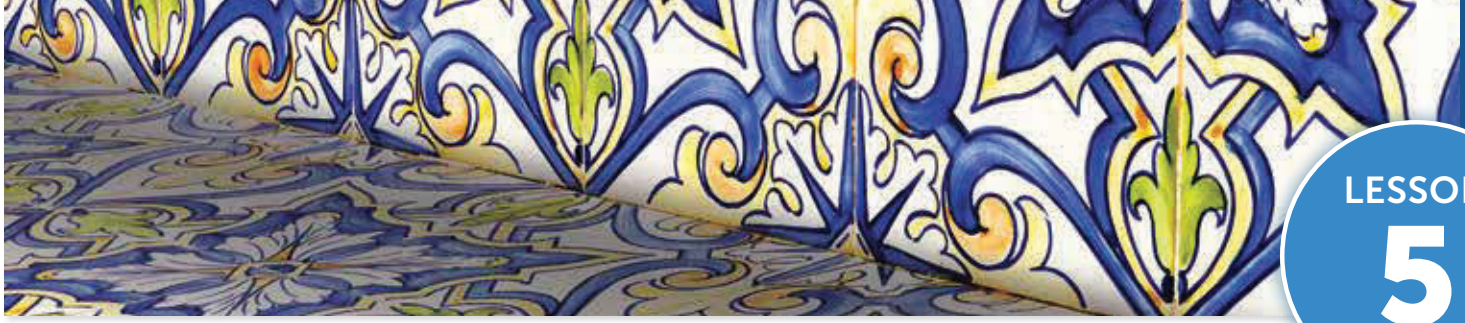


LESSON 5



## Dear Family,

This week your student is learning how to evaluate expressions with exponents.

Exponents are used to represent repeated multiplication. One way to show this is with a **power**. The **base** is the number you are multiplying. The **exponent** is the number of times the base is a factor.

base → $5^4$ ← exponent $= 5 \cdot 5 \cdot 5 \cdot 5$

power

5 is a factor 4 times.

To evaluate expressions with exponents, use the order of operations. Exponents represent multiplication, so evaluate powers before you add or subtract.

Your student will be learning how to evaluate expressions like the one below.

> Evaluate the expression $10 + 3^4$.

➤ **ONE WAY** to find the value of an expression with an exponent to rewrite the power as repeated multiplication. Then multiply from left to right.

$10 + 3^4 = 10 + 3 \cdot 3 \cdot 3 \cdot 3$

$= 10 + 9 \cdot 3 \cdot 3$

$= 10 + 27 \cdot 3$

$= 10 + 81$

$= 91$

➤ **ANOTHER WAY** is to group factors before you multiply.

$10 + 3^4 = 10 + 3 \cdot 3 \cdot 3 \cdot 3$

$= 10 + (3 \cdot 3) \cdot (3 \cdot 3)$

$= 10 + 9 \cdot 9$

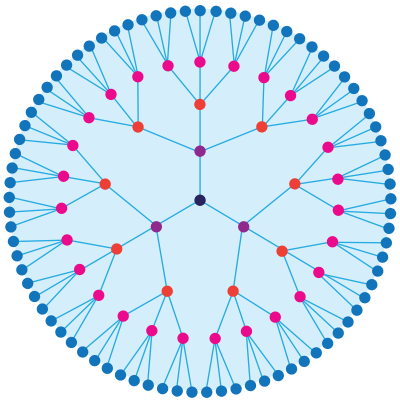
$= 10 + 81$

$= 91$

Using either method, the value of the expression is 91.

Use the next page to start a conversation about exponents.

# Activity Thinking About Exponents



➤ **Do this activity together to look for patterns in evaluating expressions with exponents.**

Look at these three sets of powers.

What pattern do you notice in each set?

**SET 1**

$3^1 = 3$

$3^2 = 3 \cdot 3 = 9$

$3^3 = 3 \cdot 3 \cdot 3 = 27$

$3^4 = 3 \cdot 3 \cdot 3 \cdot 3 = 81$

**SET 2**

$0^2 = 0 \cdot 0 = 0$

$1^2 = 1 \cdot 1 = 1$

$2^2 = 2 \cdot 2 = 4$

$3^2 = 3 \cdot 3 = 9$

$4^2 = 4 \cdot 4 = 16$

**SET 3**

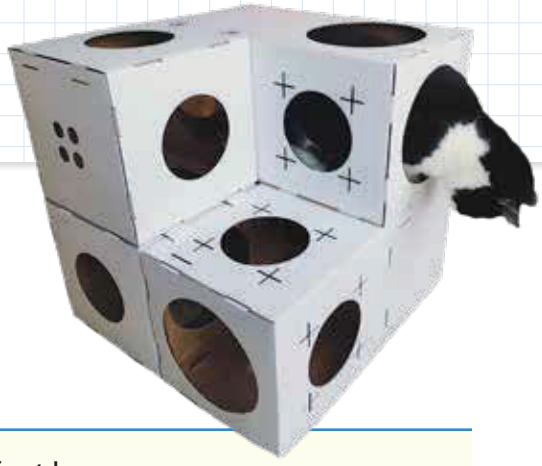
$\left(\frac{1}{2}\right)^2 = \frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$

$\left(\frac{1}{3}\right)^2 = \frac{1}{3} \cdot \frac{1}{3} = \frac{1}{9}$

$\left(\frac{2}{3}\right)^2 = \frac{2}{3} \cdot \frac{2}{3} = \frac{4}{9}$

? Do you notice any patterns between two of the sets?

# **Explore** Expressions with Exponents



Previously, you learned about using exponents to write powers of 10. In this lesson, you will learn about using exponents in both numerical and algebraic expressions.

➤ **Use what you know to try to solve the problem below.**

David builds a house for his cat using cubes with edges that are 1 foot long. He builds the house by making 4 layers of cubes. Each layer is made up of 4 rows and 4 columns of cubes. How many cubes does David use for the house?

**TRY IT**

**Math Toolkit** connecting cubes, grid paper, isometric dot paper, unit cubes

**DISCUSS IT**

***Ask:*** What strategy did you use to find the number of cubes?

***Share:*** I found the number of cubes by . . .

**Learning Targets** SMP 1, SMP 2, SMP 3, SMP 4, SMP 5, SMP 6, SMP 8

- Write and evaluate numerical expressions involving whole-number exponents.
- Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole-number exponents, in the conventional order when there are no parentheses to specify a particular order.

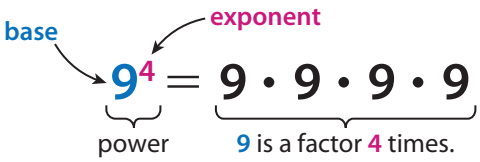
## CONNECT IT

**1 Look Back** How many cubes does David use for the house? How can you find the number of cubes?

**2 Look Ahead** One way to solve the **Try It** problem is to use repeated addition. Another way is to use repeated multiplication.

**a.** You can show repeated multiplication with an **exponent**. You have used exponents with powers of 10. Write the **power** $10^5$ as repeated multiplication.

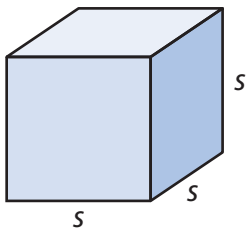
**b.** You can also write powers with numbers other than 10 as the **base**. What are the base and exponent in the power $3^8$? Write $3^8$ as repeated multiplication.




**c.** What are the base and exponent in the power $3^1$? Write $3^1$ without an exponent.

**d.** You can also use exponents with variables. Use the variable $s$ to represent the edge length of a cube. Then the volume formula $V = \ell wh$ becomes $V = s \cdot s \cdot s$, or $V = s^3$.

The house that David builds for his cat is a cube with an edge length of 4 ft. Show how to use the volume formula $V = s^3$ to find the volume of the house.




**3 Reflect** How are the expressions $2^7$ and $2 \cdot 7$ alike? How are they different?

 Name:

# **Prepare for** Writing and Evaluating Expressions with Exponents

1 Think about what you know about powers of 10. Fill in each box. Use words, numbers, and pictures. Show as many ideas as you can.

**power of 10**

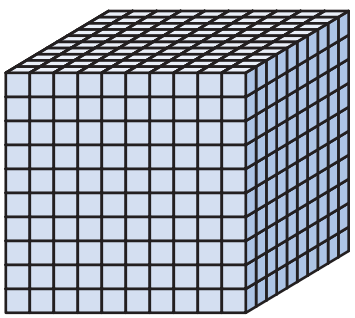
**In My Own Words**

**What I Know About It**

**Examples**

**Non-Examples**

2 What power of 10 can you write to show the number of small cubes in the model? Explain.

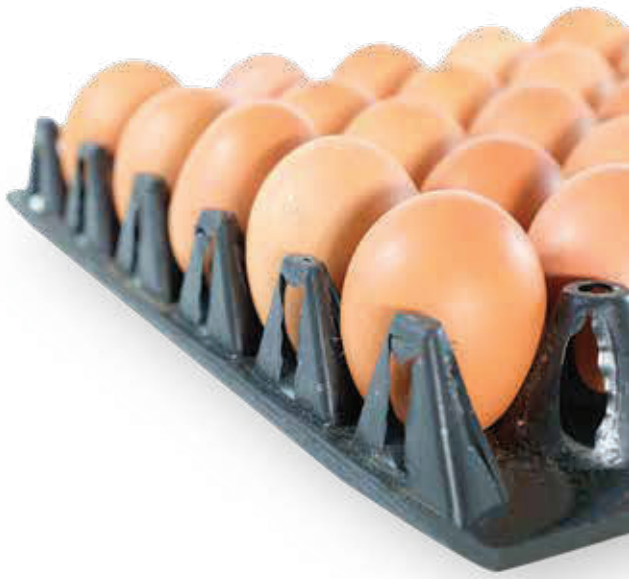


3 A restaurant keeps eggs in a rack that has 5 layers. Each layer has 5 rows, with 5 eggs in each row.

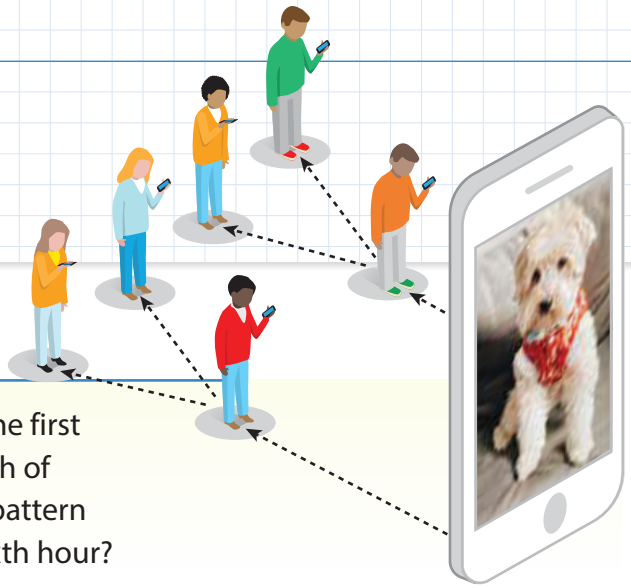
**a.** How many eggs does each 5-layer rack hold? Show your work.

**SOLUTION** _____

**b.** Check your answer to problem 3a. Show your work.



# **Develop** Writing and Evaluating Expressions with Exponents



➤ **Read and try to solve the problem below.**

Kendra posts a photo on her social media account. In the first hour, 2 friends share the photo. In the second hour, each of those friends have 2 friends who share the photo. The pattern continues. How many people share the photo in the sixth hour?

**TRY IT**

**Math Toolkit** connecting cubes, counters, grid paper

**DISCUSS IT**

***Ask:*** What did you do first to figure out how many people share the photo in the sixth hour?

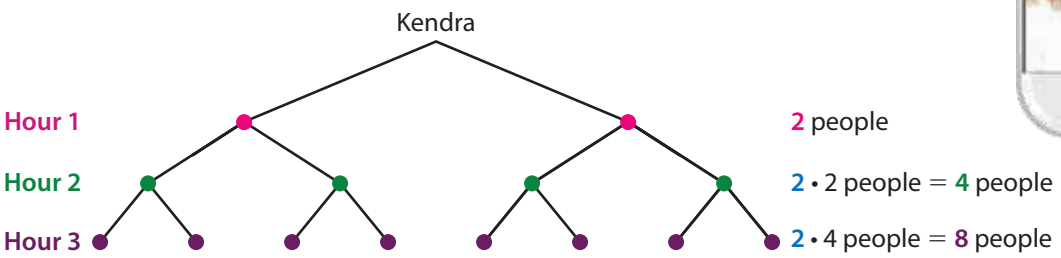
***Share:*** First I . . .

➤ **Explore different ways to write and evaluate expressions with exponents.**

Kendra posts a photo on her social media account. In the first hour, 2 friends share the photo. In the second hour, each of those friends have 2 friends who share the photo. The pattern continues. How many people share the photo in the sixth hour?

## Picture It

You can use a tree diagram to find a pattern with repeated multiplication.




## Model It

You can use an exponent to represent repeated multiplication as a power.

Each hour, the number of people who share the photo increases by a factor of 2.

| Hour | Number of People Who Share Photo | Written as a Power |
|---|---|---|
| 1 | 2 | $2^1$ |
| 2 | 2 • 2 | $2^2$ |
| 3 | 2 • 2 • 2 | $2^3$ |
| 4 | 2 • 2 • 2 • 2 | $2^4$ |
| 5 | 2 • 2 • 2 • 2 • 2 | $2^5$ |
| 6 | 2 • 2 • 2 • 2 • 2 • 2 | ? |

## CONNECT IT

**Use the problem from the previous page to help you understand how to write and evaluate expressions with exponents.**

1. Look at the tree diagram in the **Picture It**. How many dots would there be in a row for Hour 4? Explain.

2. Explain how to use the number of people shown by one row of the tree diagram to find the number people in the next row of the tree diagram.

3. Look at the table in **Model It**. Write the number of people who share the photo in the sixth hour as a power of 2. How many people share the photo in the sixth hour?

4. Alexis finds the value of $2^6$ by writing $4 \cdot 4 \cdot 4$. Xavier finds the value of $2^6$ by writing $8 \cdot 8$. Why are both expressions ways to find $2^6$?

5. Write the number of people who share the photo in Hour 9 as a power of 2. How do you know what number to use as the exponent?

6. **Reflect** Think about all the models and strategies you have discussed today. Describe how one of them helped you better understand how to solve the **Try It** problem.

## Apply It

**Use what you learned to solve these problems.**

**7** Which expression is equivalent to $7 \times 7 \times 7 \times 3 \times 3$?

**A** $3^7 \times 2^3$

**B** $7^7 \times 3^3$

**C** $7^3 \times 3^2$

**D** $21^3 \times 6^2$

**8** Evaluate $n^3$ when $n = \frac{2}{3}$. Show your work.

**SOLUTION** _____

**9** On the Lucky Five game show, Troy wins $5 if he answers one question correctly. Each time he answers another question correctly without making a mistake, the amount of money he wins is multiplied by 5. Troy answers 6 questions correctly without making a mistake. His winnings are represented by the expression $5^6$. How much money does Troy win? Show your work.


**SOLUTION** _____

# Practice Writing and Evaluating Expressions with Exponents

➤ **Study the Example showing how to write and evaluate an expression with an exponent. Then solve problems 1–6.**

## Example

**On the first day, one person texts a compliment to 3 people. On the second day, each of these 3 people texts a compliment to 3 new people. The pattern continues. How many people receive a compliment on the eighth day?**

Use a table to look for a pattern.

The number of people who receive a compliment each day is 3 times the number of people from the day before.

| Day | Number of People Who Receive a Compliment | Written as a Power |
|---|---|---|
| 1 | 3 | $3^1$ |
| 2 | 3 • 3 | $3^2$ |
| 3 | 3 • 3 • 3 | $3^3$ |
| 4 | 3 • 3 • 3 • 3 | $3^4$ |

The pattern shows that $3^8$ people receive a compliment on Day 8.

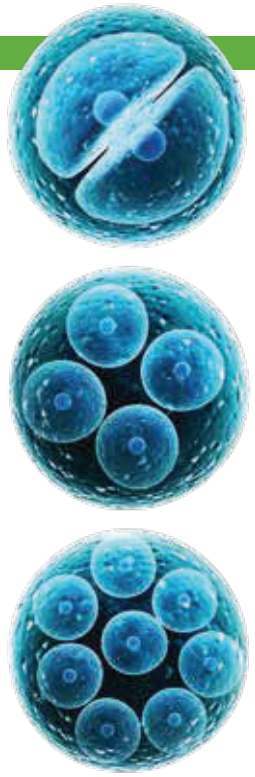
$$3^8 = (3 \cdot 3) \cdot (3 \cdot 3) \cdot (3 \cdot 3) \cdot (3 \cdot 3)$$
$$= (9 \cdot 9) \cdot (9 \cdot 9)$$
$$= 81 \cdot 81$$
$$= 6{,}561$$

On the eighth day, 6,561 people receive a compliment.

1 Suppose the pattern in the Example continues. Write the number of people who receive a compliment on the ninth day as a power of 3. How many people receive a compliment on the ninth day? Show your work.

**SOLUTION** _____

2 Look at how $3^8$ is evaluated in the Example. Write $3^8$ as a power with a base of 81.



3 A scientist places a cell in a Petri dish. At the end of 1 hour, the cell divides so that there are 2 cells in the Petri dish. At the end of 2 hours, those cells divide so there are 4 cells in the Petri dish. The cells continue to divide this way every hour. Use the expression $2^{10}$ to find the number of cells in the Petri dish after 10 hours. Show your work.

**SOLUTION** _____

4 Write 7 • 7 • 7 • 7 • 7 as a power. Then find the product. Show your work.

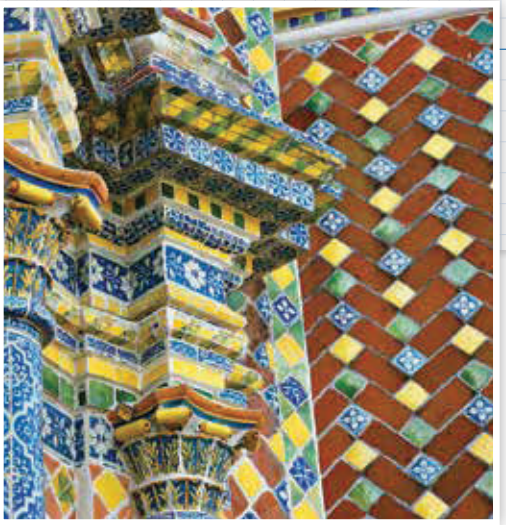
**SOLUTION** _____

5 Evaluate $n^4$ for $n = \frac{3}{4}$. Show your work.

**SOLUTION** _____

6 Paula says that $3^4 = 4^3$. Do you agree or disagree? Explain.

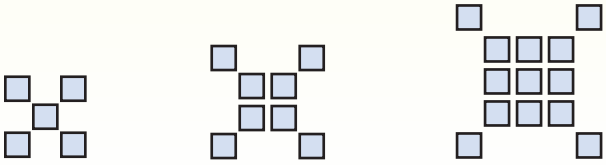
# **Develop** Using Order of Operations with Expressions with Exponents



➤ **Read and try to solve the problem below.**

Puebla, Mexico has been known for its Talavera tiles since the 1500s. Today, artists in the United States use Talavera tiles on buildings and walkways.

Three stages of a pattern with tiles are shown below.
How many tiles are needed to make Stage 40 of the pattern?




**TRY IT**

**Math Toolkit** grid paper, unit tiles

**DISCUSS IT**

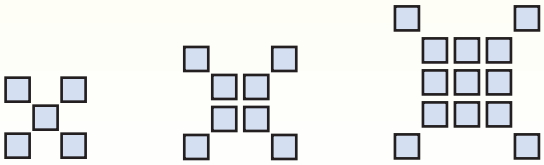
***Ask:*** How does your strategy show or describe the tile pattern?

***Share:*** My strategy shows . . .

➤ **Explore different ways to understand using order of operations when evaluating expressions with exponents.**

Puebla, Mexico has been known for its Talavera tiles since the 1500s. Today, artists in the United States use Talavera tiles on buildings and walkways.

Three stages of a pattern with tiles are shown below. How many tiles are needed to make Stage 40 of the pattern?



Stage 1 Stage 2 Stage 3

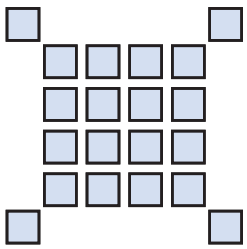
## Model It

You can write numerical expressions with exponents to represent the pattern.

In every stage, the first and last row of tiles have a total of 4 tiles.

The other rows of tiles form a square.

| Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|
| $4 + 1$ | $4 + 2 \cdot 2$ | $4 + 3 \cdot 3$ | $4 + 4 \cdot 4$ |
| $4 + 1^2$ | $4 + 2^2$ | $4 + 3^2$ | $4 + 4^2$ |



Stage 4

## Model It

You can write an algebraic expression to represent the pattern.

Use the variable $n$ to represent the stage number.

The number of tiles in the inner square is $n \cdot n$, or $n^2$.

There are 4 additional tiles at the corners.

So, the total number of tiles in Stage $n$ is $4 + n^2$.

## CONNECT IT

**Use the problem from the previous page to help you understand using the order of operations when evaluating expressions with exponents.**

1. Look at the first **Model It**. Jayden evaluated the expression $4 + 3^2$ by adding first to get $7^2$. Use the order of operations to explain Jayden's error.

2. Place parentheses in the expression $4 + 3^2$ so that the value of the expression is $7^2$.

3. Evaluate $4 + n^2$ when $n = 40$. How many tiles are in Stage 40 of the pattern?

4. The expression $4 + n^2$ represents adding 4 to a power. Now think about multiplying a power by 4.

   **a.** Write $4 \cdot n^2$ and $(4 \cdot n)^2$ without exponents.

   **b.** Should you think of $4n^2$ as $4 \cdot n^2$ or as $(4n)^2$? Explain your reasoning.

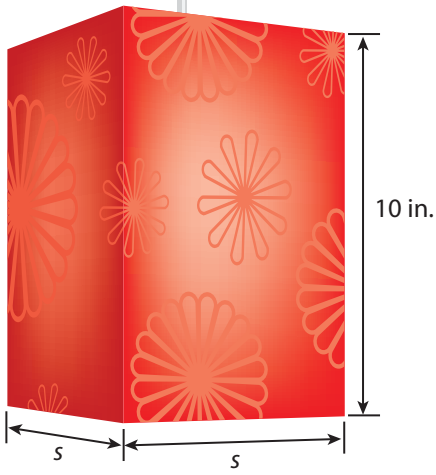
5. Describe the order of operations you would use to evaluate $8 + 4(3^2)$.

6. How do exponents fit into the order of operations?

7. **Reflect** Think about all the models and strategies you have discussed today. Describe how one of them helped you better understand how to use order of operations to evaluate expressions with exponents.

## Apply It

**Use what you learned to solve these problems.**




**8** Tamera is using rice paper to make Japanese lanterns. The expression $2s^2 + 40s$ represents the surface area of a lantern where the base edges are $s$ inches long. What is the surface area of a lantern when $s$ is 9 in.? Show your work.

**SOLUTION** _____

**9** What is the value of the expression $5(3^3 - 4)$? Show your work.

**SOLUTION** _____

**10** What is the value of $m + 4n^2 - 5q + 4$ when $m = 5$, $n = 2$, and $q = 3$?

**A** 2

**B** 10

**C** 25

**D** 58

# **Practice** Using Order of Operations with Expressions with Exponents

➤ **Study the Example showing how to evaluate an expression with exponents and parentheses. Then solve problems 1–6.**

## Example

**What is the value of the expression $4(5 - 2)^2 + 5^3$?**

Use the order of operations to evaluate the expression.

| | |
|---|---|
| Subtract inside the parentheses. | $4(5 - 2)^2 + 5^3 = 4(3)^2 + 5^3$ |
| Evaluate the powers. | $= 4(9) + 125$ |
| Multiply. | $= 36 + 125$ |
| Add. | $= 161$ |

1. What is the value of the expression $5(2^3 - 3)$? Show your work.

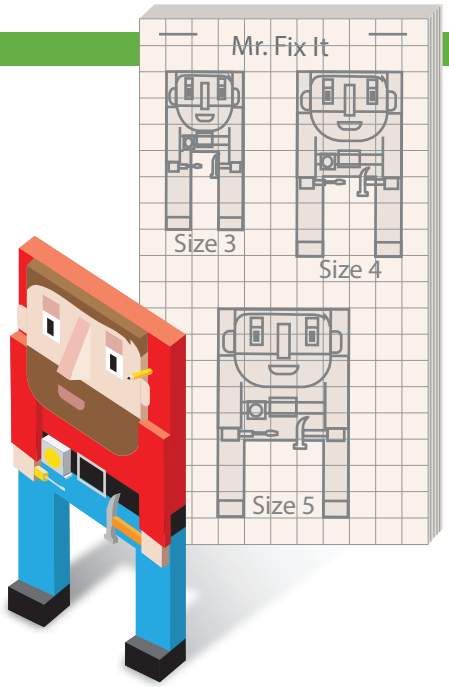
**SOLUTION** _____

2. Miguel writes the expression $2n^4$. He says that when you double the value of $n$, you double the value of the expression. Do you agree or disagree? Explain.

3. Evaluate the expression $1^4 + 3(10 - 2)^2$. Show your work.

**SOLUTION** _____

4 Zhen designs a character for a video game. He draws three sizes of the character on grid paper. Zhen use the expression $6 + s^2$ to find the number of grid squares in a character of any size $s$. Find the number of grid squares in a character of size 7. Show your work.




**SOLUTION** _____

5 Evaluate the expression $p^3 - q^4 + 3r \div 2$ for $p = 6$, $q = 2$, and $r = 4$. Show your work.

**SOLUTION** _____

6 You can use the formula $A = 6s^2$ to find the surface area of a cube with edge length $s$. A cube has edges that are 10 in. long. What is the surface area of the cube? Show your work.

**SOLUTION** _____

# **Refine** Writing and Evaluating Expressions with Exponents

➤ **Complete the Example below. Then solve problems 1–10.**

## Example

**Write an expression that is equal to 36 using each number and symbol below exactly one time in the expression.**

5 8 8 $^2$ ÷ + ( )

Look at how you could use reasoning and the order of operations to make an expression whose value is 36.

I know that $6 \times 6 = 36$, and that $6^2 = 36$.

That means I can use 5, 8, 8, ÷, and + to write an expression with a value of 6. Then I can put parentheses around the expression and square it to make 36.

I know that $8 \div 8 = 1$ and $5 + 1 = 6$.

**SOLUTION** _____

**CONSIDER THIS . . .**
How can the order of operations help you write an expression that has the correct value?

**PAIR/SHARE**
How would the value of your expression change if you removed the parentheses?

## Apply It

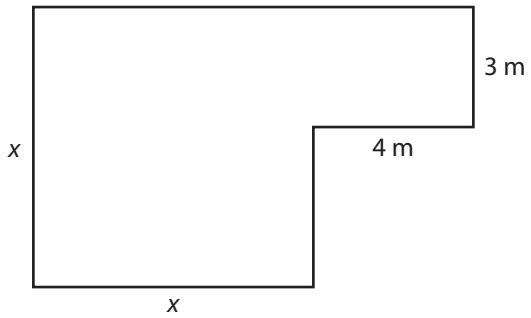
1 What is the value of the expression $(0.1)^3$? Show your work.

**CONSIDER THIS . . .**
Should the value of $(0.1)^3$ be greater than or less than 0.1?

**PAIR/SHARE**
How can you check your answer by writing $0.1^3$ as $\left(\frac{1}{10}\right)^3$?

**SOLUTION** _____

**2** An architect is trying different dimensions for the room shown below. Write an algebraic expression the architect can use to find the area of the room. Then find the area when $x$ is 6 m. Show your work.




**CONSIDER THIS . . .**
How can you decompose the room into triangles, rectangles, or squares?

**PAIR/SHARE**
How can you check that your answer is reasonable?

**SOLUTION**

**3** What is the value of $2 + b(a^2 + 4)$ when $a = 2$ and $b = 4$?

**A** 22

**B** 34

**C** 2

**D** 48

Zara chose D as the correct answer. How might she have gotten that answer?

**CONSIDER THIS . . .**
Which part of the expression would you evaluate first?

**PAIR/SHARE**
Where would you insert parentheses in the expression to make its value one of the other answer choices?

**4** Which expressions have a value of 100 when $m = 5$? Select all that apply.

**A** $2m^2 + 50$

**B** $(2m)^2 + 50$

**C** $(m + 5)^2$

**D** $m^3 \div 5 \cdot 4$

**E** $4m^2$

**F** $(4m)^2$

**5** Write $3^8$ as a power with a base of 9. Show your work.

**SOLUTION** _____

**6** What is the value of the expression $x^3 - 1{,}750$ when $x = 30$? Show your work.

**SOLUTION** _____

**7** What is the value of the expression $3[4(3^2 - 7)] - 4^2$? Show your work.

**SOLUTION** _____

**8** There are 32 teams in the first round of a basketball tournament. One half of the teams that play in each round of the tournament move on to play in the next round.

**a.** Explain why the expression $32 \times \left(\frac{1}{2}\right)^3$ represents the number of teams that play in the fourth round.

**b.** How many teams play in the fourth round? Show your work.

**Smithtown**
**Basketball Tournament**

**32 Teams**
Winner of each game moves forward to next round.

**Cheer your team to the finals!**

**SOLUTION** _____

**9** The value of $2^{14}$ is how many times as great as the value of $2^{11}$? Explain.

**10** **Math Journal** Write an expression that is equal to 8 using each number and symbol below exactly one time in the expression. Explain your thinking.

1 2 3 $^3$ + − ( )

## End of Lesson Checklist

- ☐ **INTERACTIVE GLOSSARY** Find the entry for *power*. Add another example and label the exponent and base in your example.
- ☐ **SELF CHECK** Go back to the Unit 1 Opener and see what you can check off.