CHAPTER 4: RATIOS AND RATES

Chapter Objectives

By the end of this chapter, students should be able to:
- Represent ratios in multiple ways
- Find rates and unit rates
- Solve proportions involving decimals or fractions

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SECTION 4.1 RATIOS

A ratio is a comparison of two quantities that are measured in the same unit. If we compare \(a\) and \(b\), the ratio can be written as \(\frac{a}{b}\), \(a:b\), or \(a\) to \(b\).

- Example: The ratio of 6 miles to 3 miles can be written in the following forms.
  - Fraction: \(\frac{6 \text{ miles}}{3 \text{ miles}}\)
  - Colon: 6 miles : 3 miles
  - “\(a\) to \(b\)” language: 6 miles to 3 miles

- Example: Kate is traveling 100 miles to visit Rick. So far she has traveled 40 miles.
  The ratio of miles Kate has traveled to the total number of miles is \(\frac{40 \text{ miles}}{100 \text{ miles}}\).
  We can also write this ratio as 40 : 100 or as 40 to 100.

We usually represent ratios as fractions. The first number listed in the ratio is used as the numerator and the second number in the ratio is used as the denominator. You can simplify a ratio just as you simplify a fraction.

A ratio is a comparison of two quantities in the form of a quotient.

The ratio of A and B can be written ______ ways:

- ______________
- ______________
- ______________

Ratios can be ____________ just like fractions.

A class has 15 female students and 12 male students.

What is the ratio of males to females?

What is the ratio of females to males?
What is the ratio of females to total students?

The team played a total of 24 games last season. They won 18 games and lost 6 games.

What is the ratio of wins to losses?

What is the ratio of wins to total games?

What is the ratio of losses to total games?

YOU TRY:

Represent the following scenarios as ratios in the indicated ways.

a) A baseball player takes 50 jump shots during a practice. She makes 28 of them. What is the ratio of shots made to shots taken. Simplify the ratio.

<table>
<thead>
<tr>
<th>Form</th>
<th>Ratio of shots made to shots taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction</td>
<td></td>
</tr>
<tr>
<td>Colon</td>
<td></td>
</tr>
<tr>
<td>“a to b” language</td>
<td></td>
</tr>
</tbody>
</table>

b) In Cedric’s fish tank, there were 6 blue fish and 9 yellow fish. Write the ratio of the total number of fish to blue fish. Simplify the ratio.

<table>
<thead>
<tr>
<th>Form</th>
<th>Ratio of Total Fish to Blue Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction</td>
<td></td>
</tr>
<tr>
<td>Colon</td>
<td></td>
</tr>
<tr>
<td>“a to b” language</td>
<td></td>
</tr>
</tbody>
</table>
### A. WORKING WITH RATIOS OF FRACTIONS AND DECIMALS

**Media Lesson**

Simplifying Ratios Involving Decimals and Fractions
(Duration 6:08)

View the video lesson, take notes and complete the problems below.

Examples: Write the ratios as simplified fractions.

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Simplified Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 : 0.6</td>
<td>3 : 5</td>
</tr>
<tr>
<td>3.5 : 4.25</td>
<td></td>
</tr>
<tr>
<td>2 : 0.4</td>
<td>3 : 5</td>
</tr>
<tr>
<td>0.3 : 0.45</td>
<td></td>
</tr>
<tr>
<td>3 : 5</td>
<td>3 : 4</td>
</tr>
<tr>
<td>5 : 5</td>
<td>10 : 5</td>
</tr>
<tr>
<td>3 : 4</td>
<td></td>
</tr>
</tbody>
</table>
I. **Ratios with Decimals**

We eliminate decimals in a ratio by following the following steps.

1. Set up the ratio in the colon form.
2. Get rid of the decimal point by multiplying by 10, 100 or 1000, … depends on the number with the highest decimal places.
3. Reduce your new ratio to the lowest term.

Another way to set your ratio with decimal is to rewrite it in fraction form and get rid of the decimal point just like in the example below.

Example: Consider the ratio $0.8 \text{ to } 0.05$.

We write this ratio as the following fraction.

$$\frac{0.8}{0.05}$$

Note 0.8 has one decimal place and 0.05 has two decimal places. We will move the decimal point to the right by two decimal places.

$$\frac{0.80}{0.05}$$

We end up with the ratio $\frac{80}{5}$ which reduces to $\frac{16}{1}$.

II. **Ratio with Fractions**

To solve ratios with fractions we use the following steps.

1. Setup the ratio as in the colon form.
2. Convert both fractions to have the lowest common denominator (LCD).
3. Get rid of the LCD in both fractions.

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**Media Lesson**

Simplifying Ratios Involving Decimals and Fractions

(Duration 6:08)

View the video lesson, take notes and complete the problems below.

---

III. **Ratios with Mixed Numbers:**

To solve ratios with fractions we use the following steps.

1. Setup the ratio in the colon form.
2. Change any mixed number to an improper fraction.
3. Follow the same step as above by converting the fractions to the same LCD and get rid of the LCD.
### YOU TRY:

Write each ratio in fraction form. Then eliminate the decimals. Reduce your ratio.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a)</strong> 4.8 to 11.2</td>
<td><strong>b)</strong> 2.7 to 0.54</td>
</tr>
<tr>
<td><strong>c)</strong> $\frac{5}{4} : \frac{19}{8}$</td>
<td><strong>d)</strong> $\frac{4}{7} : \frac{1}{3}$</td>
</tr>
<tr>
<td><strong>e)</strong> $\frac{2\frac{1}{2}}{m}$ to $3m$</td>
<td><strong>f)</strong> $\frac{1}{4}$ hours to $2\frac{1}{2}$ hours</td>
</tr>
</tbody>
</table>
**EXERCISES**
In the following exercises write each ratio in fraction and colon notation.

1) 12 hours to 16 hours  
2) 30 miles to 9 miles  
3) $26 to $2  
4) 5 minutes to 45 minutes

In the following exercises, write the ratio in fraction form. Simplify if possible.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>5)</td>
<td>$3 to $11</td>
<td>6)</td>
</tr>
<tr>
<td>8)</td>
<td>20 to 36</td>
<td>9)</td>
</tr>
<tr>
<td>11)</td>
<td>45 to 54</td>
<td>12)</td>
</tr>
<tr>
<td>14)</td>
<td>84 to 36</td>
<td>15)</td>
</tr>
<tr>
<td>17)</td>
<td>1.26 to 4.2</td>
<td>18)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>20) $4\frac{1}{6}$ to $3\frac{1}{3}$</td>
<td>21) $5\frac{3}{5}$ to $3\frac{3}{5}$</td>
<td>22) $18$ to $63$</td>
</tr>
<tr>
<td>23) $16$ to $72$</td>
<td>24) $1.21$ to $0.44$</td>
<td>25) $1.38$ to $0.69$</td>
</tr>
<tr>
<td>26) 28 oz. to 84 oz.</td>
<td>27) 32 oz. to 128 oz.</td>
<td>28) 12 feet to 46 feet</td>
</tr>
<tr>
<td>29) 15 feet to 57 feet</td>
<td>30) 246 mg to 45 mg</td>
<td>31) 304 mg to 48 mg</td>
</tr>
</tbody>
</table>

32) Consider the rectangle with width 10 cm and length 15 cm, write a ratio of the length to the width.

![Rectangle](rectangle.png)

33) Using the rectangle in number 16, write the ratio of the width to the length.

34) If you spend 4 hours a week studying for English and 5.5 hours studying for math what is the ratio of time spent studying in math to studying in English?

35) An employee pays $125 towards health insurance, while the employer pays $550. What is the ratio of the employer's contribution to the employee's contribution?
Check your work with the answer key!

Online Quiz

Log on to Canvas to take the section quiz

Directions: It is very useful to save your math exercise work and use it as a chapter test review when you study for your chapter test and final.
1) Write each question on the screen down to for your record

2) Solve the problem step by step below each question

3) Double check your work to see whether your answer make sense

4) Enter your answer in the answer box in Canvas. Make sure you click on the “Preview” button to make sure you enter the right format before you submit your answer. If you are not sure how to enter your answer with the correct format, ask your instructor.

5) If you did not answer the question correctly, solve the question again from the beginning below your 1st attempt. Sometimes, it is better to start a problem again from the beginning and compare your steps with your 1st attempt to figure out your mistake.

6) Insert your work at the end of each section in your workbook so that you can use it to study for your chapter test later.
SECTION 4.2 RATES AND UNIT RATES

A. WRITING RATES AND UNIT RATES

Frequently we want to compare two different types of measurements, such as miles to gallons. To make this comparison, we use a rate. A rate is a comparison with different units, such as miles per gallon and money per hours.

Like ratios we usually write rates as fractions. We put the first given in the numerator and the second amount in the denominator. When rates are simplified, the units remain in the numerator and denominator.

A special type of rate is called a unit rate. A unit rate is a rate where the denominator is a 1. Unit rates allow us to see relationships better.

For example, you are offered a job and your new employer says that you will be paid at a rate of $805 per 25 hours. We can express this rate as the following fraction.

\[ \frac{805}{25 \text{ hours}} \]

This is your rate of pay, but it may be more useful to know how much you will be paid per 1 hour instead of 25 hours. The unit rate of pay can be founds as shown below.

\[ \frac{805}{25 \text{ hours}} = \frac{805 \div 25}{25 \text{ hours} \div 25} = \frac{34}{1 \text{ hour}} \text{ or } 34 \text{ per hour} \]

I. Rates

View the video lesson, take notes and complete the problems below.

If the quantities you are comparing have different units, then your ratio is known as a rate. Units are especially important here and should absolutely be included.

Example: Write “12 miles in 10 hours” as a ratio in simplest form.

Example: In a small bag of mixed nuts, 15 were peanuts, 20 were almonds, and 5 were Brazil nuts. Write the ratio of peanuts to almonds in simplest form.

Note: With ratios, the units will cancel out. With rates, the units will not cancel out.
YOU TRY:

Use the information to write a ratio in simplest form. Indicate if the ratio is also a rate.

a) 5 feet:10 feet  

b) 12 geese to 15 ducks

I. Unit rates

View the video lesson, take notes and complete the problems below.

A unit rate is a special kind of rate in which the denominator of the ratio is __________.

This kind of rate allows for easier comparison of different rates as seen in the example below. As with rates, units ________________________________.

Example 1: Which is faster, “12 miles in 10 hours” or “10 miles in 8 hours”? Use unit rates to compare.

Example 2: Write each of the following as a unit rate:

a. There are 5280 feet in a mile

b. There are 60 seconds per each minute

c. Gasoline costs $3.49 a gallon
Example 3: Determine the unit rates.

If a plane travels 2,440 miles in 4 hours, what is the rate in miles per hour.

YOU TRY:

**a)** Anita was paid $384 last week for working 32 hours. Write this rate as a fraction.

**b)** What is Anita’s hourly rate?

**c)** Bob drove his car 525 miles in 9 hours. Write this rate as a fraction.

**d)** What is Bob’s miles per hour? Round to the tenths.
B. DETERMINE BETTER BUY USING UNIT RATES

By comparing the unit rates of two different products it is easy to identify which is the best buy. The better buy is the item that cost less per unit.

---

**Example 2:** Determine which bag of Cheetos is the better buy.

- **Bag A:** $4.99 for 20.50 oz.
- **Bag B:** $4.29 for 12.50 oz.

---

**YOU TRY:**

Round any answers to the hundredths place.

- **e)** Callie is buying cereal at the grocery store. A 12.2-ounce box costs $4.39. A 27.5-ounce box costs $10.19. Which is the better buy?

- **f)** Hector is buying cookies for a party. A regular sized bag has 34 cookies and costs $2.46. The family size bag has 48 cookies and costs $3.39 a bag. Which is the better buy?
### EXERCISES
Write the following rates as a fraction in lowest terms.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>140 calories per 12 ounces</td>
<td>2) 180 calories per 16 ounces</td>
</tr>
<tr>
<td>3</td>
<td>9.5 pounds per 4 square inches</td>
<td>4) 8.2 pounds per 3 square inches</td>
</tr>
<tr>
<td>5</td>
<td>488 miles in 7 hours</td>
<td>6) 527 miles in 9 hours</td>
</tr>
<tr>
<td>7</td>
<td>$595 for 40 hours</td>
<td>8) $798 for 40 hours</td>
</tr>
</tbody>
</table>

In the following exercises, find the unit rate. Round to two decimal places, if necessary.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>$45 dollars for 5 pounds</td>
<td>10) $24 dollars for 2 pounds</td>
</tr>
<tr>
<td>11</td>
<td>$27 dollars on 3 ounces</td>
<td>12) $44 dollars on 4 ounces</td>
</tr>
<tr>
<td>13</td>
<td>$252 per 12 people</td>
<td>14) $231 for 21 tees</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>15)</strong> 140 calories per 12 ounces</td>
<td><strong>16)</strong> 180 calories per 16 ounces</td>
<td></td>
</tr>
<tr>
<td><strong>17)</strong> 8.2 ounces per 3 pounds</td>
<td><strong>18)</strong> 9.5 ounces per 4 pounds</td>
<td></td>
</tr>
<tr>
<td><strong>19)</strong> 488 miles in 7 hours</td>
<td><strong>20)</strong> 527 miles in 9 hours</td>
<td></td>
</tr>
<tr>
<td><strong>21)</strong> $798 for 40 hours</td>
<td><strong>22)</strong> $595 for 40 hours</td>
<td></td>
</tr>
<tr>
<td><strong>23)</strong> 576 miles on 18 gallons of gas</td>
<td><strong>24)</strong> 435 miles on 15 gallons of gas</td>
<td></td>
</tr>
<tr>
<td><strong>25)</strong> 43 pounds in 12 weeks</td>
<td><strong>26)</strong> 57 pounds in 24 weeks</td>
<td></td>
</tr>
</tbody>
</table>
27) 46 beats in 0.5 minutes  

28) 54 beats in 0.5 minutes

In the following exercises, find each unit price and then identify the better buy. Round to three decimal places.

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>29)</td>
<td>Toothpaste, 6 ounce size for $3.19 or 7 ounce size for $5.19</td>
</tr>
<tr>
<td>30)</td>
<td>Breakfast cereal, 18 ounces for $3.99 or 14 ounces for $3.29</td>
</tr>
<tr>
<td>31)</td>
<td>Ketchup, 40 ounce regular bottle for $2.99 or 64 ounce squeeze bottle for $4.39</td>
</tr>
<tr>
<td>32)</td>
<td>Mayonnaise, 15 ounce regular bottle for $3.49 or 22 ounce squeeze bottle for $4.99</td>
</tr>
<tr>
<td>33)</td>
<td>Black beans, 16 ounce for $1.28 or 32 ounce for $2.40</td>
</tr>
</tbody>
</table>
34) The grocery store has a special on macaroni and cheese. The price is $3.87 for 3 boxes. How much does each box cost?

35) A store sells two different kinds of toothpaste. The first toothpaste comes in a 6-ounce tube and costs $3.19. The second toothpaste comes in a 7.8-ounce tube and costs $5.19. Find the unit rate and identify the better buy.

36) Sven drives his car 455 miles using 14 gallons of gasoline. How many miles per gallon does his car get?

37) You are renting a house in Cancun for a week at $3,600, what is the cost per day?

38) The bindery at a printing plant assembles 96,000 magazines in 12 hours. How many magazines are assembled in one hour?

39) One elementary school in Ohio has 684 students and 45 teachers. Write the student-to-teacher ratio as a unit rate.

40) The average American produces about 1,600 pounds of paper trash per year (365 days). How many pounds of paper trash does the average American produce each day? (Round to the nearest tenth of a pound.)
Check your work with the answer key!

Online Quiz

Log on to Canvas to take the section quiz

**Directions**: It is very useful to save your math exercise work and use it as a chapter test review when you study for your chapter test and final.

7) Write each question on the screen down to for your record

8) Solve the problem step by step below each question

9) Double check your work to see whether your answer make sense

10) Enter your answer in the answer box in Canvas. Make sure you click on the “Preview” button to make sure you enter the right format before you submit your answer. If you are not sure how to enter your answer with the correct format, ask your instructor.

11) If you did not answer the question correctly, solve the question again from the beginning below your 1st attempt. Sometimes, it is better to start a problem again from the beginning and compare your steps with your 1st attempt to figure out your mistake.

12) Insert your work at the end of each section in your workbook so that you can use it to study for your chapter test later.
SECTION 4.3 PROPORTIONS
When two ratios or rates are equal the equation relating them is called a proportion.

A proportion for the ratios \( \frac{a}{b} \) and \( \frac{c}{d} \) is written as an equation of the form

\[
\frac{a}{b} = \frac{c}{d},
\]

where \( b \neq 0 \) and \( d \neq 0 \).

When we say things are proportional we are saying they have the same rate or ratio.
We will explore different ways of solving proportions.

A. USE RATES TO SOLVE PROPORTIONAL PROBLEMS
Proportions and rates allow us to solve many applications.
Example:
You are making cookies. A recipe calls for 29 grams of sugar and makes 2 dozen cookies. You want to make 6 dozen cookies. We can use a proportion to figure out how much grams of sugar you will need.

Our first step is to write the rate 29 grams of sugar for 2 dozen cookies in fraction form.

\[
\frac{29 \text{ grams}}{2 \text{ dozen}}
\]

You want to make 6 dozen cookies but do not know how much sugar we need. We will use this information to write a proportion.

\[
\frac{29 \text{ grams}}{2 \text{ dozen}} = \frac{? \text{ grams}}{6 \text{ dozen}}
\]

Notice the units are lined up. Both rates have grams in the numerator and dozens in the denominator. If we think of these rates as equivalent fractions we notice \( 2 \times 3 = 6 \).

\[
\times 3
\]

\[
\frac{29 \text{ grams}}{2 \text{ dozen}} = \frac{? \text{ grams}}{6 \text{ dozen}}
\]

\[
\times 3
\]

Your total earnings for the week are 29 grams \( \times 3 \) or 87 grams.
Media Lesson
Use Proportions to Solve Applications (No Cross Product)
(Duration 5:42)

View the video lesson, take notes and complete the problems below.

a) The ratio of the lengths of corresponding sides of two similar decagons is 1:2. If the perimeter of the smaller decagon is 76 cm, what is the perimeter of the larger decagon?

\[
\frac{1}{2} : \frac{76\text{ cm}}{? \text{ cm}}
\]

b) A cookie recipe requires 4 cups of flour to make 5 dozen cookies. If Amy needs to make 15 dozen cookies, how many cups of flour will she need?

c) The president of the student body estimated that 2 out of every 3 students at school would attend the Spring Festival. If there are 1,140 students at this school, according to the estimate, how many students will not attend the Spring Festival?

d) If one bus holds 60 students, how many buses are needed to take 780 students to the Valley Fair?
YOU TRY:

a) Stephanie can walk 5 miles in 2 hours. Using a proportion how far will Stephanie walk in 8 hours?

B. USE UNIT RATES TO SOLVE PROPORTIONAL PROBLEMS

View the video lesson, take notes and complete the problems below.

1. It costs $3.60 for 6 bottles of soda.
   a) Express this as a rate of cost to bottles.
   b) Express your answer from part (a) as a unit rate.
   c) How much would two bottles of soda cost?

2. Tom can drive 180 miles on 12 gallons of gas with his new truck.
   a) Express this rate as a rate of miles per gallon.
   b) Express your answer from part (a) as a unit rate.
   c) How far can he drive on 7 gallons of gas?
C. USE CROSS PRODUCT TO SOLVE PROPORTIONAL PROBLEMS

Another way to solve a proportion is to use the **cross product**.

For any proportion \( \frac{a}{b} = \frac{c}{d} \), where \( b \neq 0, d \neq 0 \), the cross products \( a \times d = b \times c \) are equal.

Consider the following proportion.

\[
\frac{2}{3} = \frac{16}{24}
\]

The cross product multiplies numerators and denominators diagonally.

\[
\frac{2}{3} \times 24 = \frac{16}{3} \times 24
\]

The cross product is

\[2 \times 24 = 3 \times 16\]

Multiplying, we can verify that \( 2 \times 24 = 48 \) and \( 3 \times 16 = 48 \).

**Media Lesson**
Proportions (Start 3:04 )

*View the video lesson, take notes and complete the problems below.*

Procedure to solve for a missing number in a proportion.

1. Find the cross products and form an equation.
2. Solve the equation.
3. Check your answer.

Solve.

\[
\frac{5}{2} = \frac{x}{8}
\]

\[
\frac{8}{2.4} = \frac{18}{n}
\]

\[
\frac{y}{\frac{1}{3}} = \frac{6}{5}
\]
### YOU TRY:

<table>
<thead>
<tr>
<th>b) ( \frac{?}{63} = \frac{4}{7} )</th>
<th>c) ( \frac{?}{84} = \frac{11}{12} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
EXERCISES

Solve the following proportions without using a cross product.

1) \( \frac{2}{3} = \frac{?}{9} \)

2) \( \frac{56}{?} = \frac{7}{8} \)

3) \( \frac{4}{?} = \frac{64}{144} \)

4) \( \frac{5}{3} = \frac{60}{?} \)

Solve the following proportions using the cross product. Round your answers to two decimal places.

5) \( \frac{\frac{1}{2}}{\frac{1}{2}} = \frac{?}{\frac{2}{5}} \)

6) \( \frac{\frac{2}{3}}{\frac{1}{5}} = \frac{\frac{2}{3}}{?} \)

7) \( \frac{0.25}{1.4} = \frac{3}{?} \)

8) \( \frac{?}{1.2} = \frac{5}{3} \)

9) \( \frac{\frac{1}{5}}{\frac{2}{4}} = \frac{2\frac{1}{4}}{3\frac{2}{3}} \)

10) \( \frac{1.5}{2.4} = \frac{?}{3} \)

11) When pediatricians prescribe acetaminophen to children, they prescribe 5 milliliters of acetaminophen for every 25 pounds of the child’s weight. If Zoe weighs 80 pounds, how many milliliters of acetaminophen will her doctor prescribe?

12) One brand of microwave popcorn has 120 calories per serving. A whole bag of this popcorn has 3.5 servings. How many calories are in a whole bag of this microwave popcorn?

13) Josiah went to Mexico for spring break and changed $325 dollars into Mexican pesos. At that time, the exchange rate had $1 U.S. equal to 12.54 Mexican pesos. How many Mexican pesos did he get for his trip?

14) A new energy drink advertises 106 calories for 8 ounces. How many calories are in 12 ounces of the drink?

15) An oatmeal cookie recipe calls for \( \frac{1}{2} \) cup of butter to make 4 dozen cookies. Hilda needs to make 10 dozen cookies for the bake sale. How many cups of butter will she need?
Check your work with the answer key!

Directions: It is very useful to save your math exercise work and use it as a chapter test review when you study for your chapter test and final.

13) Write each question on the screen down to for your record

14) Solve the problem step by step below each question

15) Double check your work to see whether your answer make sense

16) Enter your answer in the answer box in Canvas. Make sure you click on the “Preview” button to make sure you enter the right format before you submit your answer. If you are not sure how to enter your answer with the correct format, ask your instructor.

17) If you did not answer the question correctly, solve the question again from the beginning below your 1st attempt. Sometimes, it is better to start a problem again from the beginning and compare your steps with your 1st attempt to figure out your mistake.

18) Insert your work at the end of each section in your workbook so that you can use it to study for your chapter test later.