CHAPTER

3

Each year in our country about 72,900,000,000 gallons of gasoline are consumed by automobiles. How much of a savings would occur if half of the miles traveled were done in small, fuel-efficient automobiles? Can you use your mathematics knowledge to determine this saving? Turn to page 260 to find out.

Decimals

3.1 Using Decimal Notation

Student Learning Objectives

After studying this section, you will be able to:

1. **Write a word name for a decimal fraction.**
2. **Change from fractional notation to decimal notation.**
3. **Change from decimal notation to fractional notation.**

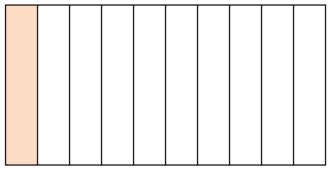
1 Writing a Word Name for a Decimal Fraction

In Chapter 2 we discussed *fractions*—the set of numbers such as $\frac{1}{2}$, $\frac{2}{3}$, $\frac{1}{10}$, $\frac{6}{7}$, $\frac{18}{100}$, and so on. Now we will take a closer look at **decimal fractions**—that is, fractions with 10, 100, 1000, and so on, in the denominator, such as $\frac{1}{10}$, $\frac{18}{100}$, and $\frac{43}{1000}$.

Why, of all fractions, do we take special notice of these? Our hands have 10 digits. Our U.S. money system is based on the dollar, which has 100 equal parts, or cents. And the international system of measurement called the *metric system* is based on 10 and powers of 10.

As with other numbers, these decimal fractions can be written in different ways (forms). For example, the shaded part of the whole in the following drawing can be written:

in words (one-tenth)
in fractional form $\left(\frac{1}{10}\right)$
in decimal form (0.1)



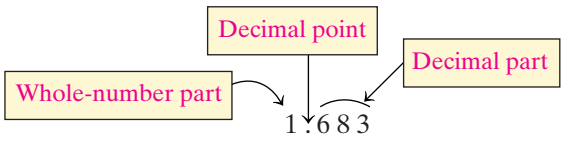
All mean the same quantity, namely 1 out of 10 equal parts of the whole. We'll see that when we use decimal notation, computations can be easily done based on the old rules for whole numbers and a few new rules about where to place the decimal point. In a world where calculators and computers are commonplace, many of the fractions we encounter are decimal fractions. A decimal fraction is a fraction whose denominator is a power of 10.

$\frac{7}{10}$ is a decimal fraction. $\frac{89}{10^2} = \frac{89}{100}$ is a decimal fraction.

Decimal fractions can be written with numerals in two ways: fractional form or decimal form. Some decimal fractions are shown in decimal form below.

Fractional Form		Decimal Form
$\frac{3}{10}$	=	0.3
$\frac{59}{100}$	=	0.59
$\frac{171}{1000}$	=	0.171

The zero in front of the decimal point is not actually required. We place it there simply to make sure that we don't miss seeing the decimal point. A number written in decimal notation has three parts.



When a number is written in decimal form, the first digit to the right of the decimal point represents tenths, the next digit hundredths, the next digit thousandths, and so on. 0.9 means nine tenths and is equivalent to $\frac{9}{10}$. 0.51 means fifty-one hundredths and is equivalent to $\frac{51}{100}$.

Some decimals are larger than 1. For example, 1.683 means one and six hundred eighty-three thousandths. It is equivalent to $1\frac{683}{1000}$. Note that the word *and* is used to indicate the decimal point. A place-value chart is helpful.

Decimal Place Values

Hundreds	Tens	Ones	Decimal point	Tenths	Hundredths	Thousandths	Ten-thousandths
100	10	1	"and"	$\frac{1}{10}$	$\frac{1}{100}$	$\frac{1}{1,000}$	$\frac{1}{10,000}$
1	5	6	·	2	8	7	4

So, we can write 156.2874 in words as one hundred fifty-six and two thousand eight hundred seventy-four ten-thousandths. We say ten-thousandths because it is the name of the last decimal place on the right.

EXAMPLE 1 Write a word name for each decimal.

(a) 0.79 **(b)** 0.5308 **(c)** 1.6 **(d)** 23.765

Solution

(a) 0.79 = seventy-nine hundredths
(b) 0.5308 = five thousand three hundred eight ten-thousandths
(c) 1.6 = one and six tenths
(d) 23.765 = twenty-three and seven hundred sixty-five thousandths

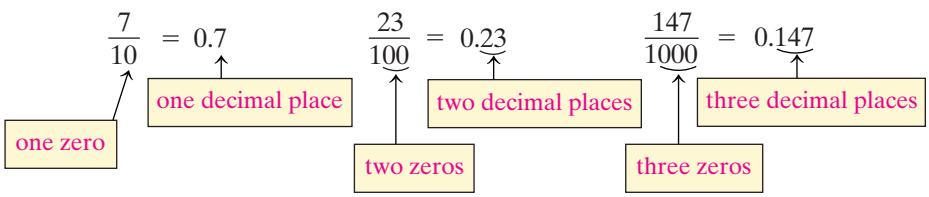
Practice Problem 1 Write a word name for each decimal.

(a) 0.073 **(b)** 4.68 **(c)** 0.0017 **(d)** 561.78

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Sometimes, decimals are used where we would not expect them. For example, we commonly say that there are 365 days in a year, with 366 days in every fourth year (or leap year). However, this is not quite correct. In fact, from time to time further adjustments need to be made to the calendar to adjust for these inconsistencies. Astronomers know that a more accurate measure of a year is called a **tropical year** (measured from one equinox to the next). Rounded to the nearest hundred-thousandth, 1 tropical year = 365.24122 days. This is read "three hundred sixty-five and twenty-four thousand, one hundred twenty-two hundred-thousandths." This approximate value is a more accurate measurement of the amount of time it takes the earth to complete one orbit around the sun.

Note the relationship between fractions and their equivalent numbers' decimal forms.



Decimal notation is commonly used with money. When writing a check, we often write the amount that is less than 1 dollar, such as 23¢, as $\frac{23}{100}$ dollar.

EXAMPLE 2 Write a word name for the amount on a check made out for \$672.89.

Solution: six hundred seventy-two and $\frac{89}{100}$ dollars

Practice Problem 2 Write a word name for the amount of a check made out for \$7863.04.

2 Changing from Fractional Notation to Decimal Notation

It is helpful to be able to write decimals in both decimal notation and fractional notation. First we illustrate changing a fraction with a denominator of 10, 100, or 1000 into decimal form.

EXAMPLE 3 Write as a decimal.

(a) $\frac{8}{10}$ **(b)** $\frac{74}{100}$ **(c)** $1\frac{3}{10}$ **(d)** $2\frac{56}{1000}$

Solution

(a) $\frac{8}{10} = 0.8$ **(b)** $\frac{74}{100} = 0.74$ **(c)** $1\frac{3}{10} = 1.3$ **(d)** $2\frac{56}{1000} = 2.056$

Note: In part (d), we need to add a zero before the digits 56. Since there are three zeros in the denominator, we need three decimal places in the decimal number.

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Practice Problem 3 Write as a decimal.

(a) $\frac{9}{10}$ **(b)** $\frac{136}{1000}$ **(c)** $2\frac{56}{100}$ **(d)** $34\frac{86}{1000}$

3 Changing from Decimal Notation to Fractional Notation

EXAMPLE 4 Write in fractional notation.

(a) 0.51 **(b)** 18.1 **(c)** 0.7611 **(d)** 1.363

Solution

(a) $0.51 = \frac{51}{100}$ **(b)** $18.1 = 18\frac{1}{10}$ **(c)** $0.7611 = \frac{7611}{10{,}000}$ **(d)** $1.363 = 1\frac{363}{1000}$

Practice Problem 4 Write in fractional notation.

(a) 0.37 **(b)** 182.3 **(c)** 0.7131 **(d)** 42.019

When we convert from decimal form to fractional form, we reduce whenever possible.

EXAMPLE 5 Write in fractional notation. Reduce whenever possible.

(a) 2.6 **(b)** 0.38 **(c)** 0.525 **(d)** 361.007

Solution

(a) $2.6 = 2\frac{6}{10} = 2\frac{3}{5}$ **(b)** $0.38 = \frac{38}{100} = \frac{19}{50}$

(c) $0.525 = \frac{525}{1000} = \frac{105}{200} = \frac{21}{40}$

(d) $361.007 = 361\frac{7}{1000}$ (cannot be reduced)

Practice Problem 5 Write in fractional notation. Reduce whenever possible.

(a) 8.5 **(b)** 0.58 **(c)** 36.25 **(d)** 106.013

EXAMPLE 6 A chemist found that the concentration of lead in a water sample was 5 parts per million. What fraction would represent the concentration of lead?

Solution Five parts per million means 5 parts out of 1,000,000. As a fraction, this is $\frac{5}{1{,}000{,}000}$. We can reduce this by dividing numerator and denominator by 5. Thus

$$\frac{5}{1{,}000{,}000} = \frac{1}{200{,}000}.$$

The concentration of lead in the water sample is $\frac{1}{200{,}000}$.

Practice Problem 6 A chemist found that the concentration of PCBs in a water sample was 2 parts per billion. What fraction would represent the concentration of PCBs?

Developing Your Study Skills

Steps Toward Success In Mathematics

Mathematics is a building process, mastered one step at a time. The foundation of this process is formed by a few basic requirements. Those who are successful in mathematics realize the absolute necessity for building a study of mathematics on the firm foundation of these six minimum requirements.

1. Attend class every day.
2. Read the textbook.
3. Take notes in class.
4. Do assigned homework every day.
5. Get help immediately when needed.
6. Review regularly.

If you are in an online class or self-paced class, do some of your math assignment on five days during each week.

3.1 Exercises

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Verbal and Writing Skills

1. Describe a decimal fraction and provide examples.

2. What word is used to describe the decimal point when writing the word name for a decimal that is greater than one?

3. What is the name of the last decimal place on the right for the decimal 132.45678?

4. When writing \$82.75 on a check, we write 75¢ as ____.

Write a word name for each decimal.

5. 0.57 **6.** 0.78 **7.** 3.8 **8.** 12.4

9. 5.803 **10.** 3.117 **11.** 28.0037 **12.** 54.0013

Write a word name as you would on a check.

13. \$124.20 **14.** \$510.31 **15.** \$1236.08

16. \$7652.02 **17.** \$12,015.45 **18.** \$20,000.67

Write in decimal notation.

19. seven tenths **20.** six tenths **21.** twelve hundredths **22.** forty-five hundredths

23. four hundred eighty-one thousandths **24.** twenty-two thousandths

25. two hundred eighty-six millionths **26.** one thousand three hundred eighteen millionths

Write each fraction as a decimal.

27. $\frac{7}{10}$ **28.** $\frac{3}{10}$ **29.** $\frac{76}{100}$ **30.** $\frac{84}{100}$ **31.** $\frac{1}{100}$ **32.** $\frac{6}{100}$

33. $\frac{53}{1000}$ **34.** $\frac{328}{1000}$ **35.** $\frac{2403}{10,000}$ **36.** $\frac{7794}{10,000}$ **37.** $8\frac{3}{10}$ **38.** $3\frac{1}{10}$

39. $84\frac{13}{100}$ **40.** $52\frac{77}{100}$ **41.** $3\frac{529}{1000}$ **42.** $2\frac{23}{1000}$ **43.** $126\frac{571}{10,000}$ **44.** $198\frac{333}{10,000}$

Write in fractional notation. Reduce whenever possible.

45. 0.02

46. 0.05

47. 3.6

48. 8.9

49. 7.41

50. 15.75

51. 12.625

52. 29.875

53. 7.0615

54. 4.0016

55. 8.0108

56. 7.0605

57. 235.1254

58. 581.2406

59. 0.0187

60. 0.5405

Applications

61. ***Cigarette Use*** The highest use of cigarettes in the United States takes place in Kentucky. In 2001 31,700 out of every 100,000 men age 18 or older who lived in Kentucky were smokers. That same year 30,100 out of every 100,000 women age 18 or older who lived in Kentucky were smokers. (a) What fractional part of the male population in Kentucky were smokers? (b) What fractional part of the female population in Kentucky were smokers? Be sure to express these fractions in reduced form. *(Source: U.S. Centers for Disease Control and Prevention)*

62. ***Cigarette Use*** The lowest use of cigarettes in the United States takes place in Utah. In 2001 14,600 out of every 100,000 men age 18 or older who lived in Utah were smokers. That same year 12,100 out of every 100,000 women age 18 or older who lived in Utah were smokers. (a) What fractional part of the male population in Utah were smokers? (b) What fractional part of the female population in Utah were smokers? Be sure to express these fractions in reduced form. *(Source: U.S. Centers for Disease Control and Prevention)*

63. ***Bald Eagle Eggs*** American bald eagles have been fighting extinction due to environmental hazards such as DDT, PCBs, and dioxin. The problem is with the food chain. Fish or rodents consume contaminated food and/or water. Then the eagles ingest the poison, which in turn affects the durability of the eagles' eggs. It takes only 4 parts per million of certain chemicals to ruin an eagle egg; write this number as a fraction in lowest terms. (In 1994 the bald eagle was removed from the endangered species list.)

64. ***Turtle Eggs*** Every year turtles lay eggs on the islands of South Carolina. Unfortunately, due to illegal polluting, a lot of the eggs are contaminated. If the turtle eggs contain more than 2 parts per one hundred million of chemical pollutants, they will not hatch and the population will continue to head toward extinction. Write the preceding amount of chemical pollutants as a fraction in the lowest terms.

Cumulative Review

65. Add.
$$\begin{array}{r} 207 \\ 54 \\ 123 \\ 86 \\ +\ 55 \\ \hline \end{array}$$

66. Subtract.
$$\begin{array}{r} 12{,}843 \\ -\ 11{,}905 \\ \hline \end{array}$$

67. Round to the nearest *hundred*. 56,758

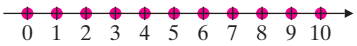
68. Round to the nearest *thousand*. 8,069,482

3.2 Comparing, Ordering, and Rounding Decimals

Student Learning Objectives

After studying this section, you will be able to:

1. **Compare decimals.**
2. **Place decimals in order from smallest to largest.**
3. **Round decimals to a specified decimal place.**



1 Comparing Decimals

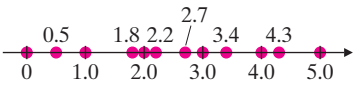
All of the numbers we have studied have a specific order. To illustrate this order, we can place the numbers on a **number line.** Look at the number line on the right. Each number has a specific place on it. The arrow points in the direction of increasing value. Thus, if one number is to the right of a second number, it is larger, or greater, than that number. Since 5 is to the right of 2 on the number line, we say that 5 is greater than 2. We write $5 > 2$.

Since 4 is to the left of 6 on the number line, we say that 4 is less than 6. We write $4 < 6$. The symbols "$>$" and "$<$" are called **inequality symbols.**

$a < b$ is read "a is less than b."

$a > b$ is read "a is greater than b."

We can assign exactly one point on the number line to each decimal number. When two decimal numbers are placed on a number line, the one farther to the right is the larger. Thus we can say that $3.4 > 2.7$ and $4.3 > 4.0$. We can also say that $0.5 < 1.0$ and $1.8 < 2.2$. Why?



To compare or order decimals, we compare each digit.

COMPARING TWO NUMBERS IN DECIMAL NOTATION

1. Start at the left and compare corresponding digits. If the digits are the same, move one place to the right.
2. When two digits are different, the larger number is the one with the larger digit.

EXAMPLE 1 Write an inequality statement with 0.167 and 0.166.

Solution The numbers in the tenths place are the same. They are both 1.

0.1 6 7 0.1 6 6

The numbers in the hundredths place are the same. They are both 6.

0.1 6 7 0.1 6 6

The numbers in the thousandths place differ.

0. 1 6 7 0.1. 6 6

Since $7 > 6$, we know that $0.167 > 0.166$.

Practice Problem 1 Write an inequality statement with 5.74 and 5.75.

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Whenever necessary, extra zeros can be written to the right of the last digit—that is, to the right of the decimal point—without changing the value of the decimal. Thus

$$0.56 = 0.56000 \qquad \text{and} \qquad 0.7768 = 0.77680.$$

The zero to the left of the decimal point is optional. Thus 0.56 = .56. Both notations are used. You are encouraged to place a zero to the left of the decimal point so that you don't miss the decimal point when you work with decimals.

EXAMPLE 2 Fill in the blank with one of the symbols <, =, or >.

0.77 _____ 0.777

Solution We begin by adding a zero to the first decimal.

0.770 0.777

We see that the tenths and hundredths digits are equal. But the thousandths digits differ. Since $0 < 7$, we have $0.770 < 0.777$.

Practice Problem 2 Fill in the blank with one of the symbols <, =, or >.

0.894 _____ 0.89

2 Placing Decimals in Order from Smallest to Largest

Which is the heaviest—a puppy that weighs 6.2 ounces, a puppy that weighs 6.28 ounces, or a puppy that weighs 6.028 ounces? Did you choose the puppy that weighs 6.28 ounces? You are correct.

You can place three or more decimals in order. If you are asked to order the decimals from smallest to largest, look for the smallest decimal and place it first.

EXAMPLE 3 Place the following five decimal numbers in order from smallest to largest.

1.834, 1.83, 1.381, 1.38, 1.8

Solution First we add zeros to make the comparison easier.

1.834, 1.830, 1.381, 1.380, 1.800

Now we rearrange with smallest first.

1.380, 1.381, 1.800, 1.830, 1.834

Practice Problem 3 Place the following five decimal numbers in order from smallest to largest.

2.45, 2.543, 2.46, 2.54, 2.5

3 Rounding Decimals to a Specified Decimal Place

Sometimes in calculations involving money, we see numbers like \$386.432 and \$29.5986. To make these useful, we usually round them to the nearest cent. \$386.432 is rounded to \$386.43. \$29.5986 is rounded to \$29.60. A general rule for rounding decimals follows.

ROUNDING DECIMALS

1. Find the decimal place (units, tenths, hundredths, and so on) for which rounding off is required.
2. If the first digit to the right of the given place value is less than 5, drop it and all digits to the right of it.
3. If the first digit to the right of the given place value is 5 or greater, increase the number in the given place value by one. Drop all digits to the right of this place.

EXAMPLE 4 Round 156.37 to the nearest tenth.

Solution

156.3 7

We find the tenths place.

Note that 7, the next place to the right, is greater than 5. We round up to 156.4 and drop the digits to the right. The answer is 156.4.

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Practice Problem 4 Round 723.88 to the nearest tenth.

EXAMPLE 5 Round to the nearest thousandth.

(a) 0.06358 **(b)** 128.37448

Solution

(a) 0.06 3 58

We locate the thousandths place.

Note that the digit to the right of the thousandths place is 5. We round up to 0.064 and drop all the digits to the right.

(b) 128.37 4 48

We locate the thousandths place.

Note that the digit to the right of the thousandths place is less than 5. We round to 128.374 and drop all the digits to the right.

Practice Problem 5 Round to the nearest thousandth.

(a) 12.92647 **(b)** 0.007892

Remember that rounding up to the next digit in a position may result in several digits being changed.

EXAMPLE 6 Round to the nearest hundredth. Fred and Linda used 203.9964 kilowatt hours of electricity in their house in May.

203.9 9 64

We locate the hundredths place.

Solution Since the digit to the right of hundredths is greater than 5, we round up. This affects the next two positions. Do you see why? The result is 204.00 kilowatt hours. Notice that we have the two zeros to the right of the decimal place to show we have rounded to the nearest hundredth.

Practice Problem 6 Round to the nearest tenth. Last month the college gymnasium used 15,699.953 kilowatt hours of electricity.

Sometimes we round a decimal to the nearest whole number. For example, when writing figures on income tax forms, a taxpayer may round all figures to the nearest dollar.

EXAMPLE 7 To complete her income tax return, Marge needs to round these figures to the nearest whole dollar.

Medical bills \$779.86 Taxes \$563.49
Retirement contributions \$674.38 Contributions to charity \$534.77

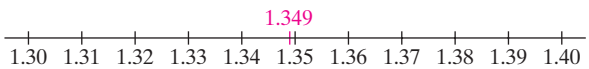
Solution Round the amounts.

	Original Figure	*Rounded To Nearest Dollar*
Medical bills	779.86	780
Taxes	563.49	563
Retirement	674.38	674
Charity	534.77	535

Practice Problem 7 Round the following figures to the nearest whole dollar.

Medical bills \$375.50 Taxes \$981.39
Retirement contributions \$980.49 Contributions to charity \$817.65

CAUTION Why is it so important to consider only *one* digit to the right of the desired round-off position? What is wrong with rounding in steps? Suppose that Mark rounds 1.349 to the nearest tenth in steps. First he rounds 1.349 to 1.35 (nearest hundredth). Then he rounds 1.35 to 1.4 (nearest tenth). What is wrong with this reasoning?



To round 1.349 to the nearest tenth, we ask if 1.349 is closer to 1.3 or to 1.4. It is closer to 1.3. Mark got 1.4, so he is not correct. He "rounded in steps" by first moving to 1.35, thus increasing the error and moving in the wrong direction. To control rounding errors, we consider *only* the first digit to the right of the decimal place to which we are rounding.

3.2 EXERCISES

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Fill in the blank with one of the symbols <, =, or >.

1. 1.3 ___ 1.29 **2.** 2.6 ___ 2.58 **3.** 0.34 ___ 0.340 **4.** 72.54 ___ 72.56

5. 18.92 ___ 18.93 **6.** 0.460 _ 0.46 **7.** 0.006 ___ 0.00063 **8.** 0.0037 ___ 0.036

9. 1.002 ___ 1.0021 **10.** 2.0056 ___ 2.006 **11.** 126.34 ___ 125.35 **12.** 406.78 ___ 407.75

13. 0.888 ___ 0.8888 **14.** 0.666 ___ 0.6666 **15.** 0.777 ___ 0.7077 **16.** 0.555 ___ 0.5505

17. $\frac{72}{1000}$ ___ 0.072 **18.** $\frac{54}{1000}$ ___ 0.054 **19.** $\frac{8}{10}$ ___ 0.08 **20.** $\frac{5}{100}$ ___ 0.005

Arrange each set of decimals from smallest to largest.

21. 12.6, 12.8, 12.65 **22.** 18.32, 18.038, 18.04 **23.** 0.0071, 0.05, 0.007

24. 0.0025, 0.0052, 0.002 **25.** 5.2, 5.23, 5.3, 5.12 **26.** 4.5, 4.67, 4.73, 4.6

27. 26.034, 26.003, 26.04, 26.033 **28.** 33.082, 33.02, 33.088, 33.079

29. 18.006, 18.060, 18.066, 18.606, 18.065 **30.** 15.020, 15.002, 15.001, 15.018, 15.0019

Round to the nearest tenth.

31. 5.67 **32.** 8.35 **33.** 28.98 **34.** 47.94

35. 578.064 **36.** 311.95 **37.** 2176.83 **38.** 4082.74

Round to the nearest hundredth.

39. 26.032 **40.** 47.071 **41.** 36.997 **42.** 24.999

43. 156.1749 **44.** 283.8441 **45.** 2786.706 **46.** 4609.285

Round to the nearest given place.

47. 1.06132 thousandths **48.** 8.10263 thousandths

49. 0.05951 ten-thousandths **50.** 0.063148 ten-thousandths

51. 5.00761238 hundred-thousandths **52.** 7.038972 hundred-thousandths

53. 135.564 nearest whole number **54.** 208.7302 nearest whole number

Round to the nearest dollar.

55. \$2536.85 **56.** \$5319.62 **57.** \$15,020.50 **58.** \$20,159.48

Round to the nearest cent.

59. \$56.9832 **60.** \$28.3951 **61.** \$5783.716 **62.** \$3928.649

Applications

63. ***Baseball*** During the 2003 baseball season, the winning percentages of the New York Yankees and the Toronto Blue Jays were 0.60869 and 0.52127, respectively. Round these values to the nearest thousandth.

64. ***Employment Compensation*** During 2003 the employer costs in the United States for employee compensation per hour worked were \$29.4235 for union members. For nonunion members the figure was \$20.7896. Round these values to the nearest cent.

65. ***Astronomy*** The number of days in a year is 365.24122. Round this value to the nearest hundredth.

66. ***Mathematics History*** The numbers π and e are approximately equal to 3.14159 and 2.71828, respectively. We will be using π later in this textbook. You will encounter e in higher level mathematics courses. Round these values to the nearest hundredth.

To Think About

67. Arrange in order from smallest to largest.

$$0.61,\ 0.062,\ \frac{6}{10},\ 0.006,\ 0.0059,$$
$$\frac{6}{100},\ 0.0601,\ 0.0519,\ 0.0612$$

68. Arrange in order from smallest to largest.

$$1.05,\ 1.512,\ \frac{15}{10},\ 1.0513,\ 0.049,$$
$$\frac{151}{100},\ 0.0515,\ 0.052,\ 1.051$$

69. A person wants to round 86.23498 to the nearest hundredth. He first rounds 86.23498 to 86.2350. He then rounds to 86.235. Finally, he rounds to 86.24. What is wrong with his reasoning?

70. ***Personal Finance*** Fred is checking the calculations on his monthly bank statement. An interest charge of \$16.3724 was rounded to \$16.38. An interest charge of \$43.7214 was rounded to \$43.73. What rule does the bank use for rounding off to the nearest cent?

Cumulative Review

71. Add. $3\frac{1}{4} + 2\frac{1}{2} + 6\frac{3}{8}$

72. Subtract. $27\frac{1}{5} - 16\frac{3}{4}$

73. ***Car Travel*** Mary drove her Dodge Caravan on a trip. At the start of the trip, the odometer (which measures distance) read 46,381. At the end of the trip, it read 47,073. How many miles long was the trip?

74. ***Boat Sales*** Don's New and Used Watercraft sold four boats one weekend for \$18,650, \$2490, \$835, and \$9845. Estimate the total amount of the sales.

3.3 Adding and Subtracting Decimals

Student Learning Objectives

After studying this section, you will be able to:

1. **Add decimals.**
2. **Subtract decimals.**

1 Adding Decimals

We often add decimals when we check the addition of our bill at a restaurant or at a store. We can relate addition of decimals to addition of fractions. For example,

$$\frac{3}{10} + \frac{6}{10} = \frac{9}{10} \qquad \text{and} \qquad 1\frac{1}{10} + 2\frac{8}{10} = 3\frac{9}{10}.$$

These same problems can be written more efficiently as decimals.

$$\begin{array}{r} 0.3 \\ +\ 0.6 \\ \hline 0.9 \end{array} \qquad \begin{array}{r} 1.1 \\ +\ 2.8 \\ \hline 3.9 \end{array}$$

The steps to follow when adding decimals are listed in the following box.

ADDING DECIMALS

1. Write the numbers to be added vertically and line up the decimal points. Extra zeros may be placed to the right of the decimal points if needed.
2. Add all the digits with the same place value, starting with the right column and moving to the left.
3. Place the decimal point of the sum in line with the decimal points of the numbers added.

EXAMPLE 1 Add.

(a) 2.8 + 5.6 + 3.2 **(b)** 158.26 + 200.07 + 315.98

(c) 5.3 + 26.182 + 0.0007 + 624

Solution

(a)
$$\begin{array}{r} {\scriptstyle 1} \\ 2.8 \\ 5.6 \\ +\ 3.2 \\ \hline 11.6 \end{array}$$

(b)
$$\begin{array}{r} {\scriptstyle 1\,1\ 2} \\ 158.26 \\ 200.07 \\ +\ 315.98 \\ \hline 674.31 \end{array}$$

(c)
$$\begin{array}{r} 5.3000 \\ 26.1820 \\ 0.0007 \\ +\ 624.0000 \\ \hline 655.4827 \end{array}$$

Extra zeros have been added to make the problem easier. *Note*: The decimal point is understood to be to the right of the digit 4.

Practice Problem 1 Add.

(a)
$$\begin{array}{r} 9.8 \\ 3.6 \\ +\ 5.4 \\ \hline \end{array}$$

(b)
$$\begin{array}{r} 300.72 \\ 163.75 \\ +\ 291.08 \\ \hline \end{array}$$

(c) 8.9 + 37.056 + 0.0023 + 945

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

SIDELIGHT: Adding In Extra Zeros

When we add decimals like 3.1 + 2.16 + 4.007, we may write in zeros, as shown:

$$\begin{array}{r} 3.100 \\ 2.160 \\ +\ 4.007 \\ \hline 9.267 \end{array}$$

What are we really doing here? What is the advantage of adding these extra zeros?

"Decimals" means "decimal fractions." If we look at the number as fractions, we see that we are actually using the property of multiplying a fraction by 1 in order to obtain common denominators. Look at the problem this way:

$$\left.\begin{aligned} 3.1 &= 3\frac{1}{10} \\ 2.16 &= 2\frac{16}{100} \\ 4.007 &= 4\frac{7}{1000} \end{aligned}\right\}$$

The least common denominator is 1000. To obtain the common denominator for the first two fractions, we multiply.

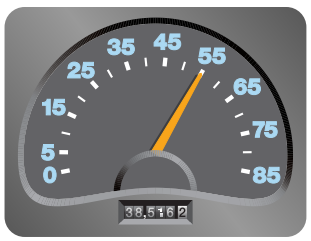
$$\left.\begin{aligned} 3\ \frac{1}{10} \times \frac{100}{100} &= 3\frac{100}{1000} \\ 2\ \frac{16}{100} \times \frac{10}{10} &= 2\frac{160}{1000} \\ +4\ \frac{7}{1000} \qquad &= 4\frac{7}{1000} \end{aligned}\right\}$$

$$9\frac{267}{1000} = 9.267$$

Once we obtain a common denominator, we can add the three fractions.

This is the answer we arrived at earlier using the decimal form for each number. Thus writing in zeros in a decimal fraction is really an easy way to transform fractions to equivalent fractions with a common denominator. Working with decimal fractions is easier than working with other fractions.

The final digit of most odometers measures tenths of a mile. The odometer reading shown in the odometer on the right is 38,516.2 miles.



Calculator

Adding Decimals

The calculator can be used to verify your work. You can use your calculator to add decimals. To find 23.08 + 8.53 + 9.31 enter:

23.08 [+] 8.53 [+]
9.31 [=]

Display:

[40.92]

EXAMPLE 2 Barbara checked her odometer before the summer began. It read 49,645.8 miles. She traveled 3852.6 miles that summer in her car. What was the odometer reading at the end of the summer?

Solution

$$\begin{array}{r} {\scriptstyle 11\ \ \ 1} \\ 49{,}645.8 \\ +\ 3{,}852.6 \\ \hline 53{,}498.4 \end{array}$$

The odometer read 53,498.4 miles.

Practice Problem 2 A car odometer read 93,521.8 miles before a trip of 1634.8 miles. What was the final odometer reading?

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

EXAMPLE 3 During his first semester at Tarrant County Community College, Kelvey deposited checks into his checking account in the amounts of \$98.64, \$157.32, \$204.81, \$36.07, and \$229.89. What was the sum of his five checks?

Solution

$$\begin{array}{r} {\scriptstyle 2\,3\,2\;\;2} \\ \$\;98.64 \\ 157.32 \\ 204.81 \\ 36.07 \\ +\;\;229.89 \\ \hline \$726.73 \end{array}$$

Practice Problem 3 During the spring semester, Will deposited the following checks into his account: \$80.95, \$133.91, \$256.47, \$53.08, and \$381.32. What was the sum of his five checks?

2 Subtracting Decimals

It is important to see the relationship between the decimal form of a mixed number and the fractional form of a mixed number. This relationship helps us understand why calculations with decimals are done the way they are. Recall that when we subtract mixed numbers with common denominators, sometimes we must borrow from the whole number.

$$\begin{array}{rcr} 5\frac{1}{10} & = & 4\frac{11}{10} \\ -\;2\frac{7}{10} & = & -\;2\frac{7}{10} \\ \hline & & 2\frac{4}{10} \end{array}$$

We could write the same problem in decimal form:

$$\begin{array}{r} {\scriptstyle 4\;11} \\ \cancel{5}.\cancel{1} \\ -\;\;2.7 \\ \hline 2.4 \end{array}$$

Subtraction of decimals is thus similar to subtraction of fractions (we get the same result), but it's usually easier to subtract with decimals than to subtract with fractions.

SUBTRACTING DECIMALS

1. Write the decimals to be subtracted vertically and line up the decimal points. Additional zeros may be placed to the right of the decimal point if not all numbers have the same number of decimal places.
2. Subtract all digits with the same place value, starting with the right column and moving to the left. Borrow when necessary.
3. Place the decimal point of the difference in line with the decimal point of the two numbers being subtracted.

EXAMPLE 4 Subtract.

(a)
$$\begin{array}{r} 84.8 \\ -\ 27.3 \\ \hline \end{array}$$

(b)
$$\begin{array}{r} 1076.320 \\ -\ 983.518 \\ \hline \end{array}$$

Solution

(a)
$$\begin{array}{r} \overset{7}{\cancel{8}}\ \overset{14}{\cancel{4}}\ .\ 8 \\ -\ 2\ 7\ .\ 3 \\ \hline 5\ 7\ .\ 5 \end{array}$$

(b)
$$\begin{array}{r} \overset{9}{\cancel{1}}\overset{}{\cancel{0}}\ \overset{17}{\cancel{7}}\ \overset{5}{\cancel{6}}\ .\ \overset{13}{\cancel{3}}\ \overset{1}{\cancel{2}}\ \overset{10}{\cancel{0}} \\ -\ 9\ 8\ 3\ .\ 5\ 1\ 8 \\ \hline 9\ 2\ .\ 8\ 0\ 2 \end{array}$$

Practice Problem 4 Subtract.

(a)
$$\begin{array}{r} 38.8 \\ -\ 26.9 \\ \hline \end{array}$$

(b)
$$\begin{array}{r} 2034.908 \\ -\ 1986.325 \\ \hline \end{array}$$

When the two numbers being subtracted do not have the same number of decimal places, write in zeros as needed.

EXAMPLE 5 Subtract.

(a) 12 − 8.362 **(b)** 156.381 − 99.82

Solution

(a)
$$\begin{array}{r} \overset{11}{\cancel{1}}\ \overset{}{\cancel{2}}\ .\ \overset{9}{\cancel{0}}\ \overset{9}{\cancel{0}}\ \overset{10}{\cancel{0}} \\ -\ 8\ .\ 3\ 6\ 2 \\ \hline 3\ .\ 6\ 3\ 8 \end{array}$$

(b)
$$\begin{array}{r} \overset{14}{\cancel{1}}\ \overset{15}{\cancel{5}}\ \overset{}{\cancel{6}}\ .\ \overset{13}{\cancel{3}}\ 8\ 1 \\ -\ 9\ 9\ .\ 8\ 2\ 0 \\ \hline 5\ 6\ .\ 5\ 6\ 1 \end{array}$$

Practice Problem 5 Subtract.

(a) 19 − 12.579 **(b)** 283.076 − 96.38

EXAMPLE 6 On Tuesday, Don Ling filled the gas tank in his car. The odometer read 56,098.5. He drove for four days. The next time he filled the tank, the odometer read 56,420.2. How many miles had he driven?

Solution

$$\begin{array}{r} 5\ 6,\ \overset{3}{\cancel{4}}\ \overset{11}{\cancel{2}}\ \overset{9}{\cancel{0}}\ .\ \overset{12}{\cancel{2}} \\ -5\ 6,\ 0\ 9\ 8\ .\ 5 \\ \hline 3\ 2\ 1\ .\ 7 \end{array}$$

He had driven 321.7 miles.

Practice Problem 6 Abdul had his car oil changed when his car odometer read 82,370.9 miles. When he changed the oil again, the odometer read 87,160.1 miles. How many miles did he drive between oil changes?

EXAMPLE 7 Find the value of x if $x + 3.9 = 14.6$.

Solution Recall that the letter x is a variable. It represents a number that is added to 3.9 to obtain 14.6. We can find the number x if we calculate $14.6 - 3.9$.

$$\begin{array}{r} {\scriptstyle 3\ 16} \\ 1\cancel{4}.\cancel{6} \\ -\ 3.9 \\ \hline 10.7 \end{array}$$

Thus $x = 10.7$.

Check. Is this true? If we replace x by 10.7, do we get a true statement?

$$\begin{aligned} x + 3.9 &= 14.6 \\ 10.7 + 3.9 &\stackrel{?}{=} 14.6 \\ 14.6 &= 14.6 \quad \checkmark \end{aligned}$$

***NOTE TO STUDENT:** Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1*

Practice Problem 7 Find the value of x if $x + 10.8 = 15.3$.

Developing Your Study Skills

Making a Friend in the Class

Attempt to make a friend in your class. You may find that you enjoy sitting together and drawing support and encouragement from each other. Exchange phone numbers so you can call each other whenever you get stuck in your study. Set up convenient times to study together on a regular basis, to do homework, and to review for exams.

You must not depend on a friend or fellow student to tutor you, do your work for you, or in any way be responsible for your learning. However, you will learn from each other as you seek to master the course. Studying with a friend and comparing notes, methods, and solutions can be very helpful. And it can make learning mathematics a lot more fun!

3.3 Exercises

Student Solutions Manual | CD/Video | PH Math Tutor Center | MathXL®Tutorials on CD | MathXL® | MyMathLab® | Interactmath.com

Add.

1. 57.1 + 19.7

2. 78.3 + 29.4

3. 718.98 + 496.57

4. 813.47 + 629.86

5.
$$\begin{array}{r} 13.4 \\ 7.6 \\ +\ 275.2 \\ \hline \end{array}$$

6.
$$\begin{array}{r} 176.5 \\ 8.4 \\ +\ 22.5 \\ \hline \end{array}$$

7.
$$\begin{array}{r} 4.71 \\ +\ 8.05 \\ \hline \end{array}$$

8.
$$\begin{array}{r} 9.284 \\ +\ 5.77 \\ \hline \end{array}$$

9.
$$\begin{array}{r} 4.9637 \\ 28.12 \\ +\ 3.645 \\ \hline \end{array}$$

10.
$$\begin{array}{r} 7.0276 \\ 3.451 \\ +\ 16.98 \\ \hline \end{array}$$

11.
$$\begin{array}{r} 12. \\ 3.62 \\ +\ 51.8 \\ \hline \end{array}$$

12.
$$\begin{array}{r} 13. \\ 4.52 \\ +\ 63.7 \\ \hline \end{array}$$

13. 156.35 + 2.79 + 126.3 + 86

14. 172.49 + 3.52 + 138.6 + 77

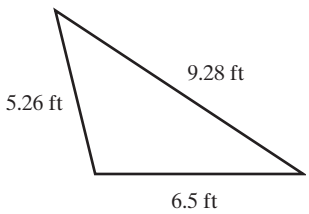
15. 753.61 + 28.75 + 162.3 + 100.5 + 67

16. 432.51 + 16.08 + 892.1 + 301.2 + 84

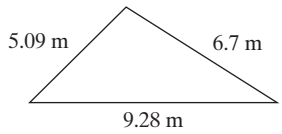
Applications

In exercises 17 and 18, calculate the perimeter of each triangle.

17.



18.



19. ***Weight Loss*** Lamar is losing weight by walking each evening after dinner. During the first week in February he lost 1.75 pounds. During the second, third, and fourth weeks, he lost 2.5 pounds, 1.55 pounds, and 2.8 pounds, respectively. How many total pounds did Lamar lose in February?

20. ***Health*** Teresa knows she needs to drink more water while at work. One day during her morning break she drank 7.15 ounces. At lunch she drank 12.45 ounces and throughout the afternoon she drank 10.75 ounces. How many total ounces of water did she drink?

21. ***Beach Vacation*** Mick and Keith have arrived in Miami and are going to the beach. They buy sunblock for $4.99, beverages for $12.50, sandwiches for $11.85, towels for $28.50, bottled water for $3.29, and two novels for $16.99. After they got what they needed, what was Mick and Keith's bill for their day at the beach?

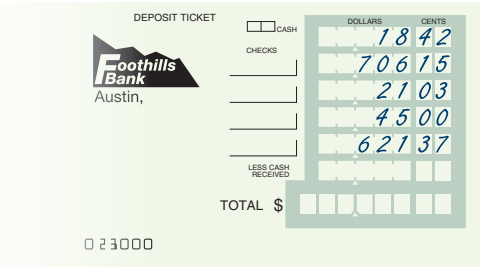
22. ***Consumer Mathematics*** Erin bought school supplies at the campus bookstore. She bought pens for $3.45, a calculator for $18.25, notebooks for $6.29 and pencils for $0.89. What was the total of Erin's bill?

23. ***Truck Travel*** A truck odometer read 46,276.0 miles before a trip of 778.9 miles. What was the final odometer reading?

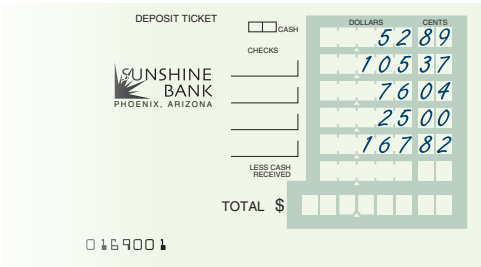
24. ***Car Travel*** Jane traveled 1723.1 miles. The car odometer at the beginning of the trip read 23,195.0 miles. What was the final odometer reading?

Personal Banking *In exercises 25 and 26, a portion of a bank checking account deposit slip is shown. Add the numbers to determine the total deposit. The line drawn between the dollars and the cents column serves as the decimal point.*

25.



26.



Subtract.

27. 6.8 − 2.9

28. 3.6 − 2.8

29. 35.75 − 9.82

30. 84.33 − 8.09

31. 126 − 76.22

32. 209 − 81.54

33. $\begin{array}{r} 586.513 \\ -\ 78.2 \\ \hline \end{array}$

34. $\begin{array}{r} 243.967 \\ -\ 84.2 \\ \hline \end{array}$

35. $\begin{array}{r} 162.4 \\ -\ 97.52 \\ \hline \end{array}$

36. $\begin{array}{r} 119.6 \\ -\ 23.91 \\ \hline \end{array}$

37. $\begin{array}{r} 24.0079 \\ -\ 19.3614 \\ \hline \end{array}$

38. $\begin{array}{r} 52.0708 \\ -\ 41.9312 \\ \hline \end{array}$

39. $\begin{array}{r} 8 \\ -\ 1.263 \\ \hline \end{array}$

40. $\begin{array}{r} 12 \\ -\ 7.981 \\ \hline \end{array}$

41. $\begin{array}{r} 7362.14 \\ -\ 6173.07 \\ \hline \end{array}$

42. $\begin{array}{r} 4986.71 \\ -\ 3615.93 \\ \hline \end{array}$

43. $\begin{array}{r} 1.5 \\ -\ 0.0365 \\ \hline \end{array}$

44. $\begin{array}{r} 2.8 \\ -\ 0.07763 \\ \hline \end{array}$

Mixed Practice

Add or subtract.

45. 123.621 + 52.96

46. 241.983 + 75.48

47. 98.3 − 56.71

48. 79.2 − 45.93

49. 0.0763 + 2 + 3.16

50. 0.0698 + 5 + 7.34

51. 197.600 − 124.375

52. 382.700 − 291.927

Applications

53. ***BOA Constrictor*** The average length of an Emerald Tree boa constrictor is 1.8 meters. A native found one that measured 3.264 meters long. How much longer was this snake than the average Emerald Tree boa constrictor?

54. ***Health*** At her 4-month checkup, baby Grace weighed 7.675 kilograms. When she was born, she weighed 3.7 kilograms. How much weight has Grace gained since she was born?

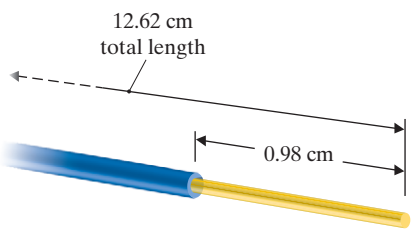
55. ***Telescope*** A child's beginner telescope is priced at $79.49. The price of a certain professional telescope is $37,026.65. How much more does the professional telescope cost?

56. ***Automobile Travel*** Tamika drove on a summer trip. When she began, the odometer read 26,052.3 miles. At the end of the trip, the odometer read 28,715.1 miles. How long was the trip?

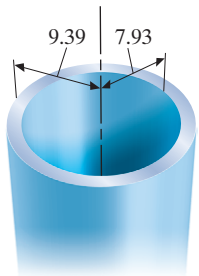
57. ***Taxi Trip*** Malcolm took a taxi from John F. Kennedy Airport in New York to his hotel in the city. His fare was $47.70 and he tipped the driver $7.00. How much change did Malcolm get back if he gave the driver a $100 bill?

58. ***Personal Banking*** Nathan took $150 out of the ATM. He bought shoes for $45.50, groceries for $38.72, and gas for $12.86. How much money does he have left?

59. ***Electric Wire Construction*** An insulated wire measures 12.62 centimeters. The last 0.98 centimeter of the wire is exposed. How long is the part of the wire that is not exposed?



60. ***Plumbing*** The outside radius of a pipe is 9.39 centimeters. The inside radius is 7.93 centimeters. What is the thickness of the pipe?



61. ***Medical Research*** A cancer researcher is involved in an important experiment. She is trying to determine how much of an anticancer drug is necessary for a Stage I (nonhuman or animal) test. She pours 2.45 liters of the experimental anticancer formula in one container and 1.35 liters of a reactive liquid in another. She then pours the contents of one container into the other. If 0.85 liters is expected to evaporate during the process, how much liquid will be left?

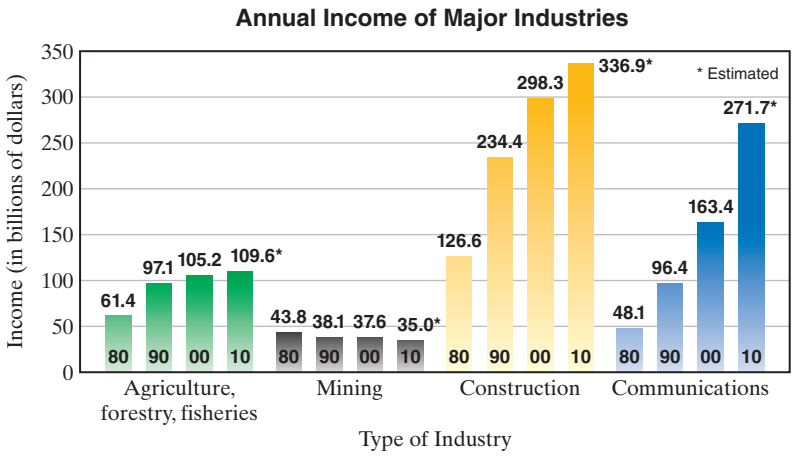
62. ***Rainforest*** Everyone is becoming aware of the rapid loss of the Earth's rainforests. Between 1981 and 2003, tropical South America lost a substantial amount of natural resources due to deforestation and development. In 1981, there were 797,100,000 hectares of rainforest. In 2003 there were 637,200,000 hectares. How much rainforest, in hectares, was destroyed? *(Source:* United Nations Statistics Division*)*

The federal water safety standard requires that drinking water contain no more than 0.015 milligram of lead per liter of water. (Source: Environmental Protection Agency)

63. ***Well Water Safety*** Carlos and Maria had the well that supplies their home analyzed for safety. A sample of well water contained 0.0089 milligram of lead per liter of water. What is the difference between their sample and the federal safety standard? Is it safe for them to drink the water?

64. ***City Water Safety*** Fred and Donna use water provided by the city for the drinking water in their home. A sample of their tap water contained 0.023 milligram of lead per liter of water. What is the difference between their sample and the federal safety standard? Is it safe for them to drink the water?

Income of Industries *The following table shows the income of the United States by industry. Use this table for exercises 65–68. Write each answer as a decimal and as a whole number. The table values are recorded in billions of dollars.*



Source: Bureau of Labor Statistics

65. How many more dollars were earned in mining in 1980 than in 2000?

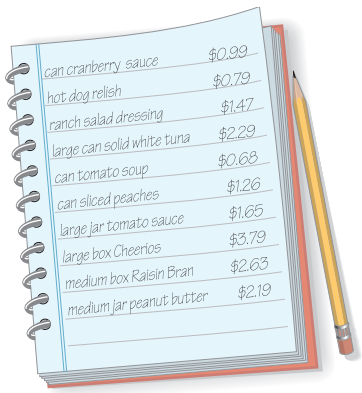
66. How many more dollars were earned in construction in 2000 than in 1980?

67. In 2010, how many more dollars will be earned in communications than in agriculture, forestry, and fisheries?

68. In 1990, how many more dollars were earned in communication than in mining?

To Think About

Mr. Jensen made up the following shopping list of items he needs and the cost of each item. Use the list to answer exercises 69 and 70.



69. ***Grocery Shopping*** Mr. Jensen goes to the store to buy the following items from his list: Raisin Bran, ranch salad dressing, sliced peaches, hot dog relish, and peanut butter. He has a ten-dollar bill. Round each item to the nearest ten cents and estimate the cost of buying these items by first rounding the cost of each item to the nearest ten cents. Does he have enough money to buy all of them? Find the exact cost of these items. How close was your estimate?

70. ***Grocery Shopping*** The next day the Jensens' daughter, Brenda, goes to the store to buy the following items from the list: Cheerios, tomato sauce, peanut butter, white tuna, tomato soup, and cranberry sauce. She has fifteen dollars. Estimate the cost of buying these items by first rounding the cost of each item to the nearest ten cents. Does she have enough money to buy all of them? Find the exact cost of these items. How close was your estimate?

Find the value of x.

71. $x + 7.1 = 15.5$

72. $x + 4.8 = 23.1$

73. $156.9 + x = 200.6$

74. $210.3 + x = 301.2$

75. $4.162 = x + 2.053$

76. $7.076 = x + 5.602$

Cumulative Review

Multiply.

77. $\begin{array}{r} 2536 \\ \times \quad 8 \\ \hline \end{array}$

78. $\begin{array}{r} 827 \\ \times 59 \\ \hline \end{array}$

79. $\frac{22}{7} \times \frac{49}{50}$

80. $2\frac{1}{3} \times 3\frac{3}{4}$

3.4 Multiplying Decimals

Student Learning Objectives

After studying this section, you will be able to:

1. **Multiply a decimal by a decimal or a whole number.**
2. **Multiply a decimal by a power of 10.**

1 Multiplying a Decimal by a Decimal or a Whole Number

We learned previously that the product of two fractions is the product of the numerators over the product of the denominators. For example,

$$\frac{3}{10} \times \frac{7}{100} = \frac{21}{1000}$$

In decimal form this product would be written

$$\underbrace{0.3}_{\text{one decimal place}} \times \underbrace{0.07}_{\text{two decimal places}} = \underbrace{0.021}_{\text{three decimal places}}$$

MULTIPLICATION OF DECIMALS

1. Multiply the numbers just as you would multiply whole numbers.
2. Find the sum of the decimal places in the two factors.
3. Place the decimal point in the product so that the product has the same number of decimal places as the sum in step 2. You may need to write zeros to the left of the number found in step 1.

Now use these steps to do the preceding multiplication problem.

EXAMPLE 1 Multiply. 0.07×0.3

Solution

	0.07	2 decimal places
	$\times$ 0.3	1 decimal place
	0.021	3 decimal places in product $(2 + 1 = 3)$

Practice Problem 1 Multiply 0.09×0.6

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

When performing the calculation, it is usually easier to place the factor with the smallest number of nonzero digits underneath the other factor.

EXAMPLE 2 Multiply.

(a) 0.38×0.26 **(b)** 12.64×0.572

Solution

(a)

0.38	2 decimal places
$\times$ 0.26	2 decimal places
228	
76	
0.0988	4 decimal places $(2 + 2 = 4)$

Note that we need to insert a zero before the 988.

(b)

12.64	2 decimal places
$\times$ 0.572	3 decimal places
2528	
8848	
6 320	
7.23008	5 decimal places $(2 + 3 = 5)$

Calculator

Multiplying Decimals

You can use your calculator to multiply a decimal by a decimal. To find 0.08×1.53 enter:

0.08 [×] 1.53 [=]

Display:

[0.1224]

Practice Problem 2 Multiply.

(a) 0.47×0.28 **(b)** 0.436×18.39

When multiplying decimal fractions by a whole number, you need to remember that a whole number has no decimal places.

EXAMPLE 3 Multiply. 5.261×45

Solution

5.261	3 decimal places
× 45	0 decimal places
26 305	
210 44	
236.745	3 decimal places (3 + 0 = 3)

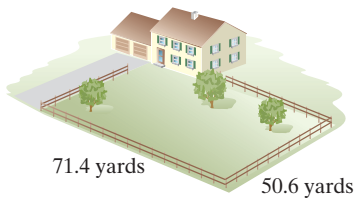
Practice Problem 3 Multiply. 0.4264×38

EXAMPLE 4 Uncle Roger's rectangular front lawn measures 50.6 yards wide and 71.4 yards long. What is the area of the lawn in square yards?

Solution Since the lawn is rectangular, we will use the fact that to find the area of a rectangle we multiply the length by the width.

71.4	1 decimal place
× 50.6	1 decimal place
42 84	
3570 0	
3612.84	2 decimal places

The area of the lawn is 3612.84 square yards.



Practice Problem 4 A rectangular computer chip measures 1.26 millimeters wide and 2.3 millimeters long. What is the area of the chip in square millimeters?

2 Multiplying a Decimal by a Power of 10

Observe the following pattern.

one zero — Decimal point moved one place to the right.

$$0.035 \times 10^1 = 0.035 \times 10 = 0.35$$

two zeros — Decimal point moved two places to the right.

$$0.035 \times 10^2 = 0.035 \times 100 = 3.5$$

three zeros — Decimal point moved three places to the right.

$$0.035 \times 10^3 = 0.035 \times 1000 = 35.$$

MULTIPLICATION OF A DECIMAL BY A POWER OF 10

To multiply a decimal by a power of 10, move the decimal point to the right the same number of places as the number of zeros in the power of 10.

EXAMPLE 5 Multiply. **(a)** 2.671×10 **(b)** 37.85×100

Solution

(a) $2.671 \times 10 = 26.71$

one zero

Decimal point moved one place to the right.

(b) $37.85 \times 100 = 3785.$

two zeros

Decimal point moved two places to the right.

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Practice Problem 5 Multiply. **(a)** 0.0561×10 **(b)** 1462.37×100

Sometimes it is necessary to add extra zeros before placing the decimal point in the answer.

EXAMPLE 6 Multiply. **(a)** 4.8×1000 **(b)** $0.076 \times 10{,}000$

Solution

(a) $4.8 \times 1\underbrace{000}_{\text{(three zeros)}} = 4800.$

Decimal point moved three places to the right. Two extra zeros were needed.

(b) $0.076 \times 10\underbrace{,000}_{\text{(four zeros)}} = 760.$

Decimal point moved four places to the right. One extra zero was needed.

Practice Problem 6 Multiply. **(a)** 0.26×1000 **(b)** $5862.89 \times 10{,}000$

If the number that is a power of 10 is in exponent form, move the decimal point to the right the same number of places as the number that is the exponent.

EXAMPLE 7 Multiply. 3.68×10^3

Solution

Exponent of 3

Decimal point moved three places to the right.

$3.68 \times 10^3 = 3680.$

Practice Problem 7 Multiply. 7.684×10^4

SIDELIGHT: Moving the Decimal Point

Can you devise a quick rule to use when multiplying a decimal fraction by $\frac{1}{10}, \frac{1}{100}, \frac{1}{1000}$, and so on? How is it like the rules developed in this section? Consider a few examples

Original Problem	Change Fraction to Decimal	Decimal Multiplication	Observation
$86 \times \frac{1}{10}$	86×0.1	$\begin{array}{r} 86 \\ \times\ 0.1 \\ \hline 8.6 \end{array}$	Decimal point moved one place to the left.
$86 \times \frac{1}{100}$	86×0.01	$\begin{array}{r} 86 \\ \times\ 0.01 \\ \hline 0.86 \end{array}$	Decimal point moved two places to the left.
$86 \times \frac{1}{1000}$	86×0.001	$\begin{array}{r} 86 \\ \times\ 0.001 \\ \hline 0.086 \end{array}$	Decimal point moved three places to the left.

Can you think of a way to describe a rule that you could use in solving this type of problem without going through all the foregoing steps?

You use multiplying by a power of 10 when you convert a larger unit of measure to a smaller unit of measure in the metric system.

EXAMPLE 8 Change 2.96 kilometers to meters.

Solution Since we are going from a larger unit of measure to a smaller one, we multiply. There are 1000 meters in 1 kilometer. Multiply 2.96 by 1000.

$$2.96 \times 1000 = 2960$$

2.96 kilometers is equal to 2960 meters.

Practice Problem 8 Change 156.2 kilometers to meters.

TO THINK ABOUT: Names Used to Describe Large Numbers Often when reading the newspaper or watching television news shows, we hear words like 3.46 trillion or 67.8 billion. These are abbreviated notations that are used to describe large numbers. When you encounter these numbers, you can change them to standard notation by multiplication of the appropriate value.

For example, if someone says that the population of China is 1.31 billion people, we can write 1.31 billion = 1.31 × 1 billion = 1.31 × 1,000,000,000 = 1,310,000,000. If someone says the population of Chicago is 2.92 million people, we can write

$$2.92 \text{ million} = 2.92 \times 1 \text{ million} = 2.92 \times 1{,}000{,}000 = 2{,}920{,}000.$$

3.4 EXERCISES

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Multiply.

Verbal and Writing Skills

1. Explain in your own words how to determine where to put the decimal point in the answer when you multiply 0.67×0.08.

2. Explain in your own words how to determine where to put the decimal point in the answer when you multiply 3.45×0.9.

3. Explain in your own words how to determine where to put the decimal point in the answer when you multiply 0.0078×100.

4. Explain in your own words how to determine where to put the decimal point in the answer when you multiply 5.0807 by 1000.

5. $\begin{array}{r} 0.6 \\ \times\ 0.2 \\ \hline \end{array}$

6. $\begin{array}{r} 0.9 \\ \times\ 0.3 \\ \hline \end{array}$

7. $\begin{array}{r} 0.12 \\ \times\ 0.5 \\ \hline \end{array}$

8. $\begin{array}{r} 0.17 \\ \times\ 0.4 \\ \hline \end{array}$

9. $\begin{array}{r} 0.0036 \\ \times\ 0.8 \\ \hline \end{array}$

10. $\begin{array}{r} 0.067 \\ \times\ 0.07 \\ \hline \end{array}$

11. $\begin{array}{r} 452 \\ \times\ 0.12 \\ \hline \end{array}$

12. $\begin{array}{r} 316 \\ \times\ 0.24 \\ \hline \end{array}$

13. $\begin{array}{r} 0.043 \\ \times\ 0.012 \\ \hline \end{array}$

14. $\begin{array}{r} 0.037 \\ \times\ 0.011 \\ \hline \end{array}$

15. $\begin{array}{r} 10.97 \\ \times\ 0.06 \\ \hline \end{array}$

16. $\begin{array}{r} 18.07 \\ \times\ 0.05 \\ \hline \end{array}$

17. $\begin{array}{r} 5167 \\ \times\ 0.19 \\ \hline \end{array}$

18. $\begin{array}{r} 7986 \\ \times\ 0.32 \\ \hline \end{array}$

19. $\begin{array}{r} 2.163 \\ \times\ 0.008 \\ \hline \end{array}$

20. $\begin{array}{r} 1.892 \\ \times\ 0.007 \\ \hline \end{array}$

21. $\begin{array}{r} 0.7613 \\ \times\ 1009 \\ \hline \end{array}$

22. $\begin{array}{r} 0.6178 \\ \times\ 5004 \\ \hline \end{array}$

23. $\begin{array}{r} 2350 \\ \times\ 3.6 \\ \hline \end{array}$

24. $\begin{array}{r} 3720 \\ \times\ 8.1 \\ \hline \end{array}$

25. 4.57×11.8

26. 73.2×2.45

27. 0.001×6523.7

28. 0.01×826.75

Applications

29. ***Car Payments*** Kenny is making payments on his Ford Escort of $155.40 per month for the next 60 months. How much will he have spent in car payments after he sends in his final payment?

30. ***Food Purchase*** Each carton of ice cream contains 1.89 liters. Paul stocked his freezer with 25 cartons. How many total liters of ice cream did he buy?

31. ***Personal Income*** Mei Lee works for a company that manufactures electric and electronic equipment and earns $14.70 per hour for a 40-hour week. How much does she earn in one week? (The average wage in 2002 for U.S. electric/electronic equipment manufacturers was $14.53 per hour for an average of 41.3 hours, for a total of $600.09 per week.) (*Source*: Bureau of Labor Statistics)

32. ***Personal Income*** Elva works for a company that manufactures textile products. She earns $11.80 per hour for a 40-hour week. How much does she earn in one week? (The average wage in 2002 for U.S. textile mill industries was $11.35 per hour for an average of 40.6 hours, for a total of $460.81 per week. (*Source*: Bureau of Labor Statistics)

▲ **33.** ***Geometry*** Ralph and Darlene are getting new carpet in their bedroom and need to find how many square feet they need to purchase. The dimensions of their rectangular bedroom are 15.5 feet and 19.2 feet. What is the area of the room in square feet?

▲ **34.** ***Geometry*** Sal is having his driveway paved by a company that charges by the square yard. Sal's driveway measures 8.6 yards by 17.5 yards. How many square yards is his driveway?

35. ***Student Loan*** Dwight is paying off a student loan at Westmont College with payments of $36.90 per month for the next 18 months. How much will he pay off during the next 18 months?

36. ***Car Payments*** Marcia is making car payments to Highfield Center Chevrolet of $230.50 per month for 16 more months. How much will she pay for car payments in the next 16 months?

37. ***Fuel Efficiency*** Steve's car gets approximately 26.4 miles per gallon. His gas tank holds 19.5 gallons. Approximately how many miles can he travel on a full tank of gas?

38. ***Fuel Efficiency*** Jim's 4×4 truck gets approximately 18.6 miles per gallon. His gas tank holds 19.5 gallons. Approximately how many miles can he travel on a full tank of gas? Compare this to your answer in exercise 37.

Multiply.

39. 2.86×10

40. 1.98×10

41. 52.0×100

42. 83.0×100

43. 22.615×1000

44. 34.105×1000

45. $5.60982 \times 10{,}000$

46. $1.27986 \times 10{,}000$

47. $17{,}561.44 \times 10^2$

48. 7163.241×10^2

49. 816.32×10^3

50. 763.49×10^4

Applications

51. ***Metric Conversion*** To convert from meters to centimeters, multiply by 100. How many centimeters are in 5.932 meters?

52. ***Metric Conversion*** One meter is about 39.36 inches. About how many inches are in 100 meters?

53. ***Metric Conversion*** To convert from kilometers to meters, multiply by 1000. How many meters are in 2.98 kilometers?

54. ***Stock Market*** Jeremy bought 1000 shares of stock each worth $1.45. How much did Jeremy spend on the stock?

55. ***Personal Finance*** In June, Gabrielle receives $820.00 on her tax return. She decides to spend her money on family holiday gifts, six months early, so that she doesn't have to worry about it later. She spends $124.00 on a gift for her parents, $110.00 on a gift for her sister, $83.60 on a gift for her brother, $76.00 on a gift for her grandmother, and $44.60 for a gift for each of her four cousins. How much money does she have left over.

56. ***Pet Cats*** Tomba is a beautiful orange tabby cat. When he was found by the side of the road, he was three weeks old and weighed 0.95 lb. At the age of three months, he weighed 2.85 lb. At the age of nine months, he weighed 6.30 lb; at one year, he weighed 11.7 lb. Today, Tomba the cat is $1\frac{1}{2}$ years old, and weighs 15.75 lb.

(a) How much weight did he gain?

(b) If the veterinarian wants him to lose 0.25 lb per week until he weighs 13.5 lb, how long will it take?

▲ **57.** ***Geometry*** The college is purchasing new carpeting for the learning center. What is the price of a carpet that is 19.6 yards wide and 254.2 yards long if the cost is $12.50 per square yard?

58. ***Jewelry Store Operations*** A jewelry store purchased long lengths of gold chain, which will be cut and made into necklaces and bracelets. The store purchased 3220 grams of gold chain at $3.50 per gram.

(a) How much did the jewelry store spend?

(b) If they sell a 28-gram gold necklace for $17.75 per gram, how much profit will they make on the necklace?

To Think About

59. State in your own words a rule for mental multiplication by 0.1, 0.01, 0.001, 0.0001, and so on.

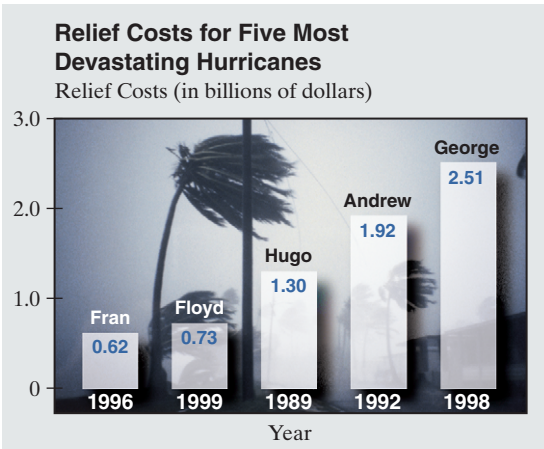
60. State in your own words a rule for mental multiplication by 0.2, 0.02, 0.002, 0.0002, and so on.

Cumulative Review

Divide. Be sure to include any remainder as part of your answer.

61. $17\overline{)1462}$ **62.** $26\overline{)2418}$ **63.** $48\overline{)6099}$ **64.** $124\overline{)56{,}024}$

Hurricane Damage Relief *The relief costs for the five most devastating hurricanes to hit the United States are represented in the following bar graph. Use the bar graph to answer exercises 65–68.*



65. How much more were the relief costs for Hurricane Floyd than Hurricane Fran?

66. How much more were the relief costs for Hurricane Hugo than Hurricane Floyd?

67. FEMA has projected a contingency budget for 2005 that is $1.963 billion more than the relief budget for Hurricane George. What is that total amount of money?

68. FEMA has projected a contingency budget for 2006 that is $3.618 billion more than the relief budget for Hurricane Hugo. What is that total amount of money?

How Am I Doing? Sections 3.1–3.4

How are you doing with your homework assignments in Sections 3.1 to 3.4? Do you feel you have mastered the material so far? Do you understand the concepts you have covered? Before you go further in the textbook, take some time to do each of the following problems.

3.1

1. Write a word name for the decimal. 47.813

2. Express as a decimal. $\frac{567}{10{,}000}$

Write as a fraction or a mixed number. Reduce whenever possible.

3. 2.11 **4.** 0.525

3.2

5. Place the set of numbers in the proper order from smallest to largest. 1.6, 1.59, 1.61, 1.601

6. Round to the nearest tenth. 123.49268

7. Round to the nearest thousandth. 1.053458

8. Round to the nearest hundredth. 17.98523

3.3

Add.

9. 5.12 + 4.7 + 8.03 + 1.6

10. 24.613 + 0.273 + 2.305

Subtract.

11.
$$\begin{array}{r} 42.16 \\ -\ 31.57 \\ \hline \end{array}$$

12. 26 − 18.329

3.4

Multiply.

13.
$$\begin{array}{r} 11.67 \\ \times\ \ 0.03 \\ \hline \end{array}$$

14. 4.7805 × 1000 **15.** 0.0003796×10^5

16. 0.768 × 0.085 **17.** 982 × 0.007 **18.** 0.00052 × 0.006

Now turn to page xxx for the answer to each of these problems. Each answer also includes a reference to the objective in which the problem is first taught. If you missed any of these problems, you should stop and review the Examples and Practice Problems in the referenced objective. A little review now will help you master the material in the upcoming sections of the text.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____

3.5 Dividing Decimals

Student Learning Objectives

After studying this section, you will be able to:

1. **Divide a decimal by a whole number.**
2. **Divide a decimal by a decimal.**

1 Dividing a Decimal by a Whole Number

When you divide a decimal by a whole number, place the decimal point for the quotient directly above the decimal point in the dividend. Then divide as if the numbers were whole numbers.

To divide 26.8 by 4, we place the decimal point of our answer (the quotient) directly *above* the decimal point in the dividend.

$$4\overline{)26.8}$$

The decimal points are aligned, one above the other.

Then we divide as if we were dividing whole numbers.

$$\begin{array}{r} 6.7 \\ 4\overline{)26.8} \\ \underline{24} \\ 28 \\ \underline{28} \\ 0 \end{array}$$

The quotient is 6.7.

The quotient to a problem may have all digits to the right of the decimal point. In some cases you will have to put a zero in the quotient as a "place holder." Let's divide 0.268 by 4.

$$\begin{array}{r} 0.067 \\ 4\overline{)0.268} \\ \underline{24} \\ 28 \\ \underline{28} \\ 0 \end{array}$$

Note that we must have a zero after the decimal point in 0.067.

EXAMPLE 1 Divide.

(a) $9\overline{)0.3204}$ **(b)** $14\overline{)36.12}$

Solution

(a)

$$\begin{array}{r} 0.0356 \\ 9\overline{)0.3204} \\ \underline{27} \\ 50 \\ \underline{45} \\ 54 \\ \underline{54} \\ 0 \end{array}$$

Note the zero *after* the decimal point.

(b)

$$\begin{array}{r} 2.58 \\ 14\overline{)36.12} \\ \underline{28} \\ 81 \\ \underline{70} \\ 112 \\ \underline{112} \\ 0 \end{array}$$

Practice Problem 1 Divide.

(a) $7\overline{)1.806}$ **(b)** $16\overline{)0.0928}$

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Some division problems do not yield a remainder of zero. In such cases, we may be asked to round off the answer to a specified place. To round off, we carry out the division until our answer contains a digit that is one place to the right of that to which we intend to round. Then we round our answer to the specified place. For example, to round to the nearest thousandth, we carry out the division to the ten-thousandths place. In some division problems, you will need to write in zeros at the end of the dividend so that this division can be carried out.

EXAMPLE 2 Divide and round the quotient to the nearest thousandth.

$$12.67 \div 39$$

Solution We will carry out our division to the ten-thousandths place. Then we will round our answer to the nearest thousandth.

```
      0.3248
39 ) 12.6700
     11 7
       97
       78
       190
       156
        340
        312
         28
```

Two extra zeros are written here to carry out the division to the required place.

Note that the remainder is not zero.

Now we round 0.3248 to 0.325. The answer is rounded to the nearest thousandth.

Practice Problem 2 Divide and round the quotient to the nearest hundredth. $23.82 \div 46$

EXAMPLE 3 Maria paid \$5.92 for 16 pounds of tomatoes. How much did she pay per pound?

Solution The cost of one pound of tomatoes equals the total cost, \$5.92, divided by 16 pounds. Thus we will divide.

```
     0.37
16 ) 5.92
     4 8
      112
      112
        0
```

Maria paid \$0.37 per pound for the tomatoes.

Practice Problem 3 Won Lin will pay off his auto loan for \$3538.75 over 19 months. If the monthly payments are equal, how much will he pay each month?

2 Dividing a Decimal by a Decimal

When the divisor is not a whole number, we can convert the division problem to an equivalent problem that has a whole number as a divisor. Think about the reasons why this procedure will work. We will ask you about it after you study Examples 4 and 5.

DIVIDING A DECIMAL BY A DECIMAL

1. Make the divisor a whole number by moving the decimal point to the right. Mark that position with a caret (∧). Count the number of places the decimal point moved.
2. Move the decimal point in the dividend to the right the same number of places. Mark that position with a caret.
3. Place the decimal point of your answer directly above the caret marking the decimal point of the dividend.
4. Divide as with whole numbers.

EXAMPLE 4 **(a)** Divide. $0.08\overline{)1.632}$ **(b)** Divide. $1.352 \div 0.026$

Solution

(a) $0.08\overline{)1.63.2}$ Move each decimal point two places to the right.

Place the decimal point of the answer directly above the caret.

$$\begin{array}{r} \\ 0.08_{\wedge}\overline{)1.63_{\wedge}2} \\ \end{array}$$

Mark the new position by a caret (∧).

$$\begin{array}{r} 20.4 \\ 0.08_{\wedge}\overline{)1.63_{\wedge}2} \\ \underline{16\phantom{.63_{\wedge}2}} \\ 3\ 2\phantom{_{\wedge}2} \\ \underline{3\ 2\phantom{_{\wedge}2}} \\ 0\phantom{_{\wedge}2} \end{array}$$

Perform the division.

The answer is 20.4.

(b)

$$\begin{array}{r} 52. \\ 0.026_{\wedge}\overline{)1.352_{\wedge}} \\ \underline{1\ 30\phantom{_{\wedge}}} \\ 52\phantom{_{\wedge}} \\ \underline{52\phantom{_{\wedge}}} \\ 0\phantom{_{\wedge}} \end{array}$$

Move each decimal point three places to the right and mark the new position by a caret.

The answer is 52.

Practice Problem 4 Divide.

(a) $0.09\overline{)0.1008}$ **(b)** $1.702 \div 0.037$

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

TO THINK ABOUT: The Multiplicative Identity Why do we move the decimal point to the right in the divisor and the dividend? What rule allows us to do this? How do we know the answer will be valid? We are actually using the property that multiplication of a fraction by 1 leaves the fraction unchanged. This is called the *multiplication identity.* Let us examine Example 4(b) again. We will write $1.352 \div 0.026$ as a fraction.

$$\frac{1.352}{0.026} \times 1$$

Multiplication of a fraction by 1 does not change the value of the fraction.

$$= \frac{1.352}{0.026} \times \frac{1000}{1000}$$

We know that $\frac{1000}{1000} = 1$.

$$= \frac{1352}{26}$$

Multiplication by 1000 can be done by moving the decimal point three places to the right.

$$= 52$$

Divide the whole numbers.

Thus in Example 4(b) when we moved the decimal point three places to the right in the divisor and the dividend, we were actually creating an equivalent fraction where the numerator and the denominator of the original fraction were multiplied by 1000.

EXAMPLE 5 Divide.

(a) $1.7\overline{)0.0323}$ **(b)** $0.0032\overline{)7.68}$

Solution

(a)
```
        0.019
1.7^)0.0^323
        17
        153
        153
          0
```

Move the decimal point in the divisor and dividend one place to the right and mark that position with a caret.

(b)
```
          2400.
0.0032^)7.6800^
        6 4
        1 28
        1 28
          000
```

Note that two extra zeros are needed in the dividend as we move the decimal point four places to the right.

Practice Problem 5 Divide.

(a) $1.8\overline{)0.0414}$ **(b)** $0.0036\overline{)8.316}$

EXAMPLE 6 **(a)** Find $2.9\overline{)431.2}$ rounded to the nearest tenth

(b) Find $2.17\overline{)0.08}$ rounded to the nearest thousandth.

Calculator

Dividing Decimals

You can use your calculator to divide a decimal by a decimal. To find $21.38\overline{)54.53}$ rounded to the nearest hundredth, enter:

54.53 [÷] 21.38 [=]

Display:

[2.5505145]

This is an approximation. Some calculators will round to eight digits. The answer rounded to the nearest hundredth is 2.55.

Solution

(a)
```
        148.68
2.9_)431.2_00
      29
      141
      116
       25 2
       23 2
        2 0 0
        1 7 4
          2 60
          2 32
            28
```

Calculate to the hundredths place and round the answer to the nearest tenth.

The answer rounded to the nearest tenth is 148.7.

(b)
```
          0.0368
2.17_)0.08_0000
        6 51
        1 490
        1 302
          1880
          1736
           144
```

Calculate to the ten-thousandths place and then round the answer. Rounding 0.0368 to the nearest thousandth, we obtain 0.037.

Practice Problem 6 **(a)** Find $3.8\overline{)521.6}$ rounded to the nearest tenth.

(b) Find $8.05\overline{)0.17}$ rounded to the nearest thousandth.

EXAMPLE 7 John drove his 1997 Cavalier 420.5 miles to Chicago. He used 14.5 gallons of gas on the trip. How many miles per gallon did his car get on the trip?

Solution To find miles per gallon we need to divide the number of miles, 420.5, by the number of gallons, 14.5.

```
          2 9.
14.5_)420.5_
      290
      1305
      1305
```

John's car achieved 29 miles per gallon on the trip to Chicago.

Practice Problem 7 Sarah rented a large truck to move to Boston. She drove 454.4 miles yesterday. She used 28.5 gallons of gas on the trip. How many miles per gallon did the rental truck get? Round to the nearest tenth.

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

EXAMPLE 8 Find the value of n if $0.8 \times n = 2.68$.

Solution Here 0.8 is multiplied by some number n to obtain 2.68. What is this number n? If we divide 2.68 by 0.8, we will find the value of n.

```
          3.35
0.8_)2.6_80
      2 4
        2 8
        2 4
          40
          40
```

Thus the value of n is 3.35.

Check. Is this true? Are we sure the value of $n = 3.35$? We substitute the value of $n = 3.35$ into the equation to see if it makes the statement true.

$$\begin{aligned} 0.8 \times n &= 2.68 \\ 0.8 \times 3.35 &\stackrel{?}{=} 2.68 \\ 2.68 &= 2.68 \quad ✔ \quad \text{Yes, it is true.} \end{aligned}$$

Practice Problem 8 Find the value of n if $0.12 \times n = 0.696$.

EXAMPLE 9 The level of sulfur dioxide emissions in the air has slowly been decreasing over the last 20 years, as can be seen in the accompanying bar graph. Find the average amount of sulfur dioxide emissions in the air over these five specific years.

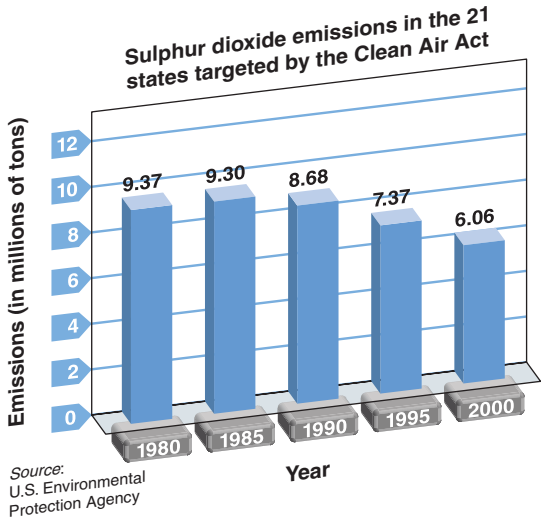
Solution

First we take the sum of the five years.

$$\begin{array}{r} 9.37 \\ 9.30 \\ 8.68 \\ 7.37 \\ +\ 6.06 \\ \hline 40.78 \end{array}$$

Then we divide by five to obtain the average.

$$\begin{array}{r} 8.156 \\ 5\overline{)40.780} \\ \underline{40} \\ 7 \\ \underline{5} \\ 28 \\ \underline{25} \\ 30 \\ \underline{30} \end{array}$$



Thus the yearly average is 8.156 million tons of sulfur dioxide emissions in these 21 states.

Practice Problem 9 Use the accompanying bar graph to find the average level of sulfur dioxide for the three years: 1985, 1990, and 1995. By how much does the three-year average differ from the five-year average?

Developing Your Study Skills

Exam Time: How To Review

Reviewing adequately for an exam enables you to bring together the concepts you have learned over several sections. For your review, you will need to do the following:

1. Reread your textbook. Make a list of any terms, rules, or formulas you need to know for the exam. Be sure you understand them all.
2. Reread your notes. Go over returned homework and quizzes. Redo the problems you missed.
3. Practice some of each type of problem covered in the chapter(s) you are to be tested on. In fact, it is a good idea to construct a practice test of your own and then discuss it with a friend from class.
4. Use the end-of-chapter materials provided in your textbook. Read carefully through the Chapter Organizer. Do the Chapter Review Problems. Take the Chapter Test. When you are finished, check your answers. Redo any problems you missed.
5. Get help if any concepts give you difficulty.

3.5 Exercises

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Divide until there is a remainder of zero.

1. $6\overline{)12.6}$ **2.** $8\overline{)17.28}$ **3.** $4\overline{)71.32}$ **4.** $6\overline{)83.16}$

5. $7\overline{)73.64}$ **6.** $8\overline{)168.48}$ **7.** $0.6\overline{)81.9}$ **8.** $0.5\overline{)32.15}$

9. $0.362 \div 0.04$ **10.** $0.7209 \div 0.09$ **11.** $153.7 \div 2.9$ **12.** $75.6 \div 3.6$

13. $68.4 \div 3.8$ **14.** $728 \div 5.6$ **15.** $40.30 \div 0.31$

Divide and round your answer to the nearest tenth.

16. $8\overline{)44}$ **17.** $9\overline{)47.31}$ **18.** $1.8\overline{)4.16}$

19. $1.9\overline{)2.36}$ **20.** $0.95\overline{)32.067}$ **21.** $0.85\overline{)41.901}$

Divide and round your answer to the nearest hundredth.

22. $4\overline{)263.82}$ **23.** $5\overline{)471.03}$ **24.** $1.7\overline{)20.8}$

25. $1.8\overline{)24.41}$ **26.** $29\overline{)4.073}$ **27.** $36\overline{)6.125}$

Divide and round your answer to the nearest thousandth.

28. $8\overline{)0.2019}$ **29.** $7\overline{)0.5681}$ **30.** $0.69\overline{)8.45}$ **31.** $0.87\overline{)79.40}$

Divide and round your answer to the nearest whole number.

32. $12\overline{)1396}$ **33.** $19\overline{)2341}$ **34.** $0.0024\overline{)0.2168}$ **35.** $0.0046\overline{)0.981}$

Applications

36. ***Travel in Mexico*** Rhett and Liza are traveling in Mexico, where distances on the highway are given in kilometers. There are approximately 1.6 kilometers in one mile. They see a sign that reads "Mexico City: 342 km." How many miles is it to Mexico City?

37. ***Computer Payments*** The Miller family wants to use the latest technology to access the Internet from their home television system. The equipment needed to upgrade their existing equipment will cost $992.76. If the Millers make 12 equal monthly payments, how much will they pay per month?

38. ***Lasagna Dinner*** Four students sit down to their weekly lasagna dinner. At one end of the table, there is a bottle containing 67.6 ounces of a popular soft drink. At the other end of the table is a bottle that contains 33.6 ounces of water.

(a) If the students share the soft drink and water equally, how many ounces of liquid will each student drink?

(b) At the last minute, another student is asked to join the group. How many ounces of liquid will each of the five students share?

39. ***Fuel Efficiency*** Wally owns a Plymouth Breeze that travels 360 miles on 13.2 gallons of gas. How many miles per gallon does it achieve? (Round your answer to the nearest tenth.)

40. ***Costs of a Ski Trip*** The church youth group went on a ski trip. The ski resort charged the group $1200 for 32 lift tickets. How much was each ticket?

41. ***Flower Sales*** Andrea makes Mother's Day bouquets each year for extra income. This year her goal is to make $300. If she sells each bouquet for $12.50, how many bouquets must she sell to reach her goal?

42. ***Outdoor Deck Payments*** Demitri had a contractor build an outdoor deck for his back porch. He now has $1131.75 to pay off, and he agreed to pay $125.75 per month. How many more payments on the outdoor deck must he make?

43. ***Wedding Reception Costs*** For their wedding reception, Sharon and Richard spent $1865.50 on food and drinks. If the caterer charged them $10.25 per person, how many guests did they have?

44. ***Food Consumption***

(a) Using the chart below, find the average number of pounds of turkey consumed per person for the years 1980 and 1985.

(b) What is the average increase in turkey consumption per person per year over this 25-year period?

Year	U.S. Annual Per Capita Turkey Consumption (Boneless Weight)
1980	8.1 lb
1985	9.2 lb
1990	13.9 lb
1995	14.3 lb
2000	14.6 lb
2005*	15.4 lb

* estimated
Source: U.S. Department of Agriculture

45. ***Quality Inspection*** Yoshi is working as an inspector for a company that makes snowboards. A Mach 1 snowboard weighs 3.8 kilograms. How many of these snowboards are contained in a box in which the contents weigh 87.40 kilograms? If the box is labeled CONTENTS: 24 SNOWBOARDS, how great an error was made in packing the box?

Find the value of n.

46. $0.9 \times n = 0.3222$

47. $0.8 \times n = 5.768$

48. $1.7 \times n = 129.2$

49. $1.3 \times n = 1267.5$

50. $n \times 0.063 = 2.835$

51. $n \times 0.098 = 4.312$

To Think About

Multiply the numerator and denominator of each fraction by 10,000. Then divide the numerator by the denominator. Is the result the same if we divided the original numerator by the original denominator? Why?

52. $\dfrac{3.8702}{0.0523}$

53. $\dfrac{2.9356}{0.0716}$

Cumulative Review

54. Add. $\dfrac{3}{8} + 2\dfrac{4}{5}$

55. Subtract. $2\dfrac{13}{16} - 1\dfrac{7}{8}$

56. Multiply. $3\dfrac{1}{2} \times 2\dfrac{1}{6}$

57. Divide. $4\dfrac{1}{3} \div 2\dfrac{3}{5}$

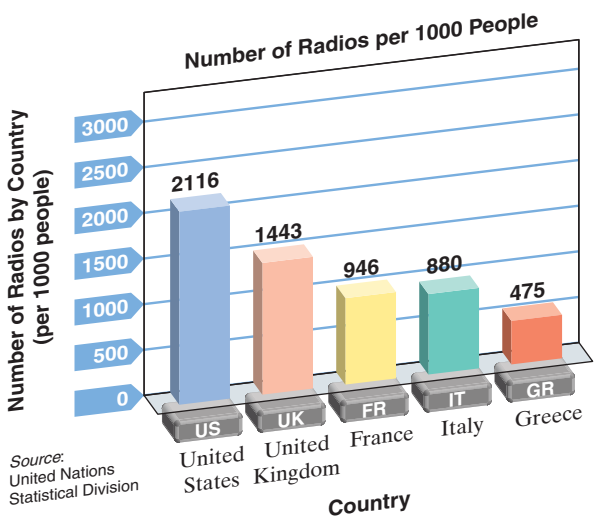
Radio Use in Europe *Use the chart at the right to answer the following questions.*

58. How many more radios per 1000 people are there in the United States than in the United Kingdom?

59. How many more radios per 1000 people are there in France than in Greece?

60. If you took an average of these five countries, how many radios are there for every 1000 people? Round to the nearest whole number if necessary.

61. If you took an average of all the countries except the United States, how many radios are there for every 1000 people? Round to the nearest whole number if necessary.



3.6 Converting Fractions to Decimals and the Order of Operations

1 Converting a Fraction to a Decimal

A number can be expressed in two equivalent forms: as a fraction or as a decimal.

Fraction $2\frac{1}{2}$ two and one-half		2.5 Decimal two and five-tenths

Same quantity, different appearance

Every decimal in this chapter can be expressed as an equivalent fraction. For example,

Decimal form ⟹ fraction form

$$0.75 = \frac{75}{100} \quad \text{or} \quad \frac{3}{4}$$

$$0.5 = \frac{5}{10} \quad \text{or} \quad \frac{1}{2}$$

$$2.5 = 2\frac{5}{10} = 2\frac{1}{2} \quad \text{or} \quad \frac{5}{2}.$$

And every fraction can be expressed as an equivalent decimal, as we will learn in this section. For example,

Fraction form ⟹ decimal form

$$\frac{1}{5} = 0.20 \quad \text{or} \quad 0.2$$

$$\frac{3}{8} = 0.375$$

$$\frac{5}{11} = 0.4545\ldots. \text{ (The "45" keeps repeating.)}$$

Some of these decimal equivalents are so common that people find it helpful to memorize them. You would be wise to memorize the following equivalents:

$$\frac{1}{2} = 0.5 \qquad \frac{1}{4} = 0.25 \qquad \frac{1}{5} = 0.2 \qquad \frac{1}{10} = 0.1.$$

We previously studied how to convert some fractions with a denominator of 10, 100, 1000, and so on to decimal form. For example, $\frac{3}{10} = 0.3$ and $\frac{7}{100} = 0.07$. We need to develop a procedure to write other fractions, such as $\frac{3}{8}$ and $\frac{5}{16}$, in decimal form.

CONVERTING A FRACTION TO AN EQUIVALENT DECIMAL

Divide the denominator into the numerator until

(a) the remainder becomes zero, or

(b) the remainder repeats itself, or

(c) the desired number of decimal places is achieved.

Student Learning Objectives

After studying this section, you will be able to:

1. **Convert a fraction to a decimal.**
2. **Use the order of operations with decimals.**

EXAMPLE 1 Write as an equivalent decimal.

(a) $\frac{3}{8}$ **(b)** $\frac{31}{40}$ of a second

Divide the denominator into the numerator until the remainder becomes zero.

Solution

(a)
$$\begin{array}{r} 0.375 \\ 8\overline{)3.000} \\ \underline{2\ 4} \\ 60 \\ \underline{56} \\ 40 \\ \underline{40} \\ 0 \end{array}$$

Therefore, $\frac{3}{8} = 0.375$.

(b)
$$\begin{array}{r} 0.775 \\ 40\overline{)31.000} \\ \underline{28\ 0} \\ 3\ 00 \\ \underline{2\ 80} \\ 200 \\ \underline{200} \\ 0 \end{array}$$

Therefore, $\frac{31}{40} = 0.775$ of a second.

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Practice Problem 1 Write as an equivalent decimal.

(a) $\frac{5}{16}$ **(b)** $\frac{11}{80}$

Athletics' times in Olympic events, such as the 100-meter dash, are measured to the nearest hundredth of a second. Future Olympic athletics' times will be measured to the nearest thousandth of a second.

Decimals such as 0.375 and 0.775 are called **terminating decimals.** When converting $\frac{3}{8}$ to 0.375 or $\frac{31}{40}$ to 0.775, the division operation eventually yields a remainder of zero. Other fractions yield a repeating pattern. For example, $\frac{1}{3} = 0.3333\ldots$ and $\frac{2}{3} = 0.6666\ldots$ have a pattern of repeating digits. Decimals that have a digit or a group of digits that repeats are called **repeating decimals.** We often indicate the repeating pattern with a bar over the repeating group of digits:

$$0.3333\ldots = 0.\overline{3} \qquad 0.74\ 74\ 74\ldots = 0.\overline{74}$$
$$0.218\ 218\ 218\ldots = 0.\overline{218} \qquad 0.8942\ 8942\ldots = 0.\overline{8942}$$

If when converting fractions to decimal form the remainder repeats itself, we know that we have a repeating decimal.

EXAMPLE 2 Write as an equivalent decimal.

(a) $\frac{5}{11}$ **(b)** $\frac{13}{22}$ **(c)** $\frac{5}{37}$

Solution

(a)
```
      0.4545
11 )5.0000
    4 4
      6 0
      5 5
       50
       44
        6 0
        5 5
          5
```
repeating remainders

(b)
```
      0.59090
22 )13.00000
    11 0
      2 00
      1 98
        2 00
        1 98
          20
```
repeating remainders

(c)
```
      0.1351
37 )5.0000
    37
     13 0
     11 1
      1 90
      1 85
        50
        37
        13
```
repeating remainders

Thus $\frac{5}{11} = 0.4545\ldots = 0.\overline{45}$.

Thus $\frac{13}{22} = 0.5909090\ldots = 0.5\overline{90}$

Notice that the bar is over the digits 9 and 0 but *not* over the digit 5.

Thus $\frac{5}{37} = 0.135135\ldots = 0.\overline{135}$.

Practice Problem 2 Write as an equivalent decimal.

(a) $\frac{7}{11}$ **(b)** $\frac{8}{15}$ **(c)** $\frac{13}{44}$

EXAMPLE 3 Write as an equivalent decimal.

(a) $3\frac{7}{15}$ **(b)** $\frac{20}{11}$

Solution

(a) $3\frac{7}{15}$ means $3 + \frac{7}{15}$

```
      0.466
15 )7.000
     60
     100
      90
      100
       90
        10
```

(b)
```
      1.818
11 )20.000
     11
      90
      88
       20
       11
        90
        88
         2
```

Thus $\frac{7}{15} = 0.4\overline{6}$ and $3\frac{7}{15} = 3.4\overline{6}$.

Thus $\frac{20}{11} = 1.818181\ldots = 1.\overline{81}$.

Practice Problem 3 Write as an equivalent decimal.

(a) $2\frac{11}{18}$ **(b)** $\frac{28}{27}$

Calculator

Fraction to Decimal

You can use a calculator to change $\frac{5}{8}$ to a decimal.

Enter:

5 [÷] 8 [=]

The display should read

[0.625]

Try the following.

(a) $\frac{17}{25}$ **(b)** $\frac{2}{9}$

(c) $\frac{13}{10}$ **(d)** $\frac{15}{19}$

Note: 0.78947368 is an approximation for $\frac{15}{19}$. Some calculators round to only eight places.

In some cases, the pattern of repeating is quite long. For example,

$$\frac{1}{7} = 0.142857142857\ldots = 0.\overline{142857}$$

Such problems are often rounded to a certain value.

EXAMPLE 4 Express $\frac{5}{7}$ as a decimal rounded to the nearest thousandth.

Solution

$$\begin{array}{r} 0.7142 \\ 7\overline{)5.0000} \\ \underline{49} \\ 10 \\ \underline{7} \\ 30 \\ \underline{28} \\ 20 \\ \underline{14} \\ 6 \end{array}$$

Rounding to the nearest thousandth, we round 0.7142 to 0.714. (In repeating form, $\frac{5}{7} = 0.714285714285\ldots = 0.\overline{714285}$.)

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Practice Problem 4 Express $\frac{19}{24}$ as a decimal rounded to the nearest thousandth.

Recall that we studied placing two decimals in order in Section 3.2. If we are required to place a fraction and a decimal in order, it is usually easiest to change the fraction to decimal form and then compare the two decimals.

EXAMPLE 5 Fill in the blank with one of the symbols <, =, or >.

Solution

$$\frac{7}{16} \_\_\_\_ 0.43$$

Now we divide to find the decimal equivalent of $\frac{7}{16}$.

$$\begin{array}{r} 0.4375 \\ 16\overline{)7.0000} \\ \underline{64} \\ 60 \\ \underline{48} \\ 120 \\ \underline{112} \\ 80 \\ \underline{80} \\ 0 \end{array}$$

Now in the thousandths place $7 > 0$, so we know

$$0.43\,7\,5 > 0.43\,0\,0.$$

Therefore, $\frac{7}{16} > 0.43$.

Practice Problem 5 Fill in the blank with one of the symbols $<$, $=$, or $>$.

$$\frac{5}{8} \_\_\_\_ 0.63$$

2 Using the Order of Operations with Decimals

The rules for order of operations that we discussed in Section 1.6 apply to operations with decimals.

ORDER OF OPERATIONS

Do first
1. Perform operations inside parentheses.
2. Simplify any expressions with exponents.
3. Multiply or divide from left to right.
4. Add or subtract from left to right.

Do last

Sometimes exponents are used with decimals. In such cases, we merely evaluate using repeated multiplication.

$$(0.2)^2 = 0.2 \times 0.2 = 0.04$$
$$(0.2)^3 = 0.2 \times 0.2 \times 0.2 = 0.008$$
$$(0.2)^4 = 0.2 \times 0.2 \times 0.2 \times 0.2 = 0.0016$$

EXAMPLE 6 Evaluate. $(0.3)^3 + 0.6 \times 0.2 + 0.013$

Solution First we need to evaluate $(0.3)^3 = 0.3 \times 0.3 \times 0.3 = 0.027$. Thus

$$\begin{aligned}
&(0.3)^3 + 0.6 \times 0.2 + 0.013 \\
&= 0.027 + 0.6 \times 0.2 + 0.013 \\
&= 0.027 + 0.12 + 0.013 \longleftarrow \\
&= 0.16
\end{aligned}$$

When addends have a different number of decimal places, writing the problem in column form makes adding easier.

$$\begin{array}{r}
0.027 \\
0.120 \\
+\ 0.013 \\
\hline
0.160
\end{array}$$

Practice Problem 6 Evaluate. $0.3 \times 0.5 + (0.4)^3 - 0.036$

In the next example all four steps of the rules for order of operations will be used.

EXAMPLE 7 Evaluate. $(8 - 0.12) \div 2^3 + 5.68 \times 0.1$

Solution

$$
\begin{aligned}
&(8 - 0.12) \div 2^3 + 5.68 \times 0.1 \\
&= 7.88 \div 2^3 + 5.68 \times 0.1 && \text{First do subtraction inside the parentheses.} \\
&= 7.88 \div 8 + 5.68 \times 0.1 && \text{Simplify the expression with exponents.} \\
&= 0.985 + 0.568 && \text{From left to right do division and multiplication.} \\
&= 1.553 && \text{Add the final two numbers.}
\end{aligned}
$$

NOTE TO STUDENT: *Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1*

Practice Problem 7 Evaluate. $6.56 \div (2 - 0.36) + (8.5 - 8.3)^2$

Developing Your Study Skills

Keep Trying

We live in a highly technical world, and you cannot afford to give up on the study of mathematics. Dropping mathematics may prevent you from entering certain career fields that you may find interesting. You may not have to take math courses as high-level as calculus, but such courses as intermediate algebra, finite math, college algebra, and trigonometry may be necessary. Learning mathematics can open new doors for you.

Learning mathematics is a process that takes time and effort. You will find that regular study and daily practice are necessary to strengthen your skills and to help you grow academically. This process will lead you toward success in mathematics. Then, as you become more successful, your confidence in your ability to do mathematics will grow.

3.6 Exercises

Student Solutions Manual | CD/ Video | PH Math Tutor Center | MathXL®Tutorials on CD | MathXL® | MyMathLab® | Interactmath.com

Verbal and Writing Skills

1. 0.75 and $\frac{3}{4}$ are different ways to express the _____.

2. To convert a fraction to an equivalent decimal, divide the _____ into the numerator.

3. Why is $0.\overline{8942}$ called a repeating decimal?

4. The order of operations for decimals is the same as the order of operations for whole numbers. Write the steps for the order of operations.

Write as an equivalent decimal. If a repeating decimal is obtained, use notation such as $0.\overline{7}$, $0.\overline{16}$, *or* $0.\overline{245}$.

5. $\frac{1}{4}$ **6.** $\frac{3}{4}$ **7.** $\frac{4}{5}$ **8.** $\frac{2}{5}$

9. $\frac{1}{8}$ **10.** $\frac{3}{8}$ **11.** $\frac{7}{20}$ **12.** $\frac{3}{40}$

13. $\frac{31}{50}$ **14.** $\frac{23}{25}$ **15.** $\frac{9}{4}$ **16.** $\frac{14}{5}$

17. $2\frac{1}{8}$ **18.** $3\frac{13}{16}$ **19.** $1\frac{7}{16}$ **20.** $1\frac{1}{40}$

21. $\frac{2}{3}$ **22.** $\frac{5}{6}$ **23.** $\frac{5}{11}$ **24.** $\frac{7}{11}$

25. $3\frac{7}{12}$ **26.** $7\frac{1}{3}$ **27.** $2\frac{5}{18}$ **28.** $6\frac{1}{6}$

Write as an equivalent decimal or a decimal approximation. Round your answer to the nearest thousandth if needed.

29. $\frac{4}{13}$ **30.** $\frac{8}{17}$ **31.** $\frac{19}{21}$ **32.** $\frac{20}{21}$

33. $\frac{7}{48}$ **34.** $\frac{5}{48}$ **35.** $\frac{35}{27}$ **36.** $\frac{37}{23}$

37. $\frac{21}{52}$ **38.** $\frac{1}{38}$ **39.** $\frac{17}{18}$ **40.** $\frac{5}{13}$

41. $\frac{22}{7}$ **42.** $\frac{17}{14}$ **43.** $3\frac{9}{19}$ **44.** $4\frac{11}{17}$

Fill in the blank with one of the symbols <, =, or >.

45. $\frac{7}{8}$ ___ 0.88 **46.** $\frac{3}{8}$ ___ 0.39 **47.** 0.573 ___ $\frac{9}{16}$ **48.** 0.689 ___ $\frac{11}{16}$

Applications

49. ***Fingernail Growth*** Your fingernails grow approximately $\frac{1}{8}$ inch each month. Write the thickness as a decimal.

50. ***Hair Growth*** The hair on your head grows approximately $\frac{9}{20}$ inch a month. Write the thickness as a decimal.

51. ***Mountain Climbing*** An ice climber had the local mountaineering shop install boot heaters to the back of his hiking boots. The installer drilled a hole $\frac{3}{8}$ inch in diameter. The hole for the boot heater should have been 0.5 inch in diameter. Is the hole too large or too small? By how much?

52. ***Carpentry*** A master carpenter is re-creating a room for the set of a movie being filmed. He is using a burled maple veneer $\frac{7}{16}$ inch thick. The designer specified maple veneer 0.45 inch thick. Is the veneer he is using too thick or too thin? By how much?

53. ***Safety Regulations*** Federal safety regulations specify that the slots between the bars on a baby's crib must not be more than $2\frac{3}{8}$ inches. One crib's slots measured 2.4 inches apart. Is this too wide? If so, by how much?

54. ***Manufacturing*** To manufacture a circuit board, Rick must program a computer to place a piece of thin plastic atop a circuit board. For the current to flow through the circuit, the top plastic piece must form a border of exactly $\frac{1}{16}$ inch with the circuit board. A few circuit boards were made with a border of 0.055 inch by accident. Is this border too small or too large? By how much?

Evaluate.

55. $2.4 + (0.5)^2 - 0.35$

56. $9.6 + 3.6 - (0.4)^2$

57. $2.3 \times 3.2 - 5 \times 0.8$

58. $9.6 \div 3 + 0.21 \times 6$

59. $12 \div 0.03 - 50 \times (0.5 + 1.5)^3$

60. $61.95 \div 1.05 - 2 \times (1.7 + 1.3)^3$

61. $(1.1)^3 + 2.6 \div 0.13 + 0.083$

62. $(1.1)^3 + 8.6 \div 2.15 - 0.086$

63. $(14.73 - 14.61)^2 \div (1.18 + 0.82)$

64. $(32.16 - 32.02)^2 \div (2.24 + 1.76)$

65. $(0.5)^3 + (3 - 2.6) \times 0.5$

66. $(0.6)^3 + (7 - 6.3) \times 0.07$

67. $(0.76 + 4.24) \div 0.25 + 8.6$

68. $(2.4)^2 + 3.6 \div (1.2 - 0.7)$

Evaluate.

69. $(1.6)^3 + (2.4)^2 + 18.666 \div 3.05 + 4.86$

70. $5.9 \times 3.6 \times 2.4 - 0.1 \times 0.2 \times 0.3 \times 0.4$

Write as a decimal. Round your answer to six decimal places.

71. $\dfrac{5236}{8921}$

72. $\dfrac{17{,}359}{19{,}826}$

To Think About

73. Subtract. $0.\overline{16} - 0.00\overline{16}$

(a) What do you obtain?

(b) Now subtract $0.\overline{16} - 0.01\overline{6}$. What do you obtain?

(c) What is different about these results?

74. Subtract. $1.\overline{89} - 0.01\overline{89}$

(a) What do you obtain?

(b) Now subtract $1.\overline{89} - 0.18\overline{9}$. What do you obtain?

(c) What is different about these results?

Cumulative Review

75. ***Boating Dock*** John and Nancy put in a new dock at the end of Tobey Lane. A pipe at the end of the dock supports the dock and is driven deep into the mud and sand at the bottom of Eel Pond. The pipe is 25 feet long. Half of the pipe is above the surface of the water at low tide. The pipe is driven $6\frac{3}{4}$ feet deep into the mud and sand. How deep is the water at the end of the dock at low tide?

76. ***Tidal Fluctuation*** Fisherman's Wharf in Digby, Nova Scotia has an average tidal range of $25\frac{4}{5}$ feet. These huge tidal ranges require considerable ingenuity in the design of docks and ramps for boats. If the water is $6\frac{1}{2}$ feet deep at low tide at the end of Fisherman's Wharf during an average low tide, how deep is the water at the same location during an average high tide. (*Source*: Nova Scotia Board of Tourism)

3.7 Estimating and Solving Applied Problems Involving Decimals

Student Learning Objectives

After studying this section, you will be able to:

1. **Estimate sums, differences, products, and quotients of decimals.**
2. **Solve applied problems using operations with decimals.**

1 Estimating Sums, Differences, Products, and Quotients of Decimals

When we encounter real-life applied problems, it is important to know if an answer is reasonable. A car may get 21.8 miles per gallon. However, a car will not get 218 miles per gallon. Neither will a car get 2.18 miles per gallon. To avoid making an error in solving applied problems, it is wise to make an estimate. The most useful time to make an estimate is at the end of solving the problem, in order to see if the answer is reasonable.

There are several different rules for estimating. Not all mathematicians agree what is the best method for estimating in each case. Most students find that a very quick and simple method to estimate is to round each number so that there is one nonzero digit. Then perform the calculation. We will use that approach in this section of the book. However, you should be aware that there are other valid approaches. Your instructor may wish you to use another method.

EXAMPLE 1 Estimate.

(a) $184{,}987.09 + 676{,}393.95$ **(b)** $0.00782 - 0.00358$

(c) 145.87×78.323 **(d)** $138.85 \div 5.887$

Solution In each case we will round to one nonzero digit to estimate.

(a) $184{,}987.09 + 676{,}393.95 \approx 200{,}000 + 700{,}000 = 900{,}000$

(b) $0.00782 - 0.00358 \approx 0.008 - 0.004 = 0.004$

(c) $145.87 \times 78.323 \approx$

$$\begin{array}{r} 100 \\ \times\ \ 80 \\ \hline 8000 \end{array}$$

Thus $145.87 \times 78.323 \approx 8000$

(d) $138.85 \div 5.887 \approx$

$$\begin{array}{r} 16 \\ 6\overline{)100} \\ \underline{6} \\ 40 \\ \underline{36} \\ 4 \end{array} = 16\frac{4}{6} \approx 17$$

Thus $138.85 \div 5.887 \approx 17$

Here we round the answer to the nearest whole number.

Practice Problem 1 Round to one nonzero digit. Then estimate the result of the indicated calculation.

(a) $385.98 + 875.34$ **(b)** $0.0952 - 0.0579$

(c) 5876.34×0.087 **(d)** $46{,}873 \div 8.456$

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Take a few minutes to review Example 1. Be sure you can perform these estimation steps. We will use this type of estimation to check our work in the applied problems in this section.

2 Solving Applied Problems Using Operations with Decimals

We use the basic plan of solving applied problems that we discussed in Section 1.8 and Section 2.9. Let us review how we analyze applied-problem situations.

1. *Understand the problem.*
2. *Solve and state the answer.*
3. *Check.*

In the United States for almost all jobs where you are paid an hourly wage, if you work more than 40 hours in one week, you should be paid overtime. The overtime rate is 1.5 times the normal hourly rate, for the extra hours worked in that week. The next problem deals with overtime wages.

EXAMPLE 2 A laborer is paid \$7.38 per hour for a 40-hour week and 1.5 times that wage for any hours worked beyond the standard 40. If he works 47 hours in a week, what will he earn?

Solution

1. ***Understand the problem.***

Mathematics Blueprint for Problem Solving

Gather the Facts	What Am I Asked to Do?	How Do I Proceed?	Key Points to Remember
He works 47 hours. He gets paid \$7.38 per hour for 40 hours. He gets paid 1.5 × \$7.38 per hour for 7 hours.	Find the earnings of the laborer if he works 47 hours in one week.	Add the earnings of 40 hours at \$7.38 per hour to the earnings of 7 hours at overtime pay.	Multiply 1.5 × \$7.38 to find the pay he earns for overtime.

2. ***Solve and state the answer.***

We want to compute his regular pay and his overtime pay and add the results.

Regular pay + Overtime pay = Total pay

Regular pay: Calculate his pay for 40 hours of work.

$$\begin{array}{r} 7.38 \\ \times \quad 40 \\ \hline 295.20 \end{array}$$

He earns \$295.20 at \$7.38 per hour.

Overtime pay: Calculate his overtime pay rate. This is 7.38×1.5.

$$\begin{array}{r} 7.38 \\ \times\ 1.5 \\ \hline 3\ 690 \\ 7\ 38 \\ \hline 11.070 \end{array}$$

He earns $11.07 per hour in overtime.

Calculate how much he earned doing 7 hours of overtime work.

$$\begin{array}{r} 11.07 \\ \times\quad 7 \\ \hline 77.49 \end{array}$$

For 7 hours overtime he earns $77.49.

Total pay: Add the two amounts.

$295.20	Regular 40-hour week earnings
+ 77.49	Overtime earnings
$372.69	Total earnings

The total earnings of the laborer for a 47-hour workweek will be $372.69.

3. ***Check***.

Estimate his regular pay.

$$40 \times \$7 = \$280$$

Estimate his overtime rate of pay, and then his overtime pay.

$$1.5 \times \$7 = \$10.50$$
$$7 \times \$11 = \$77$$

Then add.

$$\begin{array}{r} \$280 \\ +\quad 77 \\ \hline \$357 \end{array}$$

Our estimate of $357 is close to our answer of $372.69. Our answer is reasonable. ✔

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Practice Problem 2 Melinda works for the phone company as a line repair technician. She earns $9.36 per hour. She worked 51 hours last week. If she gets time and a half for all hours worked above 40 hours per week, how much did she earn last week?

EXAMPLE 3 A chemist is testing 36.85 liters of cleaning fluid. She wishes to pour it into several smaller containers that each hold 0.67 liter of fluid. (a) How many containers will she need? (b) If each liter of this fluid costs $3.50, how much does the cleaning fluid in one container cost? (Round your answer to the nearest cent.)

Mathematics Blueprint for Problem Solving

Gather the Facts	What Am I Asked to Do?	How Do I Proceed?	Key Points to Remember
The total amount of cleaning fluid is 36.85 liters. Each small container holds 0.67 liter. Each liter of fluid costs \$3.50.	**(a)** Find out how many containers the chemist needs. **(b)** Find the cost of cleaning fluid in each small container.	**(a)** Divide the total, 36.85 liters, by the amount in each small container, 0.67 liter, to find the number of containers. **(b)** Multiply the cost of one liter, \$3.50, by the amount of liters in one container, 0.67.	If you are not clear as to what to do at any stage of the problem, then do a similar, simpler problem.

Solution **(a)** How many containers will the chemist need?

She has 36.85 liters of cleaning fluid and she wants to put it into several equal-sized containers each holding 0.67 liter. Suppose we are not sure what to do. Let's do a similar, simpler problem. If we had 40 liters of cleaning fluid and we wanted to put it into little containers each holding 2 liters, what would we do? Since the little containers would only hold 2 liters, we would need 20 containers. We know that $40 \div 2 = 20$. So we see that, in general, we divide the total number of liters by the amount in the small container. Thus $36.85 \div 0.67$ will give us the number of containers in this case.

```
          55.
0.67 )36.85
      335
      3 35
      3 35
```

The chemist will need 55 containers to hold this amount of cleaning fluid.

(b) How much does the cleaning fluid in each container cost? Each container will hold only 0.67 liter. If one liter costs \$3.50, then to find the cost of one container we multiply $0.67 \times \$3.50$.

```
   3.50
 × 0.67
   2450
  2100
 2.3450
```

We round our answer to the nearest cent. Thus each container would cost \$2.35.

Check.

(a) Is it really true that 55 containers each holding 0.67 liter will hold a total of 36.85 liters? To check we multiply.

$$\begin{array}{r} 55 \\ \times\ 0.67 \\ \hline 385 \\ 330 \\ \hline 36.85 \end{array} \checkmark$$

(b) One liter of cleaning fluid costs \$3.50. We would expect the cost of 0.67 liter to be less than \$3.50. \$2.35 is less than \$3.50. ✔

We use estimation to check more closely.

$$\begin{array}{rcr} \$3.50 & \longrightarrow & \$4.00 \\ \times\quad 0.67 & \longrightarrow & \times\quad 0.7 \\ \hline & & \$2.800 \end{array}$$

\$2.80 is fairly close to \$2.35. Our answer is reasonable. ✔

NOTE TO STUDENT: Fully worked-out solutions to all of the Practice Problems can be found at the back of the text starting at page SP-1

Practice Problem 3 A butcher divides 17.4 pounds of prime steak into small equal-sized packages. Each package contains 1.45 pounds of prime steak. **(a)** How many packages of steak will he have? **(b)** Prime steak sells for \$4.60 per pound. How much will each package of prime steak cost?

Developing Your Study Skills

Applications or Word Problems

Applications or word problems are the very life of mathematics! They are the reason for doing mathematics, because they teach you how to put into use the mathematical skills you have developed.

The key to success is practice. Make yourself do as many problems as you can. You may not be able to do them all correctly at first, but keep trying. If you cannot solve a problem, try another one. Ask for help from your teacher or the tutoring lab. Ask other classmates how they solved the problem. Soon you will see great progress in your own problem solving ability.

3.7 Exercises

Student Solutions Manual | CD/Video | PH Math Tutor Center | MathXL®Tutorials on CD | MathXL® | MyMathLab® | Interactmath.com

In exercises 1–10, first round each number to one nonzero digit. Then perform the calculation using the rounded numbers to obtain an estimate.

1. 238,598,980 + 487,903,870

2. 5,927,000 + 9,983,000

3. 56,789.345 − 33,875.125

4. 6949.45 − 1432.88

5. 4832 × 0.532

6. 68,976 × 0.875

7. 879.654 ÷ 56.82

8. 34.5684 ÷ 0.55

9. ***Canadian Tourists*** It is estimated that in 2003 a total of 15,627,350 tourists from Canada visited the United States. They spent a total of $3,922,464,850 in United States currency while visiting. Estimate the amount of money spent by each Canadian tourist. (*Source*: U.S. Dept of Commerce)

10. ***Boat Sales*** Last year the sales of boats in Massachusetts totaled $865,987,273.45. If this represented a purchase of 55,872 boats, estimate the average price per boat.

Applications

Estimate an answer to each of the following by rounding each number first, then perform the actual calculation.

11. ***Currency Conversion*** Carlos is taking a trip to Denmark. Before he leaves, he checks the newspaper and finds that every U.S. dollar is equal to 7.5 kroners (Danish currency). If Carlos takes $650 on his trip, how many kroners will he receive when he does the exchange?

▲**12.** ***Geometry*** The dimensions of a football field, excluding the end zones, are 91.4 meters long and 48.75 meters wide. What is the area in square meters of the football field?

▲**13.** ***Geometry*** Juan and Gloria are having their roof reshingled and need to determine its area in square feet. The dimensions of the roof are 48.3 feet by 56.9 feet. What is the area of the roof in square feet?

14. ***Baby Formula*** A large can of infant formula contains 808 grams of powder. To prepare a bottle, 35.2 grams are needed. How many bottles can be prepared from the can? Round to the nearest whole number.

15. ***Cooking*** Hans is making gourmet chocolate in Switzerland. He has 11.52 liters of liquid white chocolate that will be poured into molds that hold 0.12 liter each. How many individual molds can Hans make with his 11.52 liters of liquid white chocolate?

16. ***Food Purchase*** David bought MacIntosh apples and Anjou pears at the grocery store for a fruit salad. At the checkout counter, the apples weighed 2.7 pounds and the pears weighed 1.8 pounds. If the apples cost $1.29 per pound and the pears cost $1.49 per pound, how much did David spend on fruit? (Round your answer to the nearest cent.)

17. ***Hawaii Rainfall*** One year in Mount Waialeale, Hawaii, considered the "rainiest place in the world," the yearly rainfall totaled 11.68 meters. The next year, the yearly rainfall on this mountain totaled 10.42 meters. The third year it was 12.67 meters. On average, how much rain fell on Mount Waialeale, Hawaii, per year?

18. ***Auto Travel*** Emma and Jennie took a trip in their Ford Taurus from Saskatoon, Saskatchewan, to Calgary, Alberta, in Canada to check out the glacier lakes. When they left, their odometer read 54,089. When they returned home, the odometer read 55,401. They used 65.6 gallons of gas. How many miles per gallon did they get on the trip?

19. ***Food Portions*** A jumbo bag of potato chips contains 18 ounces of chips. The recommended serving is 0.75 ounce. How many servings are in the jumbo bag?

20. ***Telephone Costs*** Sylvia's telephone company offers a special rate of $0.23 per minute on calls made to the Philippines during certain parts of the day. If Sylvia makes a 28.5-minute call to the Philippines at this special rate, how much will it cost?

21. ***Consumer Mathematics*** The local Police Athletic League raised enough money to renovate the local youth hall and turn it into a coffeehouse/activity center so that there is a safe place to hang out. The room that holds the Ping-Pong table needs 43.9 square yards of new carpeting. The entryway needs 11.3 square yards, and the stage/seating area needs 63.4 square yards. The carpeting will cost $10.65 per square yard. What will be the total bill for carpeting these three areas of the coffeehouse?

22. ***Painting Costs*** Kevin has a job as a house painter. One family needs its kitchen, family room, and hallway painted. The respective amounts needed are 2.7 gallons, 3.3 gallons, and 1.8 gallons. If paint costs $7.40 per gallon, how much will Kevin need to spend on paint to do the job?

23. ***Overtime Pay*** Lucy earns $8.50 per hour at the neighborhood café. She earns time and a half (1.5 times the hourly wage) for each hour she works on a holiday. Lucy worked eight hours each day for six days, then worked eight hours on New Year's Day. How much did she earn for that week?

24. ***Electrician's Pay*** An electrician is paid $14.30 per hour for a 40-hour week. She is paid time and a half for overtime (1.5 times the hourly wage) for every hour more than 40 hours worked in the same week. If she works 48 hours in one week, what will she earn for that week?

25. ***Food Costs*** Belinda bought 1.5 pounds of fish for $6.99 per pound, and 1.25 pounds of sliced turkey for $4.59 per pound. How much total did she spend? Round to the nearest cent.

26. ***Consumer Mathematics*** At the beginning of each month, Perry withdraws $80 for daily purchases. This month he spent $22.75 on soda and snacks, $3.25 on newspapers, and $25.65 for bus fares. How much did Perry have left?

27. ***Car Payments*** Charlie borrowed $11,500 to purchase a new car. His loan requires him to pay $288.65 each month over the next 60 months (five years). How much will he pay over the five years? How much more will he pay back than the amount of the loan?

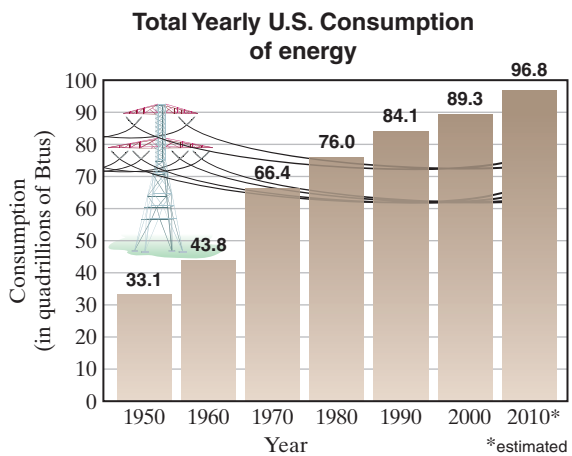
28. ***House Payments*** Hector and Junita borrowed $80,000 to buy their new home. They make monthly payments to the bank of $450.25 to repay the loan. They will be making these monthly payments for the next 30 years. How much money will they pay to the bank in the next 30 years? How much more will they pay back than they borrowed?

29. ***Drinking Water Safety*** The EPA standard for safe drinking water is a maximum of 1.3 milligrams of copper per liter of water. A study was conducted on a sample of 7 liters of water drawn from Jeff Slater's house. The analysis revealed 8.06 milligrams of copper in the sample. Is the water safe or not? By how much?

30. ***Drinking Water Safety*** The EPA standard for safe drinking water is a maximum of 0.015 milligram of lead per liter of water. A study was conducted on 6 liters of water from West Towers Dormitory. The analysis revealed 0.0795 milligram of lead in the sample. Is the water safe or not? By how much?

31. ***Jet Travel*** A jet fuel tank containing 17,316.8 gallons is being emptied at the rate of 126.4 gallons per minute. How many minutes will it take to empty the tank?

32. ***Monopoly Game*** In a New Jersey mall, the average price of a Parker Brothers Monopoly game is $11.50. The Alfred Dunhill Company made a special commemorative set for $25,000,000.00. Instead of plastic houses and hotels, you can buy and trade gold houses and silver hotels! How many regular Monopoly games could you purchase for the price of one special commemorative set?



Source: U.S. Department of Energy

Energy Consumption *Use the preceding bar graph to answer exercises 33–36.*

33. How many more Btu were consumed in the United States during 2000 than in 1970?

34. What was the greatest increase in consumption of energy in a 10-year period? When did it occur?

35. What was the average consumption of energy per year in the United States for the years 1950, 1960, and 1970? Write your answer in quadrillion Btu and then write your answer in Btu. (Remember that a quadrillion is 1000 trillion)

36. What will be the average consumption of energy per year in the United States for the years 1990, 2000 and 2010? Write your answer in quadrillion Btu and then write your answer in Btu. (Remember that a quadrillion is 1000 trillion.)

Cumulative Review

Calculate.

37. $\frac{4}{7} + \frac{1}{2} \times \frac{2}{3}$

38. $\frac{3}{19} + \frac{5}{38} - \frac{2}{19}$

39. $\frac{7}{25} \times \frac{15}{42}$

40. $2\frac{2}{3} \div \frac{1}{3}$

Putting Your Skills to Work

The Mathematics of Fuel-Efficient Automobiles

According to the U.S. Federal Highway Administration, the automobiles driven in the United States currently consume 72,900,000,000 gallons of gasoline each year. The automobiles in the U.S. averaged 22.3 miles per gallon for fuel efficiency. (This is the figure for cars only—it does not include minivans, SUVs, and pickup trucks.) A lot of gasoline could be saved if some of these cars were converted to highly efficient hybrid automobiles. For example, the 2004 Toyota Prius has an EPA rating of 55 miles per gallon in combined highway/city driving. Use the above information in considering the following questions.

Problems for Individual Investigation and Analysis

1. If cars consume 72,900,000,000 gallons of gas per year in the U.S. and the average car gets 22.3 miles per gallon, how many miles are driven per year by cars in the U.S.?

2. If all of these miles were driven by highly efficient hybrid cars that get 55 miles per gallon, how much gasoline would be used each year in the U.S. by these efficient cars? Round your answer to the nearest million gallons.

Problems for Group Analysis and Cooperative Investigation

3. It is probably not realistic to assume everyone would purchase a highly efficient hybrid automobile. However, it would be possible for half of the vehicles purchased in the U.S. to be this type of vehicle perhaps over the next twenty years. How much fuel would be used in a year by automobiles in the U.S. if half the mileage was driven by cars that obtained 22.3 miles per gallon and half the mileage was driven by cars that obtained 55 miles per gallon? Round your answer to the nearest million gallons.

4. If a person drives a car 20,000 miles each year and changes his car from a large SUV that gets 16 miles per gallon, to an efficient hydbrid that gets 55 miles per gallon, how much will that person save per year if gas is $1.95 per gallon? Round your answer to the nearest dollar.

Chapter 3 Organizer

Topic	Procedure	Examples
Word names for decimals, p. 205.	3 Hundreds 4 Tens 1 Ones . Decimal point 6 Tenths 7 Hundredths 8 Thousandths 3 Ten-thousandths	The word name for 341.6783 is three hundred forty-one and six thousand seven hundred eighty-three ten-thousandths.
Writing a decimal as a fraction, p. 206.	**1.** Read the decimal in words. **2.** Write it in fraction form. **3.** Reduce if possible.	Write 0.36 as a fraction. **1.** 0.36 is read "thirty-six hundredths." **2.** Write the fractional form. $\frac{36}{100}$ **3.** Reduce. $\frac{36}{100} = \frac{9}{25}$
Determining which of two decimals is larger, p. 210.	**1.** Start at the left and compare corresponding digits. Write in extra zeros if needed. **2.** When two digits are different, the larger number is the one with the larger digit.	Which is larger? 0.138 or 0.13 0.138 ? 0.130 8 > 0 So 0.138 > 0.130.
Rounding decimals, p. 212.	**1.** Locate the place (units, tenths, hundredths, etc.) for which the round-off is required. **2.** If the first digit to the right of the given place value is less than 5, drop it and all the digits to the right of it. **3.** If the first digit to the right of the given place value is 5 or greater, increase the number in the given place value by one. Drop all digits to the right.	Round to the nearest hundredth. 0.8652 0.87 Round to the nearest thousandth. 0.21648 0.216
Adding and subtracting decimals, p. 216.	**1.** Write the numbers vertically and line up the decimal points. Extra zeros may be written to the right of the decimal points after the nonzero digits if needed. **2.** Add or subtract all the digits with the same place value, starting with the right column, moving to the left. Use carrying or borrowing as needed. **3.** Place the decimal point of the result in line with the decimal points of all the numbers added or subtracted.	Add. 36.3 + 8.007 + 5.26 1 36.300 8.007 + 5.260 49.567 Subtract. 82.5 − 36.843 7 11 14 9 10 8 2 . 5 0 0 − 3 6 . 8 4 3 4 5 . 6 5 7
Multiplying decimals, p. 226.	**1.** Multiply the numbers just as you would multiply whole numbers. **2.** Find the sum of the decimal places in the two factors. **3.** Place the decimal point in the product so that the product has the same number of decimal places as the sum in step 2. You may need to insert zeros to the left of the number found in step 1.	Multiply. 0.2 × 0.6 = 0.12 0.3174 × 0.8 = 0.25392 0.0064 × 0.21 = 0.001344 1364 × 0.7 = 954.8
Multiplying a decimal by a power of 10, p. 227.	Move the decimal point to the right the same number of places as there are zeros in the power of 10. (Sometimes it is necessary to write extra zeros before placing the decimal point in the answer.)	Multiply. 5.623 × 10 = 56.23 0.0082 × 1000 = 8.2 28.93 × 10^2 = 2893 0.597 × 10^4 = 5970 0.075 × 10^6 = 75,000
Dividing by a decimal, p. 236.	**1.** Make the divisor a whole number by moving the decimal point to the right. Mark that position with a caret (∧). **2.** Move the decimal point in the dividend to the right the same number of places. Mark that position with a caret. **3.** Place the decimal point of your answer directly above the caret in the dividend. **4.** Divide as with whole numbers.	Divide. **(a)** 0.06)0.162 2.7 **(a)** 0.06∧)0.16∧2 12 42 42 0 **(b)** 0.003)85.8 28 600. **(b)** 0.003∧)85.800∧ 6 25 24 18 18 0

continues on next page

Topic	Procedure	Examples
Converting a fraction to a decimal, p. 243.	Divide the denominator into the numerator until **1.** the remainder is zero, or **2.** the decimal repeats itself, or **3.** the desired number of decimal places is achieved.	Find the decimal equivalent. **(a)** $\frac{13}{22}$ **(b)** $\frac{5}{7}$, rounded to the nearest ten-thousandth **(a)** $22\overline{)13.0000}$ = 0.5909; 110, 200, 198, 200, 198, 2 **(b)** $7\overline{)5.00000}$ = 0.71428; 49, 10, 7, 30, 28, 20, 14, 60, 56, 4 0.71428 rounded to the nearest ten thousandth is 0.7143. $\frac{13}{22} = 0.5\overline{90}$ or 0.5909090 . . .
Order of operations with decimal numbers, p. 247.	Same as order of operations of whole numbers. **1.** Perform operations inside parentheses. **2.** Simplify any expressions with exponents. **3.** Multiply or divide from left to right. **4.** Add or subtract from left to right.	Evaluate. $(0.4)^3 + 1.26 \div 0.12 - 0.12 \times (1.3 - 1.1)$ $= (0.4)^3 + 1.26 \div 0.12 - 0.12 \times 0.2$ $= 0.064 + 1.26 \div 0.12 - 0.12 \times 0.2$ $= 0.064 + 10.5 - 0.024$ $= 10.564 - 0.024$ $= 10.54$

Procedure for Solving Applied Problems

Using the Mathematics Blueprint for Problem Solving, p. 253

In solving a real-life problem with decimals, students may find it helpful to complete the following steps. You will not use all the steps all of the time. Choose the steps that best fit the conditions of the problem.

1. Understand the problem.

(a) Read the problem carefully.

(b) Draw a picture if it helps you visualize the situation. Think about what facts you are given and what you are asked to find.

(c) It may help to write a similar, simpler problem to get started and to determine what operation to use.

(d) Use the Mathematics Blueprint for Problem Solving to organize your work. Follow these four parts.

1. Gather the Facts (Write down specific values given in the problem.)
2. What Am I Asked to Do? (Identify what you must obtain for an answer.)
3. How Do I Proceed? (Determine what calculations need to be done.)
4. Key Points to Remember (Record any facts, warnings, formulas, or concepts you think will be important as you solve the problem.)

2. Solve and state the answer.

(a) Perform the necessary calculations.

(b) State the answer, including the unit of measure.

3. Check.

(a) Estimate the answer to the problem. Compare this estimate to the calculated value. Is your answer reasonable?

(b) Repeat your calculations.

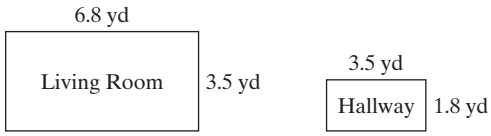
(c) Work backward from your answer. Do you arrive at the original conditions of the problem?

EXAMPLE

Fred has a rectangular living room that is 3.5 yards wide and 6.8 yards long. He has a hallway that is 1.8 yards wide and 3.5 yards long. He wants to carpet each area using carpeting that costs $12.50 per square yard. What will the carpeting cost him?

Understand the problem.

It is helpful to draw a sketch.



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Procedure for Solving Applied Problems *(continued)*

Mathematics Blueprint for Problem Solving

Gather the Facts	What Am I Asked to Do?	How Do I Proceed?	Key Points to Remember
Living room: 6.8 yards by 3.5 yards Hallway: 3.5 yards by 1.8 yards Cost of carpet: \$12.50 per square yard	Find out what the carpeting will cost Fred.	Find the area of each room. Add the two areas. Multiply the total area by \$12.50.	Multiply the length by the width to get the area of the room. Remember, area is measured in square yards.

To find the area of each room, we multiply the dimensions for each room.

Living room $6.8 \times 3.5 = 23.80$ square yards

Hallway $3.5 \times 1.8 = 6.30$ square yards

Add the two areas.

$$\begin{array}{r} 23.80 \\ +\ 6.30 \\ \hline 30.10 \end{array} \text{ square yards}$$

Multiply the total area by the cost per square yard.

$$30.1 \times 12.50 = \$376.25$$

Estimate to check. You may be able to do some of this mentally.

$7 \times 4 = 28$ square yards $\qquad 4 \times 2 = 8$ square yards

$$\begin{array}{r} 28 \\ +\ 8 \\ \hline 36 \end{array} \text{ square yards}$$

$36 \times 10 = \$360$ $\qquad$ \$360 is close to \$376.25. ✓

Chapter 3 Review Problems

Section 3.1

Write a word name for each decimal.

1. 13.672 **2.** 0.00084

Write as a decimal.

3. $\frac{7}{10}$ **4.** $\frac{81}{100}$ **5.** $1\frac{523}{1000}$ **6.** $\frac{79}{10{,}000}$

Write as a fraction or a mixed number.

7. 0.17 **8.** 0.036 **9.** 34.24 **10.** 1.00025

Section 3.2

Fill in the blank with <, =, or >.

11. $2\frac{9}{100}$ $\underline{=}$ 2.09 **12.** 0.716 $\underline{>}$ 0.706 **13.** $\frac{65}{100}$ $\underline{<}$ 0.655 **14.** 0.824 $\underline{>}$ 0.804

In exercises 15–18, arrange each set of decimal numbers from smallest to largest.

15. 0.981, 0.918, 0.98, 0.901

16. 5.62, 5.2, 5.6, 5.26, 5.59

17. 0.754, 0.745, 0.7045, 0.704

18. 8.72, 8.2, 8.27, 8.702

19. Round to the nearest tenth. 0.613

20. Round to the nearest hundredth. 19.2076

21. Round to the nearest ten-thousandth. 9.85215

22. Round to the nearest dollar. $156.48

Section 3.3

23. Add.

$$\begin{array}{r} 9.6 \\ 11.5 \\ 21.8 \\ +\ 34.7 \\ \hline \end{array}$$

24. Add.

$$\begin{array}{r} 1.8 \\ 2.603 \\ 0.52 \\ +\ 1.716 \\ \hline \end{array}$$

25. Subtract.

$$\begin{array}{r} 5.19 \\ -\ 1.296 \\ \hline \end{array}$$

26. Subtract.

$$\begin{array}{r} 182.422 \\ -\ 68.55 \\ \hline \end{array}$$

Section 3.4

In exercises 27–32, multiply.

27.

$$\begin{array}{r} 0.098 \\ \times\ 0.032 \\ \hline \end{array}$$

28.

$$\begin{array}{r} 126.83 \\ \times\ \ \ 7 \\ \hline \end{array}$$

29.

$$\begin{array}{r} 78 \\ \times\ 5.2 \\ \hline \end{array}$$

30.

$$\begin{array}{r} 7053 \\ \times\ 0.34 \\ \hline \end{array}$$

31. 0.000613×10^3

32. 1.2354×10^5

33. ***Food Cost*** Roast beef was on sale for $3.49 per pound. How much would 2.5 pounds cost? Round to the nearest cent.

Section 3.5

In exercises 34–36, divide until there is a remainder of zero.

34. $0.07\overline{)0.0001806}$

35. $5.2\overline{)191.36}$

36. $8\overline{)1863.2}$

37. Divide and round your answer to the nearest tenth.

$$1.3\overline{)746.75}$$

38. Divide and round your answer to the nearest thousandth.

$$0.06\overline{)0.003539}$$

Section 3.6

Write as an equivalent decimal.

39. $\frac{5}{18}$

40. $\frac{7}{40}$

41. $1\frac{5}{6}$

42. $\frac{19}{16}$

Write as a decimal rounded to the nearest thousandth.

43. $\frac{11}{14}$ **44.** $\frac{10}{29}$ **45.** $2\frac{5}{17}$ **46.** $3\frac{9}{23}$

Evaluate by doing the operations in proper order.

47. $2.3 \times 1.82 + 3 \times 5.12$

48. $0.03 + (1.2)^2 - 5.3 \times 0.06$

49. $(1.02)^3 + 5.76 \div 1.2 \times 0.05$

50. $2.4 \div (2 - 1.6)^2 + 8.13$

Mixed Practice

Calculate.

51. $2398.26 - 1959.07$

52. $32.15 \times 0.02 \times 10^2$

53. $1.809 - 0.62 + 3.27$

54. $2.0792 \div 2.3$

55. $8 \div 0.4 + 0.1 \times (0.2)^2$

56. $(3.8 - 2.8)^3 \div (0.5 + 0.3)$

Applications

Section 3.7

Solve each problem.

57. ***Football Tickets*** At a large football stadium there are 2,600 people in line for tickets. In the first two minutes the computer is running slowly and tickets 228 people. Then the computer stops. For the next 2.5 minutes, the computer runs at medium speed and tickets 388 people per minute. For the next three minutes the computer runs at full speed and tickets 430 people per minute. Then the computer stops. How many people still have not received their tickets?

58. ***Fuel Efficiency*** Dan drove to the mountains. His odometer read 26,005.8 miles at the start, and 26,325.8 miles at the end of the trip. He used 12.9 gallons of gas on the trip. How many miles per gallon did his car get? (Round your answer to the nearest tenth.)

59. ***Car Payments*** Robert is considering buying a car and making installment payments of \$189.60 for 48 months. The cash price of the car is \$6930.50. How much extra does he pay if he uses the installment plan instead of buying the car with one payment?

60. ***Comparing Job Salaries*** Mr. Zeno has a choice of working as an assistant manager at ABC Company at \$315.00 per week or receiving an hourly salary of \$8.26 per hour at the XYZ company. He learned from several previous assistant managers at both companies that they usually worked 38 hours per week. At which company will he probably earn more money?

61. ***Drinking Water Safety*** The EPA standard for safe drinking water is a maximum of 0.002 milligram of mercury in one liter of water. The town wells at Winchester were tested. The test was done on 12 liters of water. The entire 12-liter sample contained 0.03 milligram of mercury. Is the water safe or not? By how much does it differ from the standard?

62. ***Infant Head Size*** It is common for infants to have their heads measured during the first year of life. At two months, Will's head measured 40 centimeters. There are 2.54 centimeters in one inch. How many inches was this measurement? Round to the nearest hundredth.

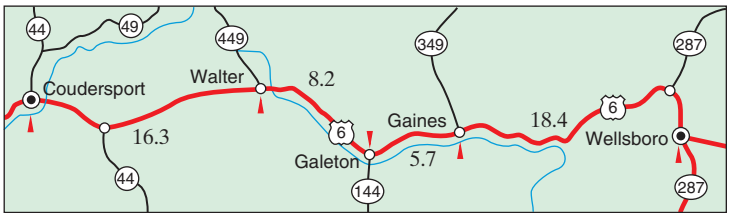
63. ***Geometry*** Dick Wright's new rectangular garden measures 18.3 feet by 9.6 feet. He needs to install wire fence on all four sides.

(a) How many feet of fence does he need?

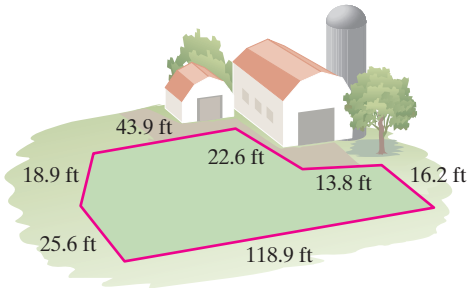
(b) The number of bags of wood chips Dick buys depends on the area of the garden. What is the area?

64. ***Geometry*** Bill Tupper's rectangular driveway needs to be resurfaced. It is 75.5 feet long and 18.5 feet wide. How large is the area of the driveway?

65. ***Travel Distances*** The following strip map shows the distances in miles between several local towns in Pennsylvania. How much longer is the distance from Coudersport to Gaines, than the distance from Galeton to Wellsboro?



66. ***Geometry*** A farmer in Vermont has a field with an irregular shape. The distances are marked on the diagram. There is no fence but there is a path on the edge of the field. How long is the walking path around the field?



67. ***Car Payments*** Marcia and Greg purchased a new car. For the next five years they will be making monthly payments of $212.50. Their bank has offered to give them a loan at a smaller interest rate so that they would make monthly payments of only $199.50. The bank would charge them $285.00 to reissue their car loan. How much would it cost them to keep their original loan? How much would it cost them if they took the new loan from the bank? Should they make the change or keep the original loan?

Social Security Benefits *Use the following bar graph to answer exercises 68–73. Round all answers to the nearest cent.*

68. How much did the average monthly social security benefit increase from 1980 to 1990?

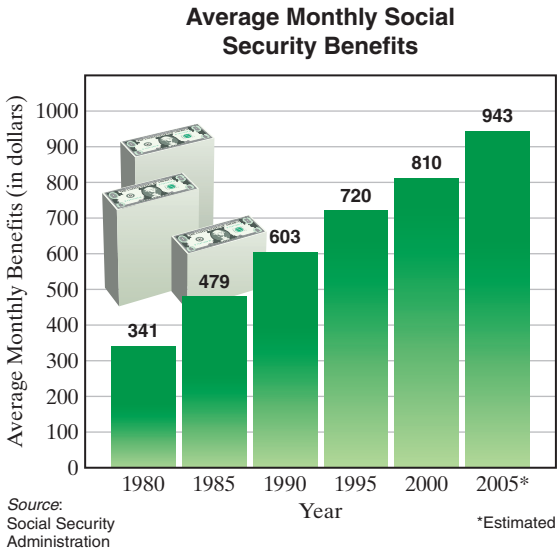
69. How much did the average monthly social security benefit increase from 1990 to 2000?

70. What was the average daily social security benefit in 1985? (Assume 30 days in a month.)

71. What was the average daily social security benefit in 1995? (Assume 30 days in a month.)

72. If the average daily social security benefit increases by the same amount from 2000 to 2015 as it did from 1985 to 2000, what will be the average daily social security benefit in 2015?

73. If the average daily social security benefit increases by the same amount from 2000 to 2010 as it did from 1990 to 2000, what will be the average daily social security benefit in 2010?



How Am I Doing? Chapter 3 Test

Remember to use your Chapter Test Prep Video CD to see the worked-out solutions to the test problems you want to review.

1. Write a word name for the decimal. 12.043

2. Write as a decimal. $\frac{3977}{10{,}000}$

In questions 3 and 4, write in fractional notation. Reduce whenever possible.

3. 7.15 **4.** 0.261

5. Arrange from smallest to largest. 2.19, 2.91, 2.9, 2.907

6. Round to the nearest hundredth. 78.6562

7. Round to the nearest ten-thousandth. 0.0341752

Add. **8.**
$$\begin{array}{r} 96.2 \\ 1.348 \\ +\ 2.15 \\ \hline \end{array}$$

9. 17 + 2.1 + 16.8 + 0.04 + 1.59

Subtract. **10.**
$$\begin{array}{r} 1.0075 \\ -\ 0.9096 \\ \hline \end{array}$$

11. 72.3 − 1.145

Multiply. **12.**
$$\begin{array}{r} 8.31 \\ \times\ 0.07 \\ \hline \end{array}$$

13. 2.189×10^3

Divide. **14.** $0.08\overline{)0.01028}$ **15.** $0.69\overline{)32.43}$

Write as a decimal. **16.** $\frac{11}{9}$ **17.** $\frac{7}{8}$

In questions 18 and 19, perform the operations in the proper order.

18. $(0.3)^3 + 1.02 \div 0.5 - 0.58$

19. $19.36 \div (0.24 + 0.26) \times (0.4)^2$

20. Peter put 8.5 gallons of gas in his car. The price per gallon is $1.41. How much did Peter spend on gas? Round to the nearest cent.

21. Frank traveled from the city to the shore. His odometer read 42,620.5 miles at the start and 42,780.5 at the end of the trip. He used 8.5 gallons of gas. How many miles per gallon did his car achieve? Round to the nearest tenth.

22. The rainfall for March in Central City was 8.01 centimeters; for April, 5.03 centimeters; and for May, 8.53 centimeters. The normal rainfall for these three months is 25 centimeters. How much less rain fell during these three months than usual; that is, how does this year's figure compare with the figure for normal rainfall?

23. Wendy is earning $7.30 per hour in her new job as a teller trainee at the Springfield National Bank. She earns 1.5 times that amount for every hour over 40 hours she works in one week. She was asked to work 49 hours last week. How much did she earn last week?

1. _____
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4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____

Cumulative Test for Chapters 1–3

Approximately one-half of this test is based on Chapter 3 material. The remainder is based on material covered in Chapters 1 and 2.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. (a) _____
(b) _____
25. _____
26. _____

1. Write in words. 38,056,954

2. Add.
$$\begin{array}{r} 156{,}028 \\ 301{,}579 \\ +\ 21{,}980 \\ \hline \end{array}$$

3. Subtract.
$$\begin{array}{r} 1{,}091{,}000 \\ -\ 1{,}036{,}520 \\ \hline \end{array}$$

4. Multiply.
$$\begin{array}{r} 589 \\ \times\ 67 \\ \hline \end{array}$$

5. Divide. $17\overline{)4386}$

6. Evaluate. $20 \div 4 + 2^5 - 7 \times 3$

7. Reduce. $\frac{18}{45}$

8. Add. $4\frac{1}{3} + 3\frac{1}{6}$

9. Subtract. $\frac{23}{35} - \frac{2}{5}$

10. Evaluate. $\frac{7}{10} \times \frac{5}{3} - \frac{5}{12} \times \frac{1}{2}$

11. Divide. $52 \div 3\frac{1}{4}$

12. Divide. $1\frac{3}{8} \div \frac{5}{12}$

13. Estimate. $58{,}216 \times 438{,}207$

14. Write as a decimal. $\frac{39}{1000}$

15. Arrange from smallest to largest. 2.1, 20.1, 2.01, 2.12, 2.11

16. Round to the nearest thousandth. 26.07984

17. Add.
$$\begin{array}{r} 1.9 \\ 2.36 \\ 15.2 \\ +\ 0.08 \\ \hline \end{array}$$

18. Subtract.
$$\begin{array}{r} 28.1 \\ -\ 14.982 \\ \hline \end{array}$$

19. Multiply. 56.8×0.02

20. Multiply. 0.1823×1000

21. Divide. $0.06\overline{)0.06348}$

22. Write as a decimal. $\frac{13}{16}$

23. Perform the operations in the correct order.

$1.44 \div 0.12 + (0.3)^3 + 1.57$

▲**24.** Dr. Bob Wells has a small square garden that measures 10.5 feet on each side.

(a) What is the area of this garden?

(b) What is the perimeter of this garden?

25. Sue's savings account balance is \$199.36. This month she earned interest of \$1.03. She deposited \$166.35 and \$93.50. She withdrew money three times, in the amounts of \$90.00, \$37.49, and \$137.18. What will her balance be at the start of next month?

26. Russ and Norma Camp borrowed some money from the bank to purchase a new car. They are paying off the car loan at the rate of \$320.50 per month. At the end of the loan period they will have paid \$19,230.00 to the bank. How many months will it take to pay off this car loan?