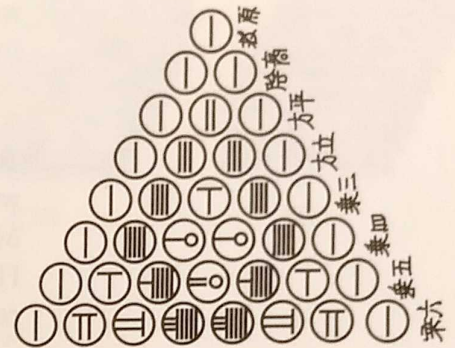
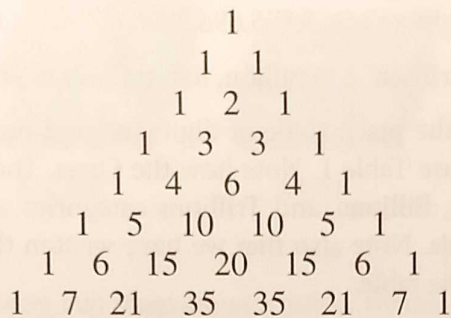


Place Value and Names for Numbers

R.1

The two diagrams below are known as Pascal's triangle, after the French mathematician and philosopher Blaise Pascal (1623–1662). Both diagrams contain the same information. The one on the left contains numbers in our number system; the one on the right uses numbers from Japan in 1781.



PASCAL'S TRIANGLE IN JAPAN
From Murai Chūzen's *Sampō Dōshi-mon* (1781)

Our number system is based on the number 10 and is therefore called a “base 10” number system. We write all numbers in our number system using the **digits** 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. The positions of the digits in a number determine the values of the digits. For example, the 5 in the number 251 has a different value from the 5 in the number 542.

The **place values** in our number system are as follows: The first digit on the right is in the *ones column*. The next digit to the left of the ones column is in the *tens column*. The next digit to the left is in the *hundreds column*. For a number like 542, the digit 5 is in the hundreds column, the 4 is in the tens column, and the 2 is in the ones column.

If we keep moving to the left, the columns increase in value. The following diagram shows the name and value of each of the first seven columns in our number system:

Millions Column	Hundred Thousands Column	Ten Thousands Column	Thousands Column	Hundreds Column	Tens Column	Ones Column
1,000,000	100,000	10,000	1,000	100	10	1

VIDEO EXAMPLES



SECTION R.1

Example 1 Give the place value of each digit in the number 305,964.

Solution Starting with the digit at the right, we have:

4 in the ones column, 6 in the tens column, 9 in the hundreds column, 5 in the thousands column, 0 in the ten thousands column, and 3 in the hundred thousands column.

Large Numbers

The photograph shown here was taken by the Hubble telescope in April 2002. The object in the photograph is called the *Cone Nebula*. In astronomy, distances to objects like the Cone Nebula are given in light-years, the distance light travels in a year. If we assume light travels 186,000 miles in one second, then a light-year is 5,865,696,000,000 miles; that is



NASA

5 trillion, 865 billion, 696 million miles

To find the place value of digits in large numbers, we can use Table 1. Note how the Ones, Thousands, Millions, Billions, and Trillions categories are each broken into Ones, Tens, and Hundreds. Note also that we have written the digits for our light-year in the last row of the table.

Trillions			Billions			Millions			Thousands			Ones		
Hundreds	Tens	Ones	Hundreds	Tens	Ones	Hundreds	Tens	Ones	Hundreds	Tens	Ones	Hundreds	Tens	Ones
		5	8	6	5	6	9	6	0	0	0	0	0	0

Table 1

Example 2

Give the place value of each digit in the number 73,890,672,540.

Solution The following diagram shows the place value of each digit.

7	3,	8	9	0,	6	7	2,	5	4	0
Ten Billions	Billions	Hundred Millions	Ten Millions	Millions	Hundred Thousands	Ten Thousands	Thousands	Hundreds	Tens	Ones

Expanded Form

We can use the idea of place value to write numbers in **expanded form**. For example, the number 542 can be written in expanded form as

$$542 = 500 + 40 + 2$$

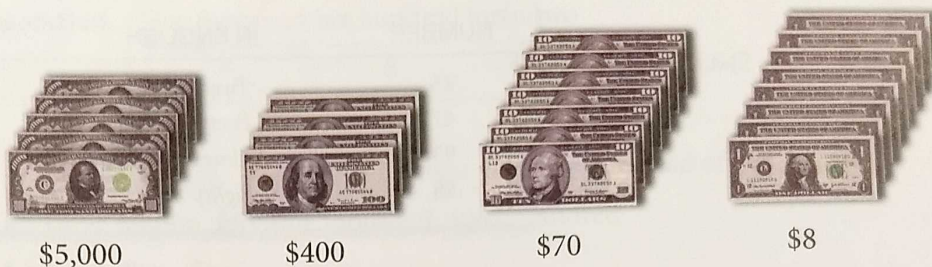
because the 5 is in the hundreds column, the 4 is in the tens column, and the 2 is in the ones column.

Here are more examples of numbers written in expanded form.

Example 3 Write 5,478 in expanded form.

Solution $5,478 = 5,000 + 400 + 70 + 8$

We can use money to make the results from Example 3 more intuitive. Suppose you have \$5,478 in cash as follows:



Using this diagram as a guide, we can write

$$5,478 = 5,000 + 400 + 70 + 8$$

which shows us that our work writing numbers in expanded form is consistent with our intuitive understanding of the different denominations of money.

Example 4 Write 354,798 in expanded form.

Solution $354,798 = 300,000 + 50,000 + 4,000 + 700 + 90 + 8$

Example 5 Write 56,094 in expanded form.

Solution Notice that there is a 0 in the hundreds column. This means we have 0 hundreds. In expanded form, we have

$$56,094 = 50,000 + 6,000 + 90 + 4$$

Note that we don't have to include the 0 hundreds

Example 6 Write 5,070,603 in expanded form.

Solution The columns with 0 in them will not appear in the expanded form.

$$5,070,603 = 5,000,000 + 70,000 + 600 + 3$$

The idea of place value and expanded form can be used to help write the names for numbers. Naming numbers and writing them in words takes some practice.

Writing Numbers in Words

Let's begin by looking at the names of some two-digit numbers. Table 2 lists a few. Notice that the two-digit numbers that do not end in 0 have two parts. These parts are separated by a hyphen.

NUMBER	IN ENGLISH	NUMBER	IN ENGLISH
25	<i>Twenty-five</i>	30	<i>Thirty</i>
47	<i>Forty-seven</i>	62	<i>Sixty-two</i>
93	<i>Ninety-three</i>	77	<i>Seventy-seven</i>
88	<i>Eighty-eight</i>	50	<i>Fifty</i>

Table 2

The following examples give the names for some larger numbers. In each case the names are written according to the place values given in Table 1.

Example 7 Write each number in words.

- a. 452 b. 397 c. 608

Solution

- a. Four hundred fifty-two
 b. Three hundred ninety-seven
 c. Six hundred eight

Example 8 Write each number in words.

- a. 3,561 b. 53,662 c. 547,801

Solution

- a. Three thousand, five hundred sixty-one
 ↑
 Notice how the comma separates the thousands from the hundreds
- b. Fifty-three thousand, six hundred sixty-two
 c. Five hundred forty-seven thousand, eight hundred one

Example 9 Write each number in words

- a. 507,034,005 b. 739,600,075 c. 5,003,007,006

Solution

- a. Five hundred seven million, thirty-four thousand, five
 b. Seven hundred thirty-nine million, six hundred thousand, seventy-five
 c. Five billion, three million, seven thousand, six

The next examples show how we write a number given in words as a number written with digits.

Example 10 Write five thousand, six hundred forty-two, using digits instead of words.

Solution $\underbrace{\text{Five thousand}}_{5,} \underbrace{\text{six hundred}}_6 \underbrace{\text{forty-two}}_{42} \rightarrow 5,642$

Example 11 Write each number with digits instead of words.

- Three million, fifty-one thousand, seven hundred
- Two billion, five
- Seven million, seven hundred seven

Solution

- 3,051,700
- 2,000,000,005
- 7,000,707

Sets and the Number Line

Note Counting numbers are also called natural numbers.

In mathematics a collection of numbers is called a *set*. In this chapter we will be working with the set of **counting numbers** and the set of **whole numbers**, which are defined as follows:

$$\text{Counting numbers} = \{1, 2, 3, \dots\}$$

$$\text{Whole numbers} = \{0, 1, 2, 3, \dots\}$$

The dots mean “and so on,” and the braces $\{ \}$ are used to group the numbers in the set together.

Another way to visualize the whole numbers is with a *number line*. To draw a number line, we simply draw a straight line and mark off equally spaced points along the line, as shown in Figure 1. We label the point at the left with 0 and the rest of the points, in order, with the numbers 1, 2, 3, 4, 5, and so on.

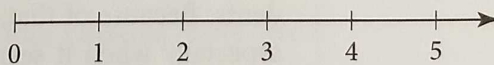


Figure 1

The arrow on the right indicates that the number line can continue in that direction forever. When we refer to numbers in this chapter, we will always be referring to the whole numbers.

Getting Ready for Class

Each section of the book will end with some problems and questions like the ones that follow. They are for you to answer after you have read through the section, but before you go to class. All of them require that you give written responses in complete sentences. Writing about mathematics is a valuable exercise. If you write with the intention of explaining and communicating what you know to someone else, you will find that you understand the topic you are writing about even better than you did before you started writing.

After reading through the preceding section, respond in your own words and in complete sentences.

- A. Give the place value of the 9 in the number 305,964.
- B. Write the number 742 in expanded form.
- C. Place a comma and a hyphen in the appropriate place so that the number 2,345 is written correctly in words below:

two thousand three hundred forty five

- D. Is there a largest whole number?



SPOTLIGHT ON SUCCESS

Student Instructor Cynthia

Each time we face our fear, we gain strength, courage, and confidence in the doing.

—Unknown

I must admit, when it comes to math, it takes me longer to learn the material compared to other students. Because of that, I was afraid to ask questions, especially when it seemed like everyone else understood what was going on. Because I wasn't getting my questions answered, my quiz and exam scores were only getting worse. I realized that I was already paying a lot to go to college and that I couldn't afford to keep doing poorly on my exams. I learned how to overcome my fear of asking questions by studying the material before class, and working on extra problem sets until I was confident enough that at least I understood the main concepts. By preparing myself beforehand, I would often end up answering the question myself. Even when that wasn't the case, the professor knew that I tried to answer the question on my own. If you want to be successful, but you are afraid to ask a question, try putting in a little extra time working on problems before you ask your instructor for help. I think you will find, like I did, that it's not as bad as you imagined it, and you will have overcome an obstacle that was in the way of your success.



Problem Set R.1

1-75 e00

Give the place value of each digit in the following numbers.

- | | | | |
|----------|-----------|-------------|-------------|
| 1. 78 | 2. 93 | 3. 45 | 4. 79 |
| 5. 348 | 6. 789 | 7. 608 | 8. 450 |
| 9. 2,378 | 10. 6,481 | 11. 273,569 | 12. 768,253 |

Give the place value of the 5 in each of the following numbers.

- | | |
|-----------------|---------------------|
| 13. 458,992 | 14. 75,003,782 |
| 15. 507,994,787 | 16. 320,906,050 |
| 17. 267,894,335 | 18. 234,345,678,789 |
| 19. 4,569,000 | 20. 50,000 |

Write each of the following numbers in expanded form.

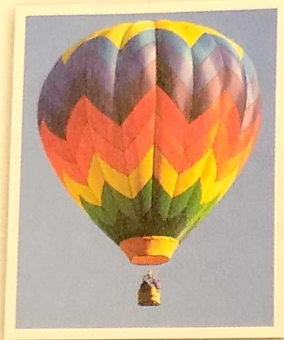
- | | | | |
|---------------|---------------|---------------|----------------|
| 21. 658 | 22. 479 | 23. 68 | 24. 71 |
| 25. 4,587 | 26. 3,762 | 27. 32,674 | 28. 54,883 |
| 29. 3,462,577 | 30. 5,673,524 | 31. 407 | 32. 508 |
| 33. 30,068 | 34. 50,905 | 35. 3,004,008 | 36. 20,088,060 |

Write each of the following numbers in words.

- | | | | |
|-----------------|-----------------|-------------------|-------------------|
| 37. 29 | 38. 75 | 39. 40 | 40. 90 |
| 41. 573 | 42. 895 | 43. 707 | 44. 405 |
| 45. 770 | 46. 450 | 47. 23,540 | 48. 56,708 |
| 49. 3,004 | 50. 5,008 | 51. 3,040 | 52. 5,080 |
| 53. 104,065,780 | 54. 637,008,500 | 55. 5,003,040,008 | 56. 7,050,800,001 |
| 57. 2,546,731 | 58. 6,998,454 | | |

Write each of the following numbers with digits instead of words.

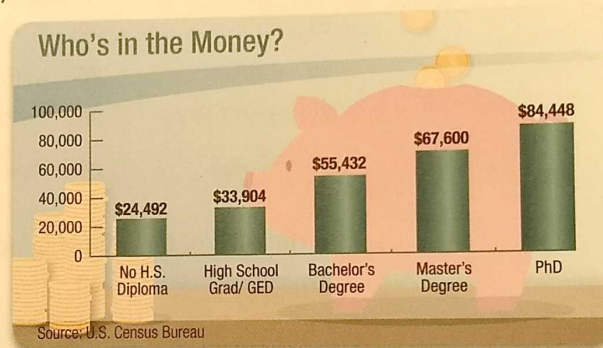
- Three hundred twenty-five
- Forty-eight
- Five thousand, four hundred thirty-two
- One hundred twenty-three thousand, sixty-one
- Eighty-six thousand, seven hundred sixty-two
- One hundred million, two hundred thousand, three hundred
- Two million, two hundred
- Two million, two
- Two million, two thousand, two hundred
- Two billion, two hundred thousand, two hundred two



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Applying the Concepts

69. **Hot Air Balloon** The first successful crossing of the Atlantic in a hot air balloon was made in August 1978 by Maxie Anderson, Ben Abruzzo, and Larry Newman of the United States. The 3,100-mile trip took approximately 140 hours. What is the place value of the 3 in the distance covered by the balloon?
70. **Seating Arrangements** The number of different ways in which 10 people can be seated at a table with 10 places is 3,628,800. What is the place value of the 3 in this number?
71. **Record Attendance** The Rose Bowl has a record attendance of 106,869. Write this number in expanded form.
72. **Education and Salary** The illustration shows the average income of workers 18 and older by education.



Write the following numbers in words:

- the average income of someone with only a high school education.
- the average income of someone with a Ph.D.

Populations of Countries The table below gives estimates of the populations to the nearest million of some countries for the year 2012. The first column under *Population* gives the population in digits. The second column gives the population in words. Fill in the blanks.

Country	Population	
	Digits	Words
73. United States	_____	Three hundred fourteen million
74. People's Republic of China	_____	One billion, three hundred fifty million
75. Japan	128,000,000	_____
76. United Kingdom	63,000,000	_____

(From Population Reference Bureau, 2012 World Population Data Sheet)

77. **Text Messaging** In 2012 approximately 2,190,000,000,000 text messages were sent and received in the United States. Write this number in words.
Source: CTIA-The Wireless Association
78. **Museum Visitors** The Getty Center and Museum in Los Angeles, CA, welcomed 1,207,203 visitors in 2012. In 1998, its first full year after opening, 1,746,246 visitors were recorded. Give the place value of the 7 in the 2012 figure and the 1998 figure.