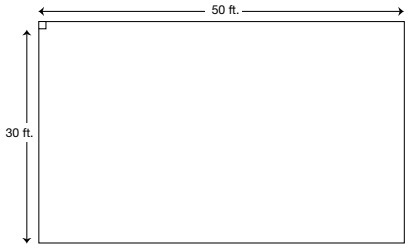
Exponents and Large Numbers

Reckoning

Reckoning is counting or calculating. In the story Sand Reckoning, a girl named Ellen learns about calculating and counting with large numbers. First, she and her father estimate the number of leaves she will have to rake in her yard.

1. The rectangle below is a sketch of Ellen's yard. What is the area of the yard?
2. If Ellen's father estimates that each square foot has 100 leaves, how many leaves does Ellen have to rake?

□ 1 square foot



3. **A.** There are 20 houses on Ellen's block. If each house has about the same number of leaves, how many leaves are on Ellen's block?
   B. There about 300 blocks in Ellen's town. Estimate the number of leaves in the town.

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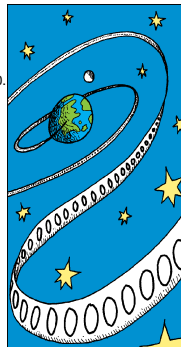
Exponents

Discuss

In the story Sand Reckoning, Archimedes estimated that the number of grains of sand it would take to fill the universe was the number 10^{63}.

10^{63} means we multiply 10 by itself 63 times.
"Who thought of that?" asked Ellen.

10^2 means $10 \times 10 = 100$.
10^3 means $10 \times 10 \times 10 = 1000$.
10^6 means $10 \times 10 \times 10 \times 10 \times 10 \times 10 = 1{,}000{,}000$.



When we write 10^6, the number 10 is called the **base.** The number 6 is the **exponent** or **power.** We say "ten to the sixth power" or just "ten to the sixth." We call 10^6 the sixth power of 10.

Other numbers can be written using exponents.

For example,
2^3 means $2 \times 2 \times 2 = 8$
5^2 means $5 \times 5 = 25$
3^4 means $3 \times 3 \times 3 \times 3 = 81$
7^1 means 7

When we write 2^3, the 2 is the base and 3 is the power or exponent.

4. **A.** Name the base and the exponent in 5^2.
   B. Name the base and the power in 3^4.
5. Find n.
   A. $4^3 = n$ **B.** $2^5 = n$ **C.** $6^1 = n$
6. Write the following using exponents. Then find the value of n.
   Example:
   $5 \times 5 \times 5 \times 5 = n$
   $5^4 = 625$
   A. $4 \times 4 \times 4 = n$ **B.** $2 \times 2 \times 2 \times 2 \times 2 \times 2 = n$ **C.** $8 \times 8 \times 8 = n$

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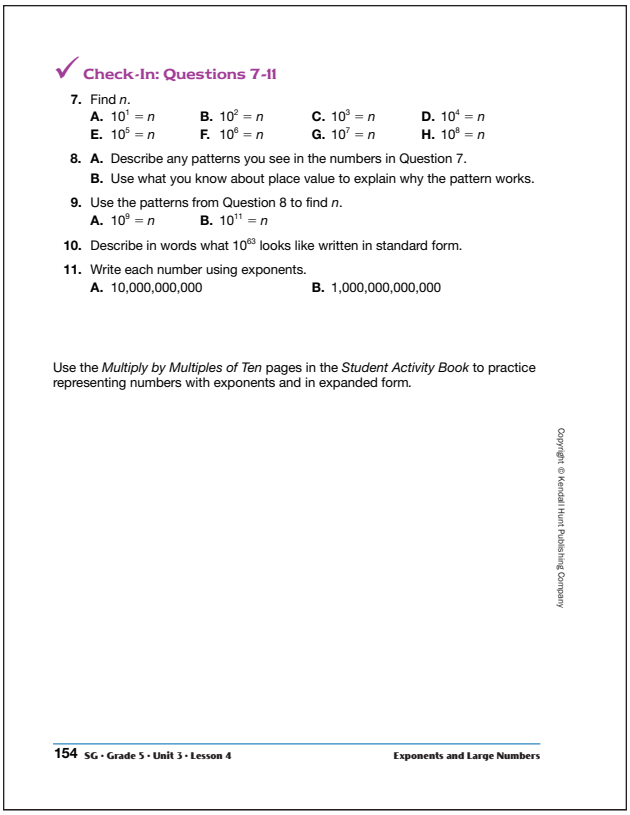
Student Guide

Exponents and Large Numbers (SG pp. 144, 153–154) Questions 1–11

1.* 30 ft. × 50 ft. = 1500 sq. ft. in the yard
2.* 1500 sq ft × 100 leaves per sq. ft. = 150,000 leaves
3. **A.*** 20 yards × 150,000 leaves per yard = 3,000,000 leaves or about 3 million leaves
   B.* 300 blocks × 3,000,000 leaves per block = 900,000,000 leaves or about 9 hundred million in town
4. **A.*** base: 5; exponent: 2
   B.* base: 3; power: 4
5. **A.*** 64
   B. 32
   C. 6
6. **A.** $4^3 = 64$
   B. $2^6 = 64$
   C. $8^3 = 512$

* Answers and/or discussion are included in the lesson.

7. **A.*** 10
   B. 100
   C. 1000
   D. 10,000
   E. 100,000
   F. 1,000,000
   G. 10,000,000
   H. 100,000,000
8. **A.*** Each power of ten can be written as 1 followed by the same number of zeros as the exponent.
   B.* The pattern works because the places in a number in the base-ten system stand for ten times the place to the right. So each time you add a zero, it adds another place to the number.
9. **A.** 1,000,000,000
   B. 100,000,000,000
10. 1 followed by 63 zeros
11. **A.** 10^{10}
    B. 10^{12}



✓ Check-In: Questions 7–11

7. Find *n*.
   A. $10^1 = n$ **B.** $10^2 = n$ **C.** $10^3 = n$ **D.** $10^4 = n$
   E. $10^5 = n$ **F.** $10^6 = n$ **G.** $10^7 = n$ **H.** $10^8 = n$
8. **A.** Describe any patterns you see in the numbers in Question 7.
   B. Use what you know about place value to explain why the pattern works.
9. Use the patterns from Question 8 to find *n*.
   A. $10^9 = n$ **B.** $10^{11} = n$
10. Describe in words what 10^{63} looks like written in standard form.
11. Write each number using exponents.
    A. 10,000,000,000 **B.** 1,000,000,000,000

Use the *Multiply by Multiples of Ten* pages in the *Student Activity Book* to practice representing numbers with exponents and in expanded form.

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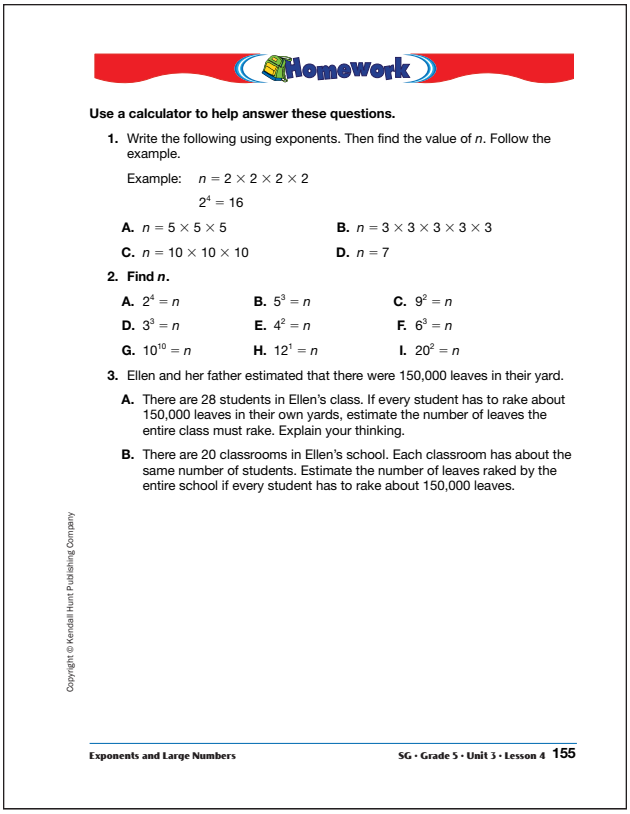
Homework (SG p. 155)
Questions 1–3

1. **A.** $5^3 = 125$
   B. $3^5 = 243$
   C. $10^3 = 1000$
   D. $7 = 7^1$
2. **A.** 16
   B. 125
   C. 81
   D. 27
   E. 16
   F. 216
   G. 10,000,000,000
   H. 12
   I. 400
3. **A.** Estimates will vary. One reasonable estimate is 150,000 leaves × 30 students or 4,500,000 leaves.
   B. Estimates will vary. One reasonable estimate is 4,500,000 leaves × 20 classrooms = 90,000,000 leaves.



Homework

Use a calculator to help answer these questions.

1. Write the following using exponents. Then find the value of *n*. Follow the example.
   Example: $n = 2 \times 2 \times 2 \times 2$
   $2^4 = 16$
   A. $n = 5 \times 5 \times 5$ **B.** $n = 3 \times 3 \times 3 \times 3 \times 3$
   C. $n = 10 \times 10 \times 10$ **D.** $n = 7$
2. **Find *n*.**
   A. $2^4 = n$ **B.** $5^3 = n$ **C.** $9^2 = n$
   D. $3^3 = n$ **E.** $4^2 = n$ **F.** $6^3 = n$
   G. $10^{10} = n$ **H.** $12^1 = n$ **I.** $20^2 = n$
3. Ellen and her father estimated that there were 150,000 leaves in their yard.
   A. There are 28 students in Ellen's class. If every student has to rake about 150,000 leaves in their own yards, estimate the number of leaves the entire class must rake. Explain your thinking.
   B. There are 20 classrooms in Ellen's school. Each classroom has about the same number of students. Estimate the number of leaves raked by the entire school if every student has to rake about 150,000 leaves.

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Name _____ Date _____

Multiply by Multiples of Ten

The distance from the Earth to the sun is 90,000,000 (rounded to the nearest ten million) miles. The number 90,000,000 is written here in standard form. We can use exponents to write this number in shorter form.

$$90{,}000{,}000 = 9 \times 10{,}000{,}000 = 9 \times 10^7$$

9×10^7 means to multiply $9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$.

1. **A.** Use your calculator to multiply $9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$. Write the number you see in the calculator's display.

   B. How many zeros do you see in this number? Use what you have learned about powers of ten to explain why.

2. Complete the table. Identify any patterns you see.

Shorter Form Using Exponents	Expanded Form	Product
9×10^1	9×10	90
9×10^2	$9 \times 10 \times 10$	
9×10^3		9000
	$9 \times 10 \times 10 \times 10 \times 10$	
9×10^5		
		9,000,000
	$9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$	

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Name _____ Date _____

✓ Check-In: Questions 3-4

3. Luis made a table to show the estimated distance each planet is from the sun. He forgot to complete some of this table. Use what you know about writing numbers in expanded form and in shorter form using exponents to complete the table.

Planet	Approximate Distance from the Sun (miles)	Distance from the Sun Expanded Form	Distance from the Sun Using Exponents
Mercury	40,000,000	$4 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 =$	
Venus	70,000,000		7×10^7
Earth	90,000,000	$9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 =$	
Mars	100,000,000		
Jupiter	500,000,000		5×10^8
Saturn	900,000,000		
Uranus	2,000,000,000		2×10^9
Neptune	3,000,000,000		

4. The NASA Apollo missions included six manned spacecraft landings on the moon. The average distance between the earth and the moon is about 200,000 miles.

   A. How many total miles were traveled to complete the six manned landings? Show or tell how you found your answer.

   B. Round your answer to the nearest million. Write the number in standard form, expanded form, and in shorter form using an exponent.

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Student Activity Book

Multiply by Multiples of Ten
Questions 1–4 (SAB pp. 135–136)

1. **A.*** 90,000,000

   B.* There are seven zeros. Possible response: Since you multiply by 10 seven times you will have seven zeros in the answer—one for each ten.)

2.*

Shorter Form Using Exponents	Expanded Form	Product
9×10^1	9×10	90
9×10^2	$9 \times 10 \times 10$	**900**
9×10^3	**$9 \times 10 \times 10 \times 10$**	9000
9×10^4	$9 \times 10 \times 10 \times 10 \times 10$	**90,000**
9×10^5	**$9 \times 10 \times 10 \times 10 \times 10 \times 10$**	**900,000**
9×10^6	**$9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$**	9,000,000
9×10^7	$9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$	**90,000,000**

3.*

Planet	Approximate Distance from the Sun (miles)	Distance from the Sun Expanded Form	Distance from the Sun Using Exponents
Mercury	40,000,000	$4 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 =$	**4×10^7**
Venus	70,000,000	**$7 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 =$**	7×10^7
Earth	90,000,000	$9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 =$	**9×10^7**
Mars	100,000,000	**$1 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$**	**1×10^8**
Jupiter	500,000,000	**$5 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$**	5×10^8
Saturn	900,000,000	**$9 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$**	**9×10^8**
Uranus	2,000,000,000	**$2 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$**	2×10^9
Neptune	3,000,000,000	**$3 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$**	**3×10^9**

4. **A.** 2,400,000 miles; Possible response: I multiplied $6 \times 200{,}000 = 1{,}200{,}000$ and then I doubled that since they had to travel both ways 1,200,000 doubled is 2,400,000 miles.

   B. 2,000,000, $2 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 2{,}000{,}000$; 2×10^6

*** Answers and/or discussion are included in the lesson.**