Whole-number Exponents and Perfect Squares

Strand: Number and Number Sense

Topic: Investigating positive exponents and perfect squares

Primary SOL: 6.4 The student will recognize and represent patterns with whole number exponents and perfect squares.

Related SOL 6.3c

Materials

- Perfect Square Grids activity sheet (attached)
- Perfect Square Grids Key (attached)
- Perfect Squares Chart activity sheet (attached)
- Multiplication Table (attached)
- Recognize Powers of 10 activity sheet (attached)
- Markers, crayons, or colored pencils in at least nine different colors

Vocabulary

powers, exponents, base, square root, perfect square, exponential notation (6.4)

Student/Teacher Actions: What should students be doing? What should teachers be doing?

1. Distribute the Perfecting Square Grids activity sheet and markers, crayons, or colored pencils so that each student has nine different colors. For each grid on the handout, have students shade the boxes along the diagonal from bottom left to top right, using a different color for each grid. Have students write down their observations about each grid (e.g., number of blocks along the diagonal, numbers of blocks on the vertical and horizontal, total number of blocks, way to calculate the total number of blocks).
2. Question students about their observations. They should notice that each grid forms a square. Ask why they are classified as squares. (Width and length are the same.) Also, they should notice that whatever numbers of blocks are along the diagonal corresponds with the number of blocks in the vertical rows and in the horizontal rows.
3. Distribute the multiplication charts and display a large version of the chart. Ask students how each of the grids can be modeled on the multiplication chart. Ask whether they can use the multiplication chart to depict other "square relationships" that are not on the grids. Explain that each square was derived from multiplying a number by itself, producing a "perfect square."
4. At this point, have students incorporate their notes by explaining/reviewing how to rewrite $9 \cdot 9$, written as "9 x 9" in previous grades, in condensed form as 9^2. Have them complete their notes by naming *x* as the base and *n* as the exponent (which is exponential form or exponential notation). Tell them how to read it ("nine squared" or "nine to the second power").
5. Distribute the Perfect Squares Chart, and have students complete it.
6. Distribute the Recognize Powers of 10 activity sheet. Students will recognize powers of 10 with whole-number exponents by examining patterns in place value. Model and discuss how to complete the table. Students must find the missing values to complete the table

using the patterns that they observe. Once students have completed the table, they should provide a response to the two prompts given. Discuss students' findings as a whole group.

7. Similar to the Recognize Powers of 10 activity sheet, have students expand and compute using bases and exponents that are whole numbers to determine any patterns that exist.
8. Ask students to describe the connection between perfect squares and the area model. Discuss with students the patterns they see as they identify perfect squares using the Multiplication Chart. Ask students what observations they see between the Multiplication Chart and the Perfect Square Grids. Facilitate a discussion with students as to why some numbers are considered perfect squares (e.g., 25, 36) and why others (e.g., 15, 18) are not. This difference can be modeled using grid paper or square tiles. Help students to recognize that the areas of these numbers are determined by their factors. However, the area does not create a perfect square; instead, a rectangular model is formed.

Assessment

- **Questions**
  - How can the area model be used to relate perfect squares to multiplication?
  - Using square tiles or grid paper, can you model why the numbers 6 and 12 are *not* perfect squares? Explain and justify your reasoning.
  - Using square tiles or grid paper, can you model why the numbers 16 and 49 are perfect squares? Explain and justify your reasoning.
  - Is zero to the zero power (0^0) a perfect square?
  - Why is any real number other than zero raised to the zero power 1?
- **Journal/writing prompts**
  - Derrick stated, "The number 225 is not a perfect square because it is an odd number." Sarah stated, "You are incorrect. The number 225 is a perfect square. In fact, there can be even and odd numbers that are perfect squares." Explain who is correct in this scenario and justify your reasoning using a concrete representation, pictorial representation, examples, and/or counterexamples.
  - Suppose you are given 10^2, 10^3, and 10^4. Provide the next three terms in the pattern and explain how you arrived at your answer.
- **Other Assessments**
  - Have students create a scenario where they must justify their identification of a perfect square using an area model, a concrete representation, or an algorithm.
  - Have students create a commercial about perfect squares, representing patterns with whole-number exponents, and/or powers of 10.

Extensions and Connections (for all students)

- Provide other numerical examples of positive exponents with powers greater than 2.
- Assist students in recognizing how the exponent is related to powers of 10.

Strategies for Differentiation

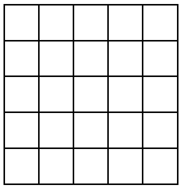
- Some students may need to use the Multiplication Chart throughout the lesson to complete the perfecting squares grids.

- Some students may need to number the blocks to see a connection between the grid and the Multiplication Chart.
- Preteach/review necessary vocabulary for some students, as needed.
- Provide two or three examples in the Expanded Form column of the Recognize Powers of 10 activity sheet, if necessary, for some students.
- Work with a peer on the Perfect Square Grids activity sheet to make their observations and discoveries orally.

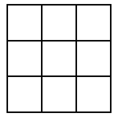
Note: The following pages are intended for classroom use for students as a visual aid to learning.

Perfect Square Grids

Name ______________________________________ **Date** ________________________



Observations



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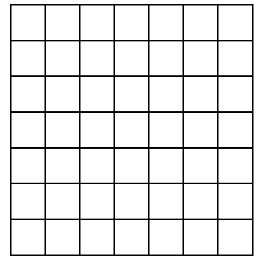

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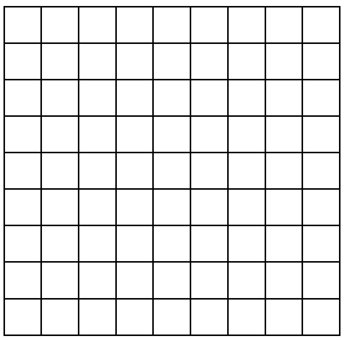

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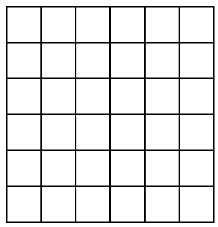

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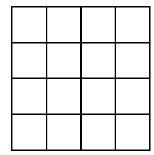

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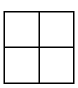

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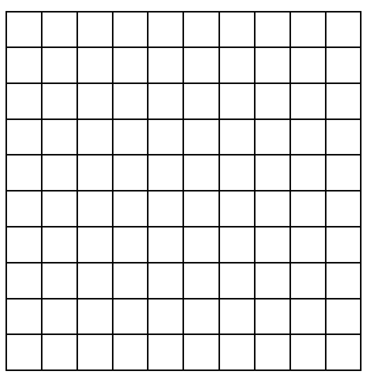

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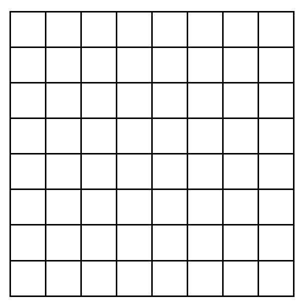
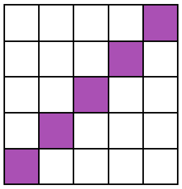
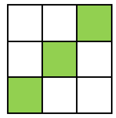


Observations

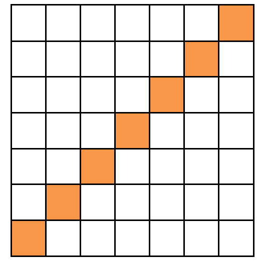
Perfect Square Grids Observations



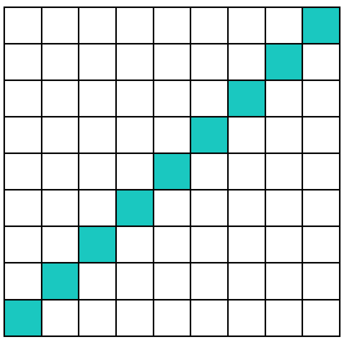
Observations
Number of blocks along the diagonal is 5.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 25, which is also the product of the length and width.



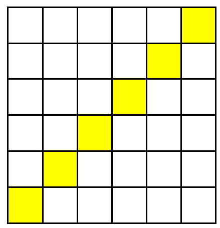
Observations
Number of blocks along the diagonal is 3.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 9, which is also the product of the length and width.



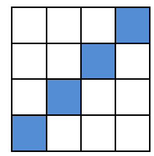
Observations
Number of blocks along the diagonal is 7.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 49, which is also the product of the length and width.



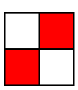
Observations
Number of blocks along the diagonal is 9.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 81, which is also the product of the length and width.



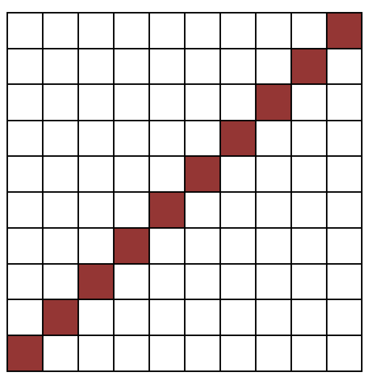
Observations
Number of blocks along the diagonal is 6.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 36, which is also the product of the length and width.



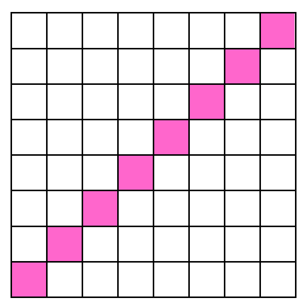
Observations
Number of blocks along the diagonal is 4.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 16, which is also the product of the length and width.



Observations
Number of blocks along the diagonal is 2.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 4, which is also the product of the length and width.



Observations
Number of blocks along the diagonal is 10.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 100, which is also the product of the length and width.



Observations
Number of blocks along the diagonal is 8.
Numbers of blocks on the vertical and horizontal are the same.
Total number of blocks is 64, which is also the product of the length and width.

Perfect Squares Chart

Name ___________________________________ Date ______________________

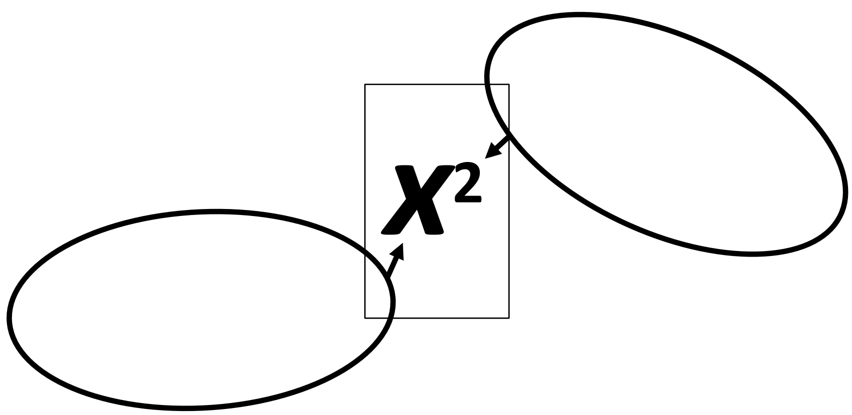
How can I write 9 · 9 in exponential notation? _______

This can be read as "_____________________" or "________________________."

How can I write 4 · 4 in exponential notation? _______

This can be read as "_____________________" or "________________________."

What are the parts called?



Perfect Squares							
n	n^2	*n*	n^2	*n*	n^2	*n*	n^2
0							
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

Recognize Powers of 10

Name ________________________________ **Date** ____________________

Determine the missing values to complete the table by examining patterns in place value.

Exponential Notation	Expanded Form	Value
10^0		1
10^1		10
10^2		100
10^3		________________
_____		10,000
10^5		________________
10^6		________________
_____		________________
10^8		________________
_____		________________
_____		10,000,000,000
10^{11}		________________
_____		________________

Explain the patterns in place value you observe.

Based on this pattern, what is the value of 10^{15}? Explain your reasoning.

Multiplication Table

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	1	2	3	4	5	6	7	8	9	10	11	12
2	2	4	6	8	10	12	14	16	18	20	22	24
3	3	6	9	12	15	18	21	24	27	30	33	36
4	4	8	12	16	20	24	28	32	36	40	44	48
5	5	10	15	20	25	30	35	40	45	50	55	60
6	6	12	18	24	30	36	42	48	54	60	66	72
7	7	14	21	28	35	42	49	56	63	70	77	84
8	8	16	24	32	40	48	56	64	72	80	88	96
9	9	18	27	36	45	54	63	72	81	90	99	108
10	10	20	30	40	50	60	70	80	90	100	110	120
11	11	22	33	44	55	66	77	88	99	110	121	132
12	12	24	36	48	60	72	84	96	108	120	132	144