1 Units of Measure and Unit Conversions

KEY TERMS

weight

volume

U.S. customary system

metric system/Système International d'Unités (SI)

avoirdupois

equivalent

mixed measurement

unit conversion

tare

KEY QUESTIONS

What types of measurements are used in a professional kitchen?

When measuring a substance by weight, what property are you measuring?

When measuring a substance by volume, what property are you measuring?

What standard U.S. and SI units are weight measures? Which are volume measures?

What are you doing when you convert units of measure?

Why do foodservice professionals need to convert units of measure?

1.1 Measurements Used in the Professional Kitchen

When measuring ingredients in the kitchen, you measure by **weight** (gravitational pull) or by **volume** (a defined amount of space). The focuses of this chapter are (1) the formal standards by which ingredients are measured in the professional kitchen and (2) converting quantities from one unit of measure to another.

There are two commonly used systems of measurement: the **U.S. customary system** and the **metric system.** The metric system, which is formally known as the **Système International d'Unités (SI),** is the most prevalent standard across the globe. Both SI and U.S. customary unit standards will be discussed in this text. Care has been taken to pare down the amount of information to manageable quantities for the emergent professional. Over time you will expand your knowledge base past the contents of this resource.

MEASURING BY WEIGHT

Standard weight measurements are defined legally. Weight measures based on the U.S. customary 16-ounce pound are called **avoirdupois** measures. The metric gram has been defined as being the weight of 1 cubic centimeter of water, and the kilogram is defined as the weight of 1000 cubic centimeters, or 1 liter, of space filled with water.

MEASURES OF WEIGHT	WEIGHT MEASURE	ABBREVIATION
METRIC SYSTEM	gram	g
	kilogram	kg
U.S. CUSTOMARY SYSTEM	pound	# or lb
	ounce	oz

Written in order from the smallest to the largest unit of weight:

gram

ounce

pound

kilogram

The standard weight **equivalents,** or relationships between the weight measures, are shown below. These relationships are constant.

28.35 g	=	1 oz				
453.6 g	=	16 oz	=	1 #	=	0.4536 kg
1000 g	=	35.27 oz	=	2.205 #	=	1 kg

Equivalent weights. Left: Butter weighed in pounds on a spring scale. Right: The same butter weighed in grams on a digital scale.

Each row in the chart contains equivalent quantities. For instance, the second row tells us that if 453.6 grams of a substance is placed on a digital scale, the scale could read 16 ounces, 1 pound, or 0.4536 kilograms. The quantity on the scale did not change, but the weight was expressed using different units of measure. Similarly, if 1000 grams of a substance was placed on a digital scale, the scale could read 35.27 ounces, 2.205 pounds, or 1 kilogram. You can also use **mixed measurements** (measurements using more than one unit) to specify a quantity. For example, 21 ounces could be written as 1 pound 5 ounces.

To measure weight you can use a traditional spring scale, a digital scale, or a balance scale.

For professional kitchen use, a digital scale accurate to within 1 gram or ⅟₀₀ of an ounce is adequate for just about any need. Many kitchens use scales weighing in intervals of 5 grams or ⅛ ounce, which are less accurate but also less expensive. Your choice of scale depends upon the needs of your particular kitchen.

Types of scales. Left to right: balance scale, digital scale, spring scale.

MEASURING BY VOLUME

Measuring an ingredient by volume means that you are filling a certain quantity of space with an ingredient. Volume measures are legally defined in the U.S. customary system, and there are liquid volume and dry volume measures. The liquid and dry volume measures are two separate sets of volume measurements, and corresponding units are different sizes. The volume units used in the professional kitchen are based on the liquid volume scale with the exception of the peck and bushel, which are U.S. customary dry volume measures. (For more information about liquid and dry volume measurements, see Appendix I.)

The milliliter is defined as 1 cubic centimeter of space, or the amount of space that 1 gram of water occupies. The liter is defined as 1000 cubic centimeters of space or 1000 milliliters of volume. This can also be looked at as the amount of space that 1 kilogram of water occupies.

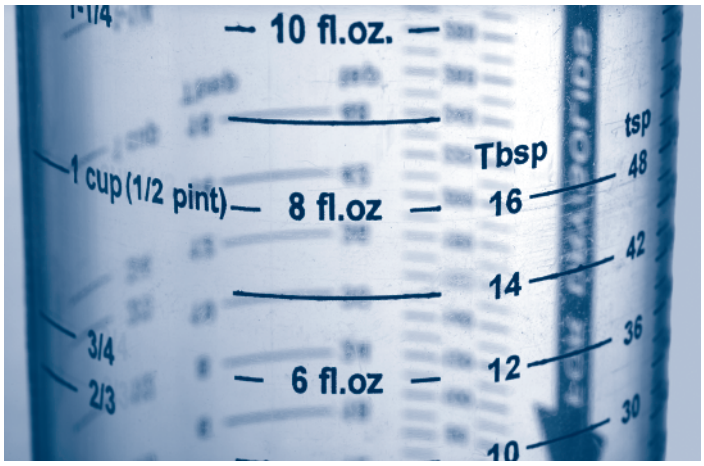
MEASURES OF VOLUME	VOLUME MEASURE	ABBREVIATION
METRIC SYSTEM	milliliter	mL or ml
	liter	L
U.S. CUSTOMARY SYSTEM	teaspoon	tsp or t
	tablespoon	tbl or T
	fluid ounce	fl oz
	cup	C
	pint	pt
	quart	qt
	gallon	G or gal

Written in order from the smallest to the largest unit of volume:

milliliter
teaspoon
tablespoon
fluid ounce
cup
pint
quart
liter
gallon

The standard volume equivalents or relationships between the volume measures are shown below. Once again, these relationships are constant.

												1 T	=	3 t	=	0.5 fl oz								
												2 T			=	1 fl oz	=	29.59 mL						
								1 C	=	16 T	=	48 t	=	8 fl oz										
					1 pt	=	2 C						=	16 fl oz										
			1 qt	=	2 pt	=	4 C						=	32 fl oz										
														33.8 fl oz	=	1000 mL	=	1 L						
1 G	=	4 qt	=	8 pt	=	16 C							=	128 fl oz										



Equivalent volumes. One cup, ½ pint, 8 fluid ounces, 16 tablespoons, and 48 teaspoons are all equivalent volumes. Note: This measuring device is correctly marked in fluid ounces. Many volume measuring devices are marked in ounces, which could potentially be confusing. A person using such a device must know it means fluid ounces by volume.

Equivalents can be found by moving across rows in the chart above. For instance, the first row shows us that 1 tablespoon is equivalent to both 3 teaspoons and 0.5 fluid ounce. This means that if you measured 3 teaspoons and poured the contents into a tablespoon, the tablespoon would be exactly full. You can move across the second row and see that 2 tablespoons is equivalent to both 1 fluid ounce and 29.59 milliliters.

It will help your efficiency to have weight equivalents and volume equivalents memorized. Equivalents are used in the process of converting units of measure, which is a necessary part of a foodservice professional's duties. Converting units of measure is addressed in the next section.

1.1 PRACTICE PROBLEMS

For questions 1–9, use your knowledge of standard unit equivalents to help you answer the questions.

1. Which object would most likely weigh 1 gram?

   (A) a peanut
   (B) a strawberry
   (C) a shallot
   (D) an artichoke

2. Which U.S. customary unit is approximately equivalent to 1 liter?

   (A) 1 pint
   (B) 1 cup
   (C) 1 quart
   (D) 1 gallon

3. One pound of butter is most closely equivalent to which of the following metric measures?

(A) ¼ kilogram
(B) ½ kilogram
(C) ¾ kilogram
(D) 1 kilogram

4. One gallon is equivalent to which of the following quantities?

(A) 4 pints
(B) 2 liters
(C) 16 cups
(D) 8 pounds

5. If a standard wine bottle holds ¾ of a liter, approximately how many fluid ounces does the bottle hold?

(A) 13 fluid ounces
(B) 16 fluid ounces
(C) 25 fluid ounces
(D) 32 fluid ounces

6. During dinner service, your chef says to you, "I need 5 cups of chicken stock!" In the walk-in refrigerator, you find four containers of stock. Without leaving your chef short on stock, which container holds an amount that is closest to the quantity that your chef needs?

(A) 1 quart
(B) 1½ quarts
(C) 2 quarts
(D) 2½ quarts

7. Your grocery list for a banquet menu includes 1 kilogram of semolina flour. Which of the following bag sizes is closest to the quantity that you need for the recipe, without leaving you short on flour?

(A) 1 pound
(B) 1½ pounds
(C) 2 pounds
(D) 2½ pounds

8. Without using any references, fill in the missing numbers in the ten standard equivalents below:

a. 1 quart = _____ cups

b. 1 kilogram = _____ grams

c. 1 gallon = _____ quarts

d. 1 tablespoon = _____ teaspoons

e. 1 cup = _____ fluid ounces

f. 1 pint = _____ cups

g. 1 pound = _____ grams

h. 1 liter = _____ fluid ounces

i. 1 cup = _____ tablespoons

j. 1 kilogram = _____ pounds

9. Match the quantity in the first column with its approximate equivalent in the second column.

a. 1 pound	i. ½ liter
b. 2 teaspoons	ii. ½ pound
c. 225 grams	iii. ½ kilogram
d. 16 fluid ounces	iv. 10 grams
e. ⅓ ounce	v. 10 milliliters
f. 280 grams	vi. 10 ounces

10. For the recipe below, rewrite the given ingredient quantities as approximately equivalent quantities expressed in the unit in the "revised quantity" column.

Example:

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Heavy cream	1 qt	approx. 1 L

Filling for Pecan Diamonds

Makes 100 pieces

(Adapted from The Professional Chef *[8th ed.] by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Butter, cubed	1 #	kg
Brown sugar, light	1 #	kg
Sugar, granulated	4 oz	g
Honey	12 oz	g
Heavy cream	4 fl oz	mL
Pecans	2 #	kg

1.2 Converting Units of Measure Within Weight or Within Volume

Unit conversion is the process of expressing a given quantity in a different unit of measure. You can also look at unit conversions as measuring an ingredient quantity two different ways. For example, 3 pounds of flour weighed in ounces would be 48 ounces of flour. By converting the units, you are calculating the equivalent weight rather than finding the equivalent weight by measuring the ingredient again with the scale set to ounces instead of pounds.

Foodservice professionals frequently convert units of measure to accomplish tasks and goals in a professional kitchen. At times the converting is done mentally as a quick estimation. A more formal procedure is done at other times: while interpreting and standardizing recipes, purchasing and portioning product, and costing recipes.

As a foodservice professional, you might need to convert units of measure to:

- **accurately measure ⅛ gallon**
- **convert 36 teaspoons to a more easily measured unit**
- **convert recipe quantities from U.S. customary to metric measurements**
- **estimate the number of portions you will make from a given recipe**

Equivalent volumes. By using a quart container to measure 1 cup, you can see that 1 cup is equivalent to ¼ quart.

Converting units for ease of measurement. Using a gallon container (especially a metal one, like that shown here) to measure ⅛ gallon could be difficult. Converting ⅛ gallon to 2 cups and using a pint container may make more sense.

In the subsequent examples, we will most often use standard equivalents from the abridged chart that follows. Our goal is to use different combinations of equivalents to give you a broad picture of the unit conversion process. You may choose to use different equivalents; in many cases, you will calculate a slightly different quantity.

COMMONLY USED VOLUME EQUIVALENTS			COMMONLY USED WEIGHT EQUIVALENTS	
1 T = 3 t	1 C = 16 T	1 G = 4 qt	1 oz = 28.35 g	1 kg = 2.205 #
1 T = 0.5 fl oz	1 pt = 2 C	1 L = 33.8 fl oz	1 # = 16 oz	1 kg = 1000 g
1 fl oz = 29.59 mL	1 qt = 2 pt	1 L = 1000 mL	1 # = 453.6 g	
1 C = 8 fl oz	1 qt = 4 C			

THE BRIDGE METHOD

A simple technique for converting units of measure easily and accurately is called dimensional analysis. It is also known as the bridge or unity fraction method. Professionals in the sciences, such as physicists, doctors, and chemists, also utilize this method.

The bridge method is one way of organizing the information used to convert a measured quantity. The procedure has seven steps:

1. Rewrite the quantity you want to convert without any fractions or mixed units of measure.
2. Identify the type of unit conversion (e.g., weight to weight, volume to volume, or between weight and volume).
3. Draw arrows to indicate the target unit to which you are converting as well as the sequence of units you will use to get to your target unit.
4. Write the original quantity as a fraction with a denominator of 1. Copy the unit from the numerator of the first fraction to the denominator of a second fraction.
5. Determine an equivalent that includes this unit and the next unit in your sequence diagram.
6. Repeat steps 4 and 5 until the final unit you are converting into is located in the numerator of the final fraction.
7. Multiply the fractions in your bridge to calculate your answer.

EXAMPLE 1.2.1 CONVERTING TO AN EASILY MEASURED UNIT

A catering function requires you to scale a recipe to a smaller number of portions. You end up with ⅛ gallon of milk as a recipe quantity. You decide that the equipment you will be taking on-site can more easily measure this amount in cups. How many cups are contained in ⅛ gallon?

We need to rewrite ⅛ gallon as a number of cups. We'll use the bridge method to convert this quantity into cups.

STEP 1: Rewrite the quantity you want to convert without any fractions or mixed units of measure.

⅛ G = 0.125 G

STEP 2: Identify the type of unit conversion.

This is a volume-to-volume unit conversion.

STEP 3: Draw arrows to indicate the target unit to which you are converting as well and as the sequence of units you will use to get to your target unit.

In this instance, the conversion is from gallons to cups. We could convert directly from gallons to cups (1 G = 16 C), but for purposes of this example, we will use quarts as an intermediary unit.

gallons ⟶ quarts ⟶ cups

STEP 4: Write the original quantity as a fraction. Put the quantity in the numerator and one (1) in the denominator. Copy the unit from the numerator of the first fraction to the denominator of the second fraction.

G ⟶ qt ⟶ C

$$\frac{0.125\ \text{G}}{1} \times \frac{}{\text{G}}$$

STEP 5: Determine an equivalent that includes this unit and the next unit in your sequence diagram. Since the next unit in our arrow chart is quarts, we write "qt" in the numerator, and insert the appropriate numerical relationship between quarts and gallons.

G ⟶ qt ⟶ C

$$\frac{0.125\ \text{G}}{1} \times \frac{4\ \text{qt}}{1\text{G}}$$

(If you evaluated the conversion at this point, the answer would be in quarts.)

STEP 6: Repeat steps 4 and 5 until the final unit you are converting into is located in the numerator of the final fraction. Our next (and desired) unit is cups, so we need one more fraction containing the relationship between quarts and cups.

G ⟶ qt ⟶ C

$$\frac{0.125\ \text{G}}{1} \times \frac{4\ \text{qt}}{1\text{G}} \times \frac{4\text{C}}{1\text{qt}}$$ ← our desired unit

STEP 7: Multiply the fractions in the bridge to calculate your answer. All the units except for cups should cancel, since each appears in one numerator and one denominator.

$$\frac{0.125\cancel{\text{G}}}{1} \times \frac{4\cancel{\text{qt}}}{1\cancel{\text{G}}} \times \frac{4\text{C}}{1\cancel{\text{qt}}} = \frac{2}{1}\text{C} = 2\text{C}$$

As you may remember, if a fraction's numerator and denominator have the same value, the fraction is equal to 1. Given that the fractions in our bridge above, except for our initial fraction, are unit equivalents, they have the value of 1. Thus you are multiplying the original quantity by 1 and are not changing the initial quantity at all. You are merely rewriting the quantity in a different unit of measure.

EXAMPLE 1.2.2 CONVERTING TO AN EASILY MEASURED UNIT

After scaling a home recipe for large-scale production, you end up with 36 teaspoons of baking soda. Rewrite this quantity in a larger unit of volume so it can be more efficiently measured.

As in the last example, we'll use the bridge method to do the conversion.

STEP 1: Since 36 teaspoons doesn't contain a fraction or a mixed unit of measure, we're ready to convert.

STEP 2: This is a volume-to-volume unit conversion.

STEP 3: It seems like cups would be a good unit in which to measure our ingredient, so we'll convert teaspoons to cups. You could convert directly from teaspoons to cups (1 C = 48 t), but for purposes of this example, tablespoons are used as an intermediary unit.

teaspoons ⟶ tablespoons ⟶ cups

STEP 4: Copy the unit from the numerator of the first fraction into the denominator of the next fraction.

t ⟶ T ⟶ C

$$\frac{36\,\text{t}}{1}\times\frac{\quad}{\text{t}}$$

STEP 5: Since tablespoons is the next unit in this case, you write "T" in the numerator, and insert the appropriate numerical relationship between tablespoons and teaspoons.

t ⟶ T ⟶ C

$$\frac{36\,\text{t}}{1}\times\frac{1\,\text{T}}{3\,\text{t}}$$

STEP 6: Our next (and desired) unit is cups, so we need one more fraction containing the relationship between tablespoons and cups.

$$\frac{36\,\text{t}}{1}\times\frac{1\,\text{T}}{3\,\text{t}}\times\frac{1\,\text{C}}{16\,\text{T}}$$ ← our desired unit

STEP 7: Calculate the answer.

$$\frac{36\cancel{\text{t}}}{1}\times\frac{1\cancel{\text{T}}}{3\cancel{\text{t}}}\times\frac{1\,\text{C}}{16\cancel{\text{T}}}=\frac{36}{48}\,\text{C}=0.75\,\text{C}$$

EXAMPLE 1.2.3 CONVERTING TO METRIC UNITS

During a menu development meeting, your executive chef asks you to convert 3 # 5 oz of beets, 1 # 10 oz of onions, 4 fl oz of olive oil, and ⅔ oz of salt to metric units. **What metric quantities are these recipe amounts equivalent to?**

Since there is a sizable quantity of each of the vegetables, a logical metric unit to convert them to is kilograms. The olive oil and salt are relatively small quantities, so the logical metric units to convert to are milliliters and grams, respectively.

Beets: 3 # 5 oz = 53 oz, or 3.3125 #
Onions: 1 # 10 oz = 26 oz, or 1.625 #
Salt: ⅔ oz = 0.6666 oz

First, eliminate the mixed measurements given for the beets and the onions, and convert ⅔ into a decimal.

Beets: oz ⟶ # ⟶ kg

$$\frac{53\text{ oz}}{1}\times\frac{1\text{ \#}}{16\text{ oz}}\times\frac{1\text{ kg}}{2.205\text{ \#}}=\frac{53}{35.28}\text{kg}=1.5022\text{ kg}$$

Use standard unit equivalents to convert the ingredient quantities into metric units.

Onions: # ⟶ kg

$$\frac{1.625\text{ \#}}{1}\times\frac{1\text{ kg}}{2.205\text{ \#}}=\frac{1.625}{2.205}\text{kg}=0.7369\text{ kg}$$

Olive oil: fl oz ⟶ L ⟶ mL

$$\frac{4\text{ fl oz}}{1}\times\frac{1\text{L}}{33.8\text{ fl oz}}\times\frac{1{,}000\text{ mL}}{1\text{L}}=\frac{4{,}000}{33.8}\text{mL}=118.3431\text{ mL}$$

Salt: oz ⟶ g

$$\frac{0.6666\text{ oz}}{1}\times\frac{28.35\text{ g}}{1\text{ oz}}=\frac{18.8981}{1}\text{g}=18.8981\text{g}$$

The choice to start with the ounce weight of the beets and the pound weight of the onions was to demonstrate different ways to convert units. You could just as easily have used the other unit to start those two calculations.

Our conversion examples thus far have used only standard equivalents; however, nonstandard unit equivalents may be used as well. In the following two examples, we will use 1 serving = 3 ounces and 1 bottle = 750 milliliters as equivalents. These are examples of nonstandard equivalents, since serving sizes and bottle capacities are not all the same.

EXAMPLE 1.2.4 PORTIONING

A recipe for potato latkes makes 1 kilogram of batter. How many 3-ounce servings will you get from one batch?

kilograms ⟶ pounds ⟶ ounces ⟶ servings

Determine the order of units needed to convert kilograms into servings. Use 1 serving = 3 ounces as an equivalent.

$$\frac{1\text{ kg}}{1}\times\frac{2.205\text{ \#}}{1\text{ kg}}\times\frac{16\text{ oz}}{1\text{ \#}}\times\frac{1\text{ serving}}{3\text{ oz}}=\frac{35.28}{3}\text{servings}=11.76\text{ servings}$$

Use standard unit equivalents to convert the quantity of batter into a number of servings.

EXAMPLE 1.2.5 PORTIONING

You have 12 bottles of champagne in inventory. If each bottle contains 750 milliliters, how many servings of 4 fluid ounces can you pour from the case?

bottles ⟶ milliliters ⟶ fluid ounces ⟶ servings

Determine the order of units needed to convert bottles into servings. The given information gives us two equivalents to use: 1 bottle = 750 milliliters and 1 serving = 4 fluid ounces.

$$\frac{12\text{ btl}}{1}\times\frac{750\text{ mL}}{1\text{btl}}\times\frac{33.8\text{ fl oz}}{1{,}000\text{ mL}}\times\frac{1\text{serving}}{4\text{ fl oz}}=\frac{304200}{4000}\text{ servings}=76.05\text{ servings}$$

There are two common equivalents between fluid ounces and milliliters.

$$\frac{12\text{ btl}}{1}\times\frac{750\text{ mL}}{1\text{btl}}\times\frac{1\text{ fl oz}}{29.59\text{ mL}}\times\frac{1\text{serving}}{4\text{ fl oz}}=\frac{9000}{118.36}\text{ servings}=76.04\text{ servings}$$

You will note that the answers above do not match exactly because two different equivalents between milliliters and fluid ounces were used. Keep in mind that many unit equivalents contain rounded numbers, so using different combinations of unit equivalents may result in slight variations between answers. For the most part, you need not be too concerned about these small differences. In Appendix I there is more information about exact equivalents.

1.2 PRACTICE PROBLEMS

Use your knowledge of equivalents to answer the following questions. Your answers may vary slightly from those given in the back of the book depending on which equivalents you use. Round all answers to the nearest hundredth (2 decimal places).

1. A scaled recipe calls for 12 teaspoons of baking powder. How many cups of baking powder would you need to measure for this recipe?

2. A recipe for crème brûlée calls for 960 milliliters of heavy cream. If you have 1 pint in the walk-in refrigerator, do you have enough heavy cream to make the recipe?

3. A recipe calls for 430 milliliters of white wine. How many cups would you need to use?

4. At an upcoming catering event, you will be serving 6 fluid ounces of gazpacho to each of 110 people. How many gallons of soup will you need to make?

5. You are making cheese tuiles, each of which requires ½ ounce of imported Parmesan cheese. How many kilograms of Parmesan cheese would you need to make 1200 tuiles?

6. Your recipe for oatmeal raisin cookies calls for 3 pounds 3 ounces of rolled oats. Assuming you had enough of the other ingredients, how many times can you make the recipe using a 25-pound bag of rolled oats?

7. A recipe for bread dough yields 7½ kilograms of dough. If you divide the dough into 275-gram loaves, how many loaves will you be able to make from the recipe?

8. You are planning to serve salmon with béarnaise sauce to 64 people at a banquet. Each serving requires 1½ fluid ounces of béarnaise sauce. How many quarts of béarnaise sauce do you need to make?

9. For a banquet, you will be serving 1 taco to each of 50 people. You have 12½ pounds of prepared turkey taco filling. If you want to divide this filling equally between the tacos, how many ounces of taco meat should you add to each taco shell?

10. Convert each given recipe yield to an appropriate unit of measure based on the given serving size. Then, use that serving size to determine the number of portions that can be made. (Round answers *down* to a whole number of servings.)

	RECIPE YIELD	UNIT CONVERSION	SERVING SIZE	NUMBER OF SERVINGS
a.	1½ gallons		4 fl oz	
b.	2 gallons		½ C	
c.	1 pound 10 ounces		¾ oz	
d.	2 quarts		2 T	
e.	1 pint		⅓ C	
f.	1½ liters		3 fl oz	
g.	1 liter		50 mL	
h.	375 milliliters		1 fl oz	
i.	2½ kilograms		6 oz	
j.	1¾ kilograms		118 g	
k.	2¾ pounds		50 g	
l.	3 pounds		4 oz	
m.	5 kilograms		250 g	

11. For each ingredient in the recipe below, convert the given quantity so it is expressed in the unit in the "revised quantity" column. Round your revised quantities to the nearest hundredth of a kilogram (2 decimal places) or to the nearest gram.

Cottage Dill Rolls

Makes 24 dozen rolls

(Adapted from The Professional Chef *[8th ed.] by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Water	3 #	kg
Yeast	1¼ #	g
Flour, bread	21 #	kg
Cottage cheese, low-fat	12 #	kg
Sugar, granulated	1 # 2 oz	kg
Onions, minced	6 oz	g
Butter	1½ #	kg
Salt	6 oz	g
Dill, chopped	4 oz	g
Baking soda	4 oz	g
Eggs, large	1½ #	kg
Horseradish	¾ oz	g

12. For each ingredient in the recipe below, convert the given quantity so it is expressed in the unit in the "revised quantity" column. Round your revised quantities to the hundredths place (2 decimal places).

Rustic Raisin Bread

Makes 4 small loaves

(Adapted from The Professional Chef *[8th ed.] by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Flour, bread	2.83 kg	#
Yeast, instant dry	43 g	oz
Milk, whole	2.4 L	G
Honey	85 g	oz
Salt	57 g	oz
Raisins	1.47 kg	#
Butter	113 g	#
Egg yolks	1 ea	ea

13. For each ingredient in the recipe below, convert the given quantity so it is expressed in the unit in the "revised quantity" column. Truncate your revised quantities at the ten-thousandths place (4 decimal places).

Trout Amandine

Makes 60 servings

(Adapted from The Professional Chef *[8th ed.] by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Milk	3 pt	G
Flour, all-purpose (1 bag = 25 #)	18 oz	bag
Oil	12 fl oz	qt
Butter	60 oz	#
Almonds, slivered	24 oz	#
Trout filets	60 filets (6 oz ea)	#
Lemon juice	3¾ C	qt
Parsley, dried (1 jar = 3 oz)	4 oz	jar

14. For each ingredient in the recipe below, convert the given quantity so it is expressed in the unit in the "revised quantity" column. Truncate your revised quantities at the ten-thousandths place (4 decimal places).

Lemon Meringue Pie

Makes fifteen 9-inch pies

(Adapted from The Professional Chef *[8th ed.] by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Water	5¾ L	G
Sugar (1 bag = 5 #)	2¾ kg	bag
Salt (1 box = 26 oz)	42 g	box
Lemon juice	900 mL	pt
Lemon zest	84 g	oz
Cornstarch (1 box = 1 #)	510 g	box
Egg yolks	24 ea	dozen
Butter	340 g	#

1.3 Converting Between Weight and Volume

Standardizing recipes for quality control purposes, ordering, and planning in your professional kitchen can get a bit more complicated when recipes measure dry ingredients by volume. For the sake of accuracy and product consistency, you will sometimes need to convert between volume and weight.

The recipe below is from a cookbook written for a home cook, and many of the ingredients are measured by volume.

Cheddar Corn Fritters

Makes 6 to 8 fritters

(Adapted from Vegetables *by The Culinary Institute of America)*

¾ C all-purpose flour

3 T granulated sugar

2 t chili powder

2 C fresh corn niblets

3 T diced red or green pepper

2 large eggs

½ C grated cheddar

½ C water

2 T butter

2 T vegetable oil

2 t salt, table grind

If you were to use this recipe in a professional kitchen, you might want to rewrite the recipe to measure all ingredients by weight (for accuracy, for ease of use, or due to available equipment). To do so, you need information in addition to standard unit equivalents, because you are now converting units of volume to units of weight.

Take our first ingredient, all-purpose (AP) flour. Our recipe calls for ¾ cup, but our chef would like all dry ingredients measured by the pound. Thus, you would need to convert ¾ cups of AP flour to pounds. You might be thinking, "That's easy. One cup weighs 8 ounces, and three-quarters of that would be 6 ounces. Divide 6 ounces by sixteen to convert it to pounds, so you need to use 0.375 pounds of flour to make this recipe."

If this is what you were thinking, think it over one more time. If you **tared,** or zeroed, a scale with a 1-cup measuring tool on it, then measured 1 cup of flour and put the full cup of flour on the scale, the scale would read approximately 4.6 ounces in weight. Where is the logic in the above paragraph flawed? One cup is 8 fluid ounces of space, but a cup of an ingredient does not necessarily weigh 8 ounces. *Do not assume that 1 fluid ounce of an ingredient weighs 1 ounce. A fluid ounce is a quantity of space, and an ounce is a quantity of weight!*

In order to revise these recipe quantities (which are, with the exception of eggs, written by volume), you need to know the weight of some volume of each ingredient. That is, you need an equivalent to set the relationship between weight and volume for that ingredient. You can get equivalents like these by weighing the ingredients yourself, or you can get approximations from resources such as *The Book of Yields* by Francis T. Lynch, as we have done throughout this text. (Appendix V contains information from *The Book of Yields*.)

The following are volume-to-weight equivalents from *The Book of Yields*. These will be used in Example 1.3.1 to convert the quantities in our recipe for Cheddar Corn Fritters to their weight equivalents.

All-purpose flour	1 cup = 4.6 ounces
Granulated sugar	1 cup = 7.10 ounces
Chili powder	1 tablespoon = 0.235 ounces
Corn niblets	1 cup = 5.75 ounces
Green pepper, diced	1 cup = 3.2 ounces
Cheddar, grated	1 pint = ½ pound
Butter	2 cups = 1 pound
Salt, table grind	1.6 cups = 1 pound

Take some time to review these equivalents. For the sake of this example, various options of available volume-to-weight information have been used. If utilizing one type of volume-to-weight equivalent makes the conversion process easier, use the information that is easiest for your mind to visualize. For example, many utilize the weight-per-cup equivalent consistently, which makes the unit conversions more familiar. Listen to your internal sense of logic about these relationships.

Effect of density on weight. Each container holds 1 cup of an ingredient (left to right: corn kernels, water, chili powder), yet the weights are all different because the density of each ingredient is different.

What factors affect the weight of a specific volume of substance? Think about your answer to this question as we convert the recipe quantities below.

EXAMPLE 1.3.1 CONVERTING RECIPE QUANTITIES

For each ingredient in the Cheddar Corn Fritters recipe, convert the given recipe quantity so it is expressed in the specified unit. Truncate all quantities after four decimal places.

Cheddar Corn Fritters

Makes 6 to 8 fritters

(Adapted from Vegetables *by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	CONVERT RECIPE QUANTITY INTO THIS UNIT	REVISED RECIPE QUANTITY
Flour, all-purpose	¾ C	pounds	$\frac{0.75\text{ C}}{1}\times\frac{4.6\text{ oz}}{1\text{ C}}\times\frac{1\text{ \#}}{16\text{ oz}}\times\frac{3.45}{16}\text{\#}=\mathbf{0.2156\ \#}$
Sugar, granulated	3 T	ounces	$\frac{3\text{ T}}{1}\times\frac{1\text{ C}}{16\text{ T}}\times\frac{7.10\text{ oz}}{1\text{ C}}=\frac{21.3}{16}\text{ oz}=\mathbf{1.3312\ oz}$
Chili powder	2 t	ounces	$\frac{2\text{ t}}{1}\times\frac{1\text{ T}}{3\text{ t}}\times\frac{0.235\text{ oz}}{1\text{ T}}=\frac{0.47}{3}\text{ oz}=\mathbf{0.1566\ oz}$
Corn niblets, fresh	2 C	pounds	$\frac{2\text{ C}}{1}\times\frac{5.75\text{ oz}}{1\text{ C}}\times\frac{1\text{ \#}}{16\text{ oz}}=\frac{11.5}{16}\text{\#}=\mathbf{0.7187\ \#}$
Pepper, red or green, diced	3 T	ounces	$\frac{3\text{ T}}{1}\times\frac{1\text{ C}}{16\text{ T}}\times\frac{3.2\text{ oz}}{1\text{ C}}=\frac{9.6}{16}\text{ oz}=\mathbf{0.6\ oz}$
Eggs, large	2 ea	each	**2 ea**
Cheddar, grated	½ C	pounds	$\frac{0.5\text{ C}}{1}\times\frac{1\text{ pt}}{2\text{ C}}\times\frac{0.5\text{ \#}}{1\text{ pt}}=\frac{0.25}{2}\text{\#}=\mathbf{0.125\ \#}$
Water	½ C	cups	**½ C**
Butter	2 T	pounds	$\frac{2\text{ T}}{1}\times\frac{1\text{ C}}{16\text{ T}}\times\frac{1\text{ \#}}{2\text{ C}}=\frac{2}{32}\text{\#}=\mathbf{0.0625\ \#}$
Vegetable oil	2 T	tablespoons	**2 T**
Salt, table grind	2 t	ounces	$\frac{2\text{ t}}{1}\times\frac{1\text{ C}}{48\text{ t}}\times\frac{16\text{ oz}}{1.6\text{ C}}=\frac{32}{76.8}\text{ oz}=\mathbf{0.4166\ oz}$

So, what factors affect the weight of a substance when measured by volume? The most common factors are:

- **THE INGREDIENT USED.** Different ingredients have different densities. All-purpose flour weighs 4.6 ounces per cup, corn weighs 5.75 ounces per cup, and chili powder weighs 3.76 ounces per cup.

Effect of preparation method on weight. One cup of shredded cheddar (left) weighs less than 1 cup of diced cheddar (right).

- **COMPACTION. If we sifted all-purpose flour before weighing it, a cup would weigh 4 ounces. Compare this to unsifted flour, which weighs 4.6 ounces per cup. Unpacked brown sugar weighs 5.10 ounces per cup, but when it's packed, brown sugar weighs 7.75 ounces per cup.**

- **PREPARATION METHOD. Shredded cheddar cheese weighs 4 ounces per cup, diced cheddar weighs 4.65 ounces per cup, and melted cheddar cheese weighs 8.6 ounces per cup.**

When working with volume-to-weight equivalents for recipe interpretation and adaptation into a professional production kitchen, be sure that you take these factors into consideration. It is very easy to make the assumption that 1 fluid ounce equals 1 ounce in weight, which will not always be true.

Take a moment before you begin each conversion to identify the type of conversion you are doing. If you are converting from a weight measure to another weight measure or from a volume measure to another volume measure, then all you need are standard unit equivalents. If, however, you are converting from a weight measure to a volume measure or from a volume measure to a weight measure, then you need more information. You need to weigh a certain volume of that ingredient, or you need a resource (such as *The Book of Yields*) with volume-to-weight approximations. If your ingredient is, for any reason, not consistent with the information listed in your resource, you should take your own measurement with your own product. Additionally, it is advisable to find and use volume-to-weight equivalents of your own when you need to plan for the use of an expensive or atypical ingredient, or when the preparation method varies greatly from that in your resource.

In sum, the most accurate method to measure ingredients by is weight. Typically, in a professional kitchen, dry ingredients are measured by weight and liquid ingredients are measured by volume, but some kitchens prefer to measure everything by weight. It is up to the chef to determine the best way to measure each ingredient. We have calculated our recipe quantities to different levels of accuracy

to demonstrate different procedures. Ultimately, the equipment you use to measure your ingredients will determine how accurate your recipe quantities need to be. Accurate measurement will help with product consistency, planning, and ordering. Be sure to test any recipes converted from volume to weight measures and adjust them as necessary to finalize.

1.3 PRACTICE PROBLEMS

Use the information from *The Book of Yields* in Appendix V as necessary to answer the following questions. Your answers may vary slightly from those given in the back of the book depending on which equivalents you use. Round your answers to the nearest hundredth, unless otherwise specified.

1. **For each ingredient in the recipe below, convert the given quantity so it is expressed in the unit in the "revised quantity" column. Round your revised quantities to the nearest hundredth of a unit.**

Italian-Style Spinach

Makes 50 servings

(Adapted from Cooking at Home with the CIA *by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Olive oil (1 C = 7.7 oz)	5 T	C
Pancetta, thinly sliced (1 # = 32 slices)	15 oz	#
Onion, ¼" dice (1 C = 4.45 oz)	2½ C	#
Garlic cloves (12 cloves = 2.1 oz)	15 ea	oz
Spinach (1 C = 1.5 oz)	6¼ G	#
Salt, table grind (1 T = 0.645 oz)	4 T	oz
Black pepper, cracked (1 T = 0.25 oz)	3 T plus 1 t	oz
Parmesan, grated fresh (1 C = 3 oz)	3¾ C	#
Nutmeg, ground (1 T = 0.235 oz)	2½ t	oz

2. For each ingredient in the recipe below, convert the given quantity so it is expressed in the unit in the "revised quantity" column. Round your revised quantities to the nearest gram or milliliter, or to the nearest hundredth of a kilogram.

Sweet Polenta Cake

Makes two 8-inch cakes

(Adapted from Baking at Home with the CIA *by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Flour, all-purpose (1 # = 3.48 C)	1½ C	kg
Baking powder (1 C = 6.9 oz)	2 t	g
Salt, table grind (1 T = 0.645 oz)	1 t	g
Eggs, large, shelled (1 ea = 1.777 oz)	6 ea	g
Egg yolks, large (1 ea = 0.586 oz)	12 ea	g
Vanilla extract (1 C = 8 oz)	1 t	mL
Butter (1 # = 2 C)	2 C	kg
Sugar, granulated (1 C = 7.1 oz)	2 C	kg
Cornmeal, fine (1 # = 2.5 C)	1 C	kg

3. Fill in the missing information in the chart below.

	INGREDIENT	VOLUME-TO-WEIGHT EQUIVALENT	NUMBER OF OUNCES IN 1 CUP	NUMBER OF FLUID OUNCES IN 1 CUP
a.	Rosemary, chopped fresh	1 T = 0.15 oz	$\frac{1\text{ C}}{1} \times \frac{16\text{ T}}{1\text{ C}} \times \frac{0.15\text{ oz}}{1\text{ T}} = 2.4\text{ oz}$	8 fl oz
b.	Flour, spelt	1 pt = 7.8 oz		
c.	Pecans, chopped	3.8 C = 1 #		
d.	Nutmeg, ground	4.25 T = 1 oz		

4. Fill in the missing information in the chart below.

	INGREDIENT	VOLUME-TO-WEIGHT EQUIVALENT	NUMBER OF CUPS THAT 8 OUNCES WOULD FILL	NUMBER OF CUPS THAT 8 FLUID OUNCES WOULD FILL
a.	Honey	1 C = 12 oz	$\frac{8\text{ oz}}{1} \times \frac{1\text{ C}}{12\text{ oz}} = \frac{2}{3}\text{ C}$	1 C
b.	Lime juice	1 C = _____ oz		
c.	Carrots, 1/3" dice	1 C = _____ oz		
d.	Chile flakes, red	1 C = _____ oz		

5. A recipe calls for 1 cup of ground almonds. How many ounces of ground almonds should you use for this recipe if 1 pint of ground almonds weighs 0.42 pounds?

6. A recipe calls for 1½ pounds of honey. How many cups of honey should you measure for this recipe if 1 cup of honey weighs 12 ounces?

7. A recipe for blueberry smoothies calls for 6 cups of yogurt. How many quarts of yogurt do you need to use if 1 cup of yogurt weighs 8.6 ounces?

8. A recipe calls for 2½ quarts of high-gluten flour. If high-gluten flour weighs 5 ounces per cup, how many pounds of flour should you use for this recipe?

9. A recipe for individual chocolate hazelnut tarts calls for ½ cup of hazelnuts per tart. If 1 cup of hazelnuts weighs 4 ounces, will a 5-kilogram bag of hazelnuts be sufficient to make 75 tarts?

10. Your recipe for risotto cakes calls for 1 cup of risotto per 3 servings. If 1 cup of risotto weighs 6¼ ounces, how many pounds of risotto would you need to use for 555 servings?

11. You are writing a cookbook for the home cook. One of the recipes you are testing calls for 14 ounces of shredded cheddar cheese. How many cups of shredded cheddar cheese should the revised recipe call for if shredded cheddar cheese weighs 8 ounces per pint?

12. What, if any, is the difference in the ounce weights of 2 cups of unsifted powdered sugar and 2 cups of sifted powdered sugar?

13. A recipe for focaccia calls for 6 ounces of olive oil. If olive oil weighs 7.7 ounces per cup, how many full recipes could you make using a 5-liter bottle of oil?

14. How much will ¼ cup of nutmeg weigh in grams?

15. A carrot cake recipe calls for 2¾ pints of grated carrot. How many pounds of grated carrot do you need for this recipe?

16. How many ounces should 200 milliliters of lemon juice weigh?

17. A recipe calls for 3 pounds of whole grape tomatoes. How many pints of grape tomatoes do you need?

18. A recipe calls for ¾ cup of molasses. The sous chef making this recipe decides it would be easier to measure the molasses by weight, and adds 6 ounces to the mixing bowl.

a. Explain the incorrect assumption that this sous chef made.

b. If the molasses is weighed for this recipe, how much does the sous chef really need?

19. An extern is working with a recipe that calls for 2 tablespoons of curry powder. Remembering that measuring by weight is often more accurate than measuring by volume, he measures 1 ounce of curry powder and mixes it into the recipe.

a. Explain the mistake that this extern made.

b. Correctly determine the weight of 2 tablespoons of curry powder.

20. Standardize the recipe below for production in a bakery that uses a digital scale accurate to 1/100 of a pound. For each ingredient, convert the given quantity into an equivalent quantity rounded to the nearest hundredth of a pound. Use the information from *The Book of Yields* in Appendix V as necessary.

Sour Cream Shortcake Biscuits

Makes 72 biscuits

(Adapted from The Herbfarm Cookbook *by Jerry Traunfeld)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Flour, all-purpose	6 qt	#
Baking powder	¼ C	#
Baking soda	2 T	#
Salt, kosher flake	1 T	#
Sugar, granulated	4½ C	#
Butter, unsalted	3 C	#
Sour cream	3 qt	#
Milk, whole (4%)	3 C	#

21. For each ingredient in the recipe below, convert the given quantity so it is expressed in the unit in the "revised quantity" column. Use the information from *The Book of Yields* in Appendix V as necessary. Round your revised quantities to the nearest gram or milliliter.

Orange Soufflé

Makes 8 servings

(Adapted from Cooking at Home with the CIA *by The Culinary Institute of America)*

INGREDIENT	RECIPE QUANTITY	REVISED QUANTITY
Butter	2 T	g
Sugar, granulated	½ C plus 2 T	g
Egg yolks, large	4 ea	g
Flour, all-purpose	¼ C	g
Salt, kosher flake	1 t	g
Milk, whole (4%)	1¾ C	mL
Vanilla extract	1 t	mL
Orange juice	¼ C	mL
Orange zest (1 T = 0.165 oz)	1 T	g
Egg whites, large	10 ea	g
Sugar, powdered (unsifted)	1 T plus 1 t	g