, convert the weight of the package from pounds and ounces into just ounces.

$$2 \text{ pounds } 3 \text{ ounces} = \_\_\_\_\_ \text{ounces}$$

First use the factor label method to convert 2 pounds to ounces.

$$\frac{2 \text{ pounds}}{1} \cdot \frac{16 \text{ ounces}}{\text{pound}} = \_\_\_\_\_ \text{ounces}$$

$$\frac{2}{1} \cdot \frac{16 \text{ ounces}}{1} = 32 \text{ ounces}$$

$$\therefore 2 \text{ pounds} = 32 \text{ ounces}$$

Add the additional 3 ounces to find the weight of the package. The package weighs 35 ounces.

$$32 \text{ ounces} + 3 \text{ ounces} = 35 \text{ ounces}$$

There are 34 additional ounces, since 35 – 1 = 34.

Apply the pricing formula. \$0.44 for the first ounce and \$0.17 for each additional ounce.

$$\$0.44(1) + \$0.17(34)$$

$$\$0.44 + \$5.78$$

$$\$0.44 + \$5.78 = \$6.22$$

Answer: It will cost \$6.22 to mail a package that weighs 2 pounds 3 ounces.

Try It 1.1.4

The average weight of a northern Bluefin tuna is 1800 pounds. The average weight of a great white shark is $2\frac{1}{2}$ tons. On average, how much more does a great white shark weigh, in pounds, than a northern Bluefin tuna?

Answer

$2\frac{1}{2}$ tons = 5000 pounds. 5000 pounds – 1800 pounds = 3200 pounds.

Summary

In the U.S. customary system of measurement, weight is measured in three units: ounces, pounds, and tons. A pound is equivalent to 16 ounces, and a ton is equivalent to 2000 pounds. While an object's weight can be described using any of these units, it is typical to describe very heavy objects using tons and very light objects using an ounce. Pounds are used to describe the weight of many objects and people. Often, in order to compare the weights of two objects or people or to solve problems involving weight, you must convert from one unit of measurement to another unit of measurement. Using conversion factors with the factor label method is an effective strategy for converting units and solving problems.

Capacity

Introduction

Capacity is the amount of liquid (or other pourable substance) that an object can hold when it's full. When a liquid, such as milk, is being described in gallons or quarts, this is a measure of capacity.

Understanding units of capacity can help you solve problems like this: Sven and Johanna were hosting a potluck dinner. They did not ask their guests to tell them what they would be bringing, and three people ended up bringing soup. Erin brought 1 quart,

Richard brought 3 pints, and LeVar brought 9 cups. How many cups of soup did they have all together?

Units of Capacity

There are five main units for measuring capacity in the U.S. customary measurement system. The smallest unit of measurement is a **fluid ounce**. “Ounce” is also used as a measure of weight, so it is important to use the word “fluid” with ounce when you are talking about capacity. Sometimes the prefix “fluid” is not used when it is clear from the context that the measurement is capacity, not weight.

The other units of capacity in the customary system are the **cup**, **pint**, **quart**, and **gallon**. The table below describes each unit of capacity and provides an example to illustrate the size of the unit of measurement.

Fluid Ounce A unit of capacity equal to $\frac{1}{8}$ of a cup. One fluid ounce of water at 62°F weighs about one ounce. The amount of liquid medicine is often measured in fluid ounces.	
Cup A unit equal to 8 fluid ounces. The capacity of a standard measuring cup is one cup.	
Pint A unit equal to 16 fluid ounces, or 2 cups. The capacity of a carton of ice cream is often measured in pints.	
Quart A unit equal to 32 fluid ounces, or 4 cups. You often see quarts of milk being sold in the supermarket.	
Gallon A unit equal to 4 quarts, or 128 fluid ounces. When you fill up your car with gasoline, the price of gas is often listed in dollars per gallon.	

You can use any of these five measurement units to describe the capacity of an object, but it makes more sense to use certain units for certain purposes. For example, it makes more sense to describe the capacity of a swimming pool in gallons and the capacity of an expensive perfume in fluid ounces. However, unlike the units for length and weight, the units of capacity are not that far apart and often multiple units would be appropriate for one situation.

Sometimes you will need to convert between units of measurement. For example, you might want to express 5 gallons of lemonade in cups if you are trying to determine how many 8-fluid ounce servings the amount of lemonade would yield.

The table below shows some of the most common equivalents and conversion factors for the five customary units of measurement of capacity.

Unit Equivalents	Conversion Factors (heavier to lighter units of measurement)	Conversion Factors (lighter to heavier units of measurement)
1 cup = 8 fluid ounces	$\frac{1\text{ cup}}{8\text{ fluid ounces}}$	$\frac{8\text{ fluid ounces}}{1\text{ cup}}$
1 pint = 2 cups	$\frac{1\text{ pint}}{2\text{ cups}}$	$\frac{2\text{ cups}}{1\text{ pint}}$
1 quart = 2 pints	$\frac{1\text{ quart}}{2\text{ pints}}$	$\frac{2\text{ pints}}{1\text{ quart}}$
1 quart = 4 cups	$\frac{1\text{ quart}}{4\text{ cups}}$	$\frac{4\text{ cups}}{1\text{ quart}}$
1 gallon = 4 quarts	$\frac{1\text{ gallon}}{4\text{ quarts}}$	$\frac{4\text{ quarts}}{1\text{ gallon}}$
1 gallon = 16 cups	$\frac{1\text{ gallon}}{16\text{ cups}}$	$\frac{16\text{ cups}}{1\text{ gallon}}$

Converting Between Units of Capacity

As with converting units of length and weight, you can use the factor label method to convert from one unit of capacity to another. An example of this method is shown below.

Example 1.1.10

How many pints is $2\frac{3}{4}$ gallons?

Solution

Begin by reasoning about your answer. Since a gallon is larger than a pint, expect the answer in pints to be a number greater than $2\frac{3}{4}$.

$$2\frac{3}{4}\text{ gallons} = \_\_\_\_\_\text{ pints}$$

The table above does not contain a conversion factor for gallons and pints, so you cannot convert it in one step. However, you can use quarts as an intermediate unit, as shown here. Set up the equation so that two sets of labels cancel—gallons and quarts.

$$\frac{11\text{ gallons}}{4}\cdot\frac{4\text{ quarts}}{1\text{ gallon}}\cdot\frac{2\text{ pints}}{1\text{ quart}} = \_\_\_\_\_\text{ pints}$$

$$\frac{11}{4}\cdot\frac{4}{1}\cdot\frac{2\text{ pints}}{1} = \_\_\_\_\_\text{ pints}$$

Multiply and simplify.

$$\frac{11\cdot 4\cdot 2\text{ pints}}{4\cdot 1\cdot 1} = \_\_\_\_\_\text{ pints}$$

$$\frac{88\text{ pints}}{4} = 22\text{ pints}$$

Answer: $2\frac{3}{4}$ gallons is 22 pints.

Example 1.1.11

How many gallons is 32 fluid ounces?

Solution

Begin by reasoning about your answer. Since gallons is a larger unit than fluid ounces, expect the answer to be less than 32.

$$32 \text{ fluid ounces} = \_\_\_\_\_ \text{ gallons}$$

The table above does not contain a conversion factor for gallons and fluid ounces, so you cannot convert it in one step. Use a series of intermediate units, as shown here.

$$\frac{32 \text{ fluid ounces}}{1} \cdot \frac{1 \text{ cup}}{8 \text{ fluid ounces}} \cdot \frac{1 \text{ pint}}{2 \text{ cups}} \cdot \frac{1 \text{ quart}}{2 \text{ pints}} \cdot \frac{1 \text{ gallon}}{4 \text{ quarts}} \quad \_\_\_\_\_ \text{ gallons}$$

Cancel units that appear in both the numerator and denominator.

$$\frac{32}{1} \cdot \frac{1}{8} \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1 \text{ gallon}}{4} = \_\_\_\_\_ \text{ gallons}$$

Multiply and simplify.

$$\frac{32 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \text{ gallon}}{1 \cdot 8 \cdot 2 \cdot 2 \cdot 4} = \_\_\_\_\_ \text{ gallons}$$

$$\frac{32 \text{ gallons}}{128} = \frac{1}{4} \text{ gallons}$$

Answer: 32 fluid ounces is the same as $\frac{1}{4}$ gallon.

Try It 1.1.5

Find the sum of 4 gallons and 2 pints. Express your answer in cups.

Answer

Each gallon has 16 cups, so $4 \cdot 16 = 64$ will give you the number of cups in 4 gallons. Each pint has 2 cups, so $2 \cdot 2 = 4$ will give you the number of cups in 2 pints. $64 + 4 = 68$ cups.

Applying Unit Conversions

There are times when you will need to combine measurements that are given in different units. In order to do this, you need to convert first so that the units are the same.

Consider the situation posed earlier in this topic.

Example 1.1.12

Sven and Johanna were hosting a potluck dinner. They did not ask their guests to tell them what they would be bringing, and three people ended up bringing soup. Erin brought 1 quart, Richard brought 3 pints, and LeVar brought 9 cups. How much soup did they have total?

Solution

Since the problem asks for the total amount of soup, you must add the three quantities. Before adding, you must convert the quantities to the same unit.

$$1 \text{ quart} + 3 \text{ pints} + 9 \text{ cups}$$

The problem does not require a particular unit, so you can choose. Cups might be the easiest computation because going to a smaller unit will multiply the numbers and not divide and yield fractions.

Converting 1 quart to cups is given in the table of equivalents.

$$1 \text{ quart} = 4 \text{ cups}$$

Use the factor label method to convert pints to cups.

$$\frac{3 \text{ pints}}{1} \cdot \frac{2 \text{ cups}}{1 \text{ pint}} = \_\_\_\_\_ \text{cups}$$

$$\frac{3}{1} \cdot \frac{2 \text{ cups}}{1} = 6 \text{ cups}$$

Add the 3 quantities.

$$4 \text{ cups} + 6 \text{ cups} + 9 \text{ cups} = 19 \text{ cups}$$

Answer: There are 19 cups of soup for the dinner.

Example 1.1.13

Natasha is making lemonade to bring to the beach. She has two containers. One holds one gallon and the other holds 2 quarts. If she fills both containers, how many cups of lemonade will she have?

Solution

This problem requires you to find the sum of the capacity of each container and then convert that sum to cups.

$$1 \text{ gallon} + 2 \text{ quarts} = \_\_\_\_\_ \text{ cups}$$

First, find the sum in quarts. 1 gallon is equal to 4 quarts.

$$4 \text{ quarts} + 2 \text{ quarts} = 6 \text{ quarts}$$

Since the problem asks for the capacity in cups, convert 6 quarts to cups.

$$\frac{6 \text{ quarts}}{1} \cdot \frac{2 \text{ pints}}{1 \text{ quart}} \cdot \frac{2 \text{ cups}}{1 \text{ pint}} = \_\_\_\_\_ \text{ cups}$$

Cancel units that appear in both the numerator and denominator.

$$\frac{6}{1} \cdot \frac{2}{1} \cdot \frac{2 \text{ cups}}{1} = \_\_\_\_\_ \text{ cups}$$

Multiply.

$$6 \cdot 2 \cdot 2 = 24 \text{ cups}$$

Answer: Natasha will have 24 cups of lemonade.

Another way to work the problem above would be to first change 1 gallon to 16 cups and change 2 quarts to 8 cups. Then add: 16 + 8 = 24 cups.

Try It 1.1.6

Alan is making chili. He is using a recipe that makes 24 cups of chili. He has a 5-quart pot and a 2- gallon pot and is trying to determine whether the chili will all fit in one of these pots. Which of the pots will fit the chili?

Answer

The chili will fit into the 2-gallon pot only. $5 \text{ quarts} = 5 \cdot 4 \text{ cups} = 20 \text{ cups}$, so 24 cups of chili will not fit into the 5-quart pot. $2 \text{ gallons} = 32 \text{ cups}$, so 24 cups of chili will fit in this pot.

Summary

There are five basic units for measuring capacity in the U.S. customary measurement system. These are the fluid ounce, cup, pint, quart, and gallon. These measurement units are related to one another, and capacity can be described using any of the units. Typically, people use gallons to describe larger quantities and fluid ounces, cups, pints, or quarts to describe smaller quantities. Often, in order to compare or to solve problems involving the amount of liquid in a container, you need to convert from one unit of measurement to another.