CITYTUTOR DC

Eighth Grade Math Lesson Materials

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CITYTUTOR DC

G8 Unit 5:

Exponents and Scientific Notation

G8 U5 Lesson 1

Compare quantities using expressions that represent repeated multiplication, and comprehend that repeated division of a number is equivalent to repeated multiplication by its reciprocal.

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G8 U5 Lesson 1 - Students will compare quantities using expressions that represent repeated multiplication, and comprehend that repeated division of a number is equivalent to repeated multiplication by its reciprocal.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): Today is our first lesson in our unit that's all about exponents and scientific notation. We'll learn more about scientific notation in later lessons, but I imagine you're already somewhat familiar with the idea of exponents from earlier grades. What do you already know about exponents? Possible Student Answers, Key Points:

- I know they are represented by a little number at the top right corner of a larger number.
- I know the larger number is called the base.
- They tell us how many times to multiply the base by itself.

Let's explore more about exponents. Today, we'll compare quantities using expressions that represent repeated multiplication, and we'll see how we can use exponents to help us think about repeated division.

Let's Talk (Slide 3): Before we jump into some problems, take a look at the four cards here. *(pause)* After looking at them, try to think of a reason why one of the cards doesn't belong and the other three do belong. Depending on how you think about the cards, you might have more than one idea. Possible Student Answers, Key Points:

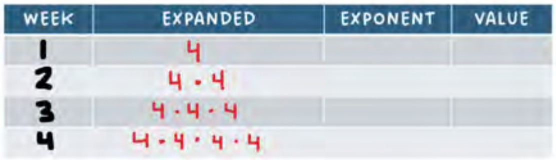
- The yellow card doesn't belong because it is the only one that shows an exponential expression in expanded form.
- The red card doesn't belong because it is the only one that operates with a value of 3.
- The blue card doesn't belong because it is the only one that deals with addition.
- The green card doesn't belong because it is the only one that includes an exponent.

Great ideas! Let's look closely at the yellow and the green cards, since those most directly relate to our upcoming work with exponents. The green card shows 2 to the third power. We call 2 the base, and 3 is the exponent. We know that when we have 2 to the third power, that means we multiply 2 by itself three times. So the yellow card is equivalent to the green card, just in expanded form. What is the value of 2 to the third power? How do you know? Possible Student Answers, Key Points:

- The value of 2 to the third power is 8.
- I know 2 x 2 is 4, and I know 4 times another 2 is 8.

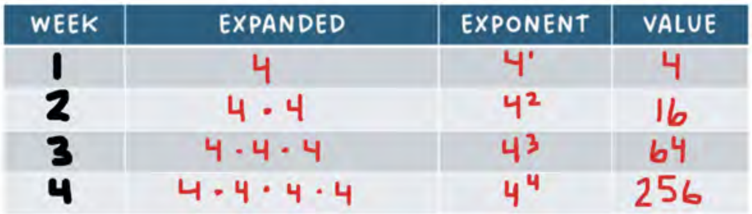
Nice work. Let's work on some problems involving exponents together.

Let's Think (Slide 4): This problem wants us to think about how exponents show up in a real-world scenario. *(read the problem aloud)* When we double something, we multiply it by 2. When we triple something, we multiply it by 3. When we quadruple something, like in this problem, we multiply it by 4. Let's work together to fill in the table.



WEEK	EXPANDED	EXPONENT	VALUE
1	4		
2	4 · 4		
3	4 · 4 · 4		
4	4 · 4 · 4 · 4		

In week 1, they only earned 4 dollars. *(write 4 in the expanded column)* In week 2, they want to quadruple that amount, or multiply it by 4. *(write 4 • 4 in expanded column)* In week 3, they want to quadruple their money from week 2. I can write that by writing 4 • 4 then times 4 again. *(fill the expression in the expanded column)* These expressions are in expanded form, because we can see every factor being multiplied. How could I write the expression for week 4 in expanded form? (4 • 4 • 4 • 4) *(fill in table)*

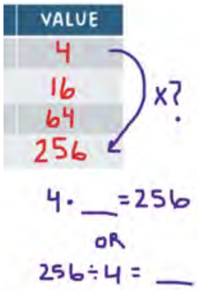


WEEK	EXPANDED	EXPONENT	VALUE
1	4	4^1	4
2	4 • 4	4^2	16
3	4 • 4 • 4	4^3	64
4	4 • 4 • 4 • 4	4^4	256

We can write each of these expanded values using an exponent, since each expression involves repeated multiplication. Week 1 is just one factor of 4, so we can write that as 4 to the first power. *(write that in the exponent column)* Week 2 is two factors of 4, so we can write that as 4 to the second power. *(write that in the exponent column)* How could we write the expanded expressions from the other weeks using an exponent? How do you know? *(complete exponent column as student shares)* Possible Student Answers, Key Points:

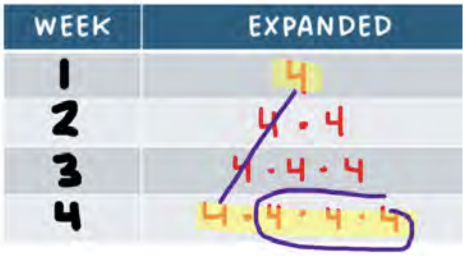
- Week 3 would be 4 to the third power, because there are 3 factors of 4.
- Week 4 would be 4 to the fourth power, because there are 4 factors of 4.

Each of our exponential expressions has the same base, 4. This makes sense, because we were multiplying factors of 4 every week. The exponent increased by one each time, since we were multiplying by an extra factor of 4 in each consecutive week. Let's fill in the values. *(fill in last column as you narrate and as student shares)* Week 1 is just 4. Week 2 is 16, because 4 times 4 is 16. What are the last two values? Use scratch paper to help you if necessary. (64 and 256)



We've completed the table. Let's look at our values closely to answer the last part that asks us how many times more money plan to earn in Week 4 than in Week 1. *(draw arrow from 4 to 256 with "x ?")* We can think of this a couple ways.

We can think 4, the value from week 1, times what number would give us 256, the value from week 4. *(write 4 • _____ = 256)* I could also think about that relationship in terms of division. Instead of 4 times something equals 256, I can think of it as 256 divided by 4 equals something. *(write 256 divided by 4 = _____)* Use either equation to figure out the value. I encourage you to use scratch paper. (64)



WEEK	EXPANDED
1	4
2	4 • 4
3	4 • 4 • 4
4	4 • 4 • 4 • 4

The value of week 4 is 64 times greater than the value of week 1. There is another way we can think of this. Let's look at the expanded form from each week. *(highlight week 1 and week 4 in expanded form)* If I want to know how many times greater week 4 is than week 1, I can look at their factors. I notice they both have one factor of 4. *(draw line to connect one factor of 4 in each expression)* How many more factors of 4 does week 4 have? (3 factors of 4) Week 4 has 3 more factors of 4, and I know 3 factors of 4 is 64. That's the same answer we got when we used the equations a minute ago. Either strategy can help us determine how many times greater one exponential value is than another.

Let's Think (Slide 5): Let's look at one more problem before we get some practice. This problem wants us to evaluate each expression. Notice, the base of each expression is a fraction.

$$\frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2}=\frac{1}{8}$$

$$\frac{1}{2\cdot2\cdot2}=\frac{1}{8}$$

Let's find ½ to the third power. I can write this as ½ times ½ times ½ , since the exponent tells me I need 3 factors of the base. *(write it out)* I know ½ times ½ is ¼, and I know ¼ times another ½ is ⅛. *(write = ⅛)*

If multiplying with fractions isn't your favorite, you may have noticed that multiplying by ½ is the same as dividing by 2. You can think of multiplying a fraction repeatedly as dividing repeatedly by the denominator. That might look like this. *(write 1 in numerator and 2 • 2 • 2 in denominator as shown)* Either representation is acceptable.

$$\frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2}=\frac{1}{16}$$

$$\frac{1}{2\cdot 2\cdot 2\cdot 2}=\frac{1}{16}$$

Help me with the other expression. How could I expand the expression to help me find the value? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- We need 4 factors of ½ since the exponent is 4. That would look like ½ times ½ times ½ times ½.
- I know ½ times ½ is ¼. I know ¼ times ½ is ⅛. I know ⅛ times ½ is 1/16.

We can think of this expression as ½ times itself four times. We could also think of it as 1 divided by 2 four times. In either case, we end up with a value of 1/16. Repeated multiplication of a unit fraction, like ½, can be thought of as repeated division of the reciprocal.

Let's Try it (Slides 6 - 7): Now let's try out a few more practice problems together before you get a chance to independently show what you know. We'll use the exponent to help us determine how many factors of the base we need to write in expanded form. We also know that if we see a fractional base, we can think of it as dividing by the reciprocal if we prefer. Let's use everything we've learned so far to tackle these next problems.

WARM WELCOME

Today we will compare quantities using expressions that represent repeated multiplication, and comprehend that repeated division of a number is equivalent to repeated multiplication by its reciprocal.

Let’s Talk:

Which one doesn’t belong? Why?

2 x 2 x 2

2 x 3

2 + 2 + 2

2^3

Let’s Think:

A drama club earned $4 the first week of their fundraiser. They want to quadruple their earnings each week for the next several weeks. Complete the table to show how much they’ll earn in Week 4.

WEEK	EXPANDED	EXPONENT	VALUE
1			
2			
3			
4			

They plan to earn __________ times as much money in Week 4 as they earned in Week 1.

Let's Think:

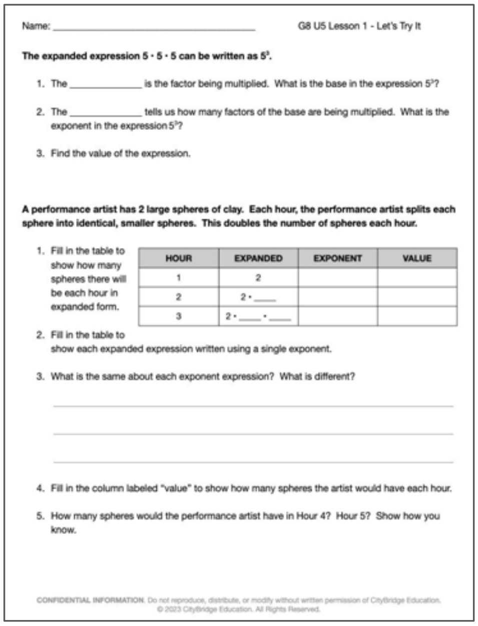
Evaluate each expression.

$(½)^3$

$(½)^4$

Let's Try It:

Let's explore comparing quantities using expressions that represent repeated multiplication together.



Name: ______________________________ G8 U5 Lesson 1 - Let's Try It

The expanded expression 5 · 5 · 5 can be written as 5^3.

1. The ____________ is the factor being multiplied. What is the base in the expression 5^3?
2. The ____________ tells us how many factors of the base are being multiplied. What is the exponent in the expression 5^3?
3. Find the value of the expression.

A performance artist has 2 large spheres of clay. Each hour, the performance artist splits each sphere into identical, smaller spheres. This doubles the number of spheres each hour.

1. Fill in the table to show how many spheres there will be each hour in expanded form.

HOUR	EXPANDED	EXPONENT	VALUE
1	2		
2	2 · ____		
3	2 · ____ · ____		

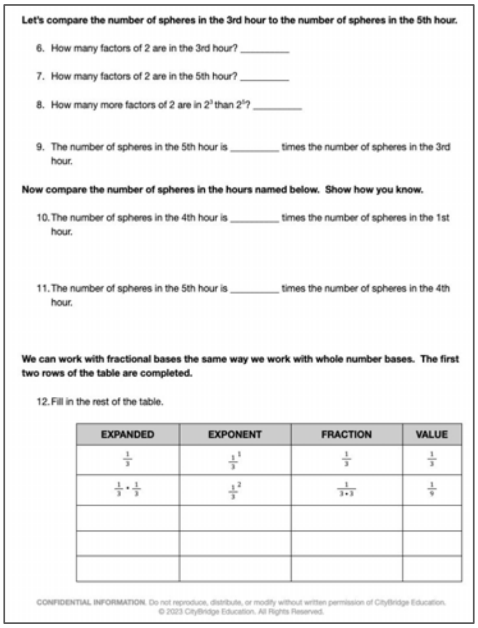
2. Fill in the table to show each expanded expression written using a single exponent.
3. What is the same about each exponent expression? What is different?

____

____

____

4. Fill in the column labeled "value" to show how many spheres the artist would have each hour.
5. How many spheres would the performance artist have in Hour 4? Hour 5? Show how you know.



Let's compare the number of spheres in the 3rd hour to the number of spheres in the 5th hour.

6. How many factors of 2 are in the 3rd hour? ________
7. How many factors of 2 are in the 5th hour? ________
8. How many more factors of 2 are in 2^3 than 2^5? ________
9. The number of spheres in the 5th hour is ________ times the number of spheres in the 3rd hour.

Now compare the number of spheres in the hours named below. Show how you know.

10. The number of spheres in the 4th hour is ________ times the number of spheres in the 1st hour.
11. The number of spheres in the 5th hour is ________ times the number of spheres in the 4th hour.

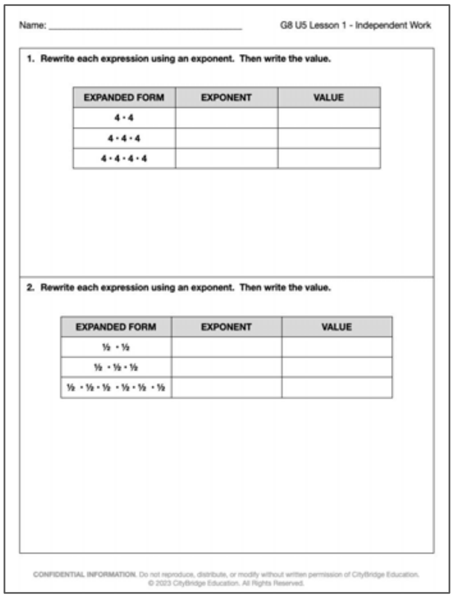
We can work with fractional bases the same way we work with whole number bases. The first two rows of the table are completed.

12. Fill in the rest of the table.

EXPANDED	EXPONENT	FRACTION	VALUE
$\frac{1}{3}$	$\frac{1}{3}^1$	$\frac{1}{3}$	$\frac{1}{3}$
$\frac{1}{3} \cdot \frac{1}{3}$	$\frac{1}{3}^2$	$\frac{1}{3 \cdot 3}$	$\frac{1}{9}$

On your Own:

Now it’s time to compare quantities using expressions that represent repeated multiplication on your own.



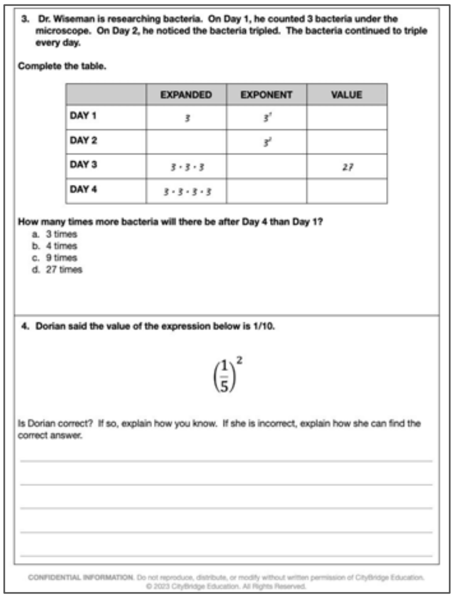
Name: ______________________________ G8 U5 Lesson 1 - Independent Work

1. **Rewrite each expression using an exponent. Then write the value.**

EXPANDED FORM	EXPONENT	VALUE
4 • 4		
4 • 4 • 4		
4 • 4 • 4 • 4		

2. **Rewrite each expression using an exponent. Then write the value.**

EXPANDED FORM	EXPONENT	VALUE
½ • ½		
½ • ½ • ½		
½ • ½ • ½ • ½ • ½ • ½		



3. **Dr. Wiseman is researching bacteria. On Day 1, he counted 3 bacteria under the microscope. On Day 2, he noticed the bacteria tripled. The bacteria continued to triple every day.**

Complete the table.

	EXPANDED	EXPONENT	VALUE
DAY 1	3	3^1	
DAY 2		3^2	
DAY 3	3 • 3 • 3		27
DAY 4	3 • 3 • 3 • 3		

How many times more bacteria will there be after Day 4 than Day 1?

a. 3 times
b. 4 times
c. 9 times
d. 27 times

4. **Dorian said the value of the expression below is 1/10.**

$$\left(\frac{1}{5}\right)^2$$

Is Dorian correct? If so, explain how you know. If she is incorrect, explain how she can find the correct answer.

____

____

____

____

____

The expanded expression 5 • 5 • 5 can be written as 5^3.

1. The _____________ is the factor being multiplied. What is the base in the expression 5^3?

2. The _____________ tells us how many factors of the base are being multiplied. What is the exponent in the expression 5^3?

3. Find the value of the expression.

A performance artist has 2 large spheres of clay. Each hour, the performance artist splits each sphere into identical, smaller spheres. This doubles the number of spheres each hour.

1. Fill in the table to show how many spheres there will be each hour in expanded form.

HOUR	EXPANDED	EXPONENT	VALUE
1	2		
2	2 • ____		
3	2 • ____ • ____		

2. Fill in the table to show each expanded expression written using a single exponent.

3. What is the same about each exponent expression? What is different?

____

____

____

4. Fill in the column labeled “value” to show how many spheres the artist would have each hour.

5. How many spheres would the performance artist have in Hour 4? Hour 5? Show how you know.

Let's compare the number of spheres in the 3rd hour to the number of spheres in the 5th hour.

6. How many factors of 2 are in the 3rd hour? __________

7. How many factors of 2 are in the 5th hour? __________

8. How many more factors of 2 are in 2^3 than 2^5? __________

9. The number of spheres in the 5th hour is __________ times the number of spheres in the 3rd hour.

Now compare the number of spheres in the hours named below. Show how you know.

10. The number of spheres in the 4th hour is __________ times the number of spheres in the 1st hour.

11. The number of spheres in the 5th hour is __________ times the number of spheres in the 4th hour.

We can work with fractional bases the same way we work with whole number bases. The first two rows of the table are completed.

12. Fill in the rest of the table.

EXPANDED	EXPONENT	FRACTION	VALUE
$\frac{1}{3}$	$\frac{1}{3}^{1}$	$\frac{1}{3}$	$\frac{1}{3}$
$\frac{1}{3} \bullet \frac{1}{3}$	$\frac{1}{3}^{2}$	$\frac{1}{3 \bullet 3}$	$\frac{1}{9}$

1. Rewrite each expression using an exponent. Then write the value.

EXPANDED FORM	EXPONENT	VALUE
4 • 4		
4 • 4 • 4		
4 • 4 • 4 • 4		

2. Rewrite each expression using an exponent. Then write the value.

EXPANDED FORM	EXPONENT	VALUE
½ • ½		
½ • ½ • ½		
½ • ½ • ½ • ½ • ½ • ½		

3. **Dr. Wiseman is researching bacteria. On Day 1, he counted 3 bacteria under the microscope. On Day 2, he noticed the bacteria tripled. The bacteria continued to triple every day.**

Complete the table.

	EXPANDED	EXPONENT	VALUE
DAY 1	3	3^1	
DAY 2		3^2	
DAY 3	$3 \cdot 3 \cdot 3$		27
DAY 4	$3 \cdot 3 \cdot 3 \cdot 3$		

How many times more bacteria will there be after Day 4 than Day 1?

a. 3 times
b. 4 times
c. 9 times
d. 27 times

4. **Dorian said the value of the expression below is 1/10.**

$$\left(\frac{1}{5}\right)^2$$

Is Dorian correct? If so, explain how you know. If she is incorrect, explain how she can find the correct answer.

Name: KEY

The expanded expression $5 \cdot 5 \cdot 5$ can be written as 5^3.

1. The base is the factor being multiplied. What is the base in the expression 5^3?
2. The exponent tells us how many factors of the base are being multiplied. What is the exponent in the expression 5^3?
3. Find the value of the expression.

$$5 \cdot 5 \cdot 5$$

$$25 \cdot 5 = \boxed{125}$$

A performance artist has 2 large spheres of clay. Each hour, the performance artist splits each sphere into identical, smaller spheres. This doubles the number of spheres each hour.

1. Fill in the table to show how many spheres there will be each hour in expanded form.

HOUR	EXPANDED	EXPONENT	VALUE
1	2	2^1	2
2	$2 \cdot 2$	2^2	4
3	$2 \cdot 2 \cdot 2$	2^3	8

2. Fill in the table to show each expanded expression written using a single exponent.
3. What is the same about each exponent expression? What is different?

The base is the same in each expression. The exponents increase by 1.

4. Fill in the column labeled "value" to show how many spheres the artist would have each hour.
5. How many spheres would the performance artist have in Hour 4? Hour 5? Show how you know.

Hour 4

$$2 \cdot 2 \cdot 2 \cdot 2$$

$$4 \cdot 4$$

$$\boxed{16}$$

Hour 5

$$2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$$

$$16 \cdot 2$$

$$\boxed{32}$$

Let's compare the number of spheres in the 3rd hour to the number of spheres in the 5th hour.

6. How many factors of 2 are in the 3rd hour? 3

7. How many factors of 2 are in the 5th hour? 5

8. How many more factors of 2 are in 2^3 than 2^5? 2

9. The number of spheres in the 5th hour is $\underset{2\times 2}{4}$ times the number of spheres in the 3rd hour.

Now compare the number of spheres in the hours named below. Show how you know.

10. The number of spheres in the 4th hour is 8 times the number of spheres in the 1st hour.

4th: $2 \cdot \boxed{2\cdot 2\cdot 2}$

1st: 2

11. The number of spheres in the 5th hour is 2 times the number of spheres in the 4th hour.

5th: $2\cdot 2\cdot 2\cdot 2 \cdot ② $

4th: $2\cdot 2\cdot 2\cdot 2$

We can work with fractional bases the same way we work with whole number bases. The first two rows of the table are completed.

12. Fill in the rest of the table.

EXPANDED	EXPONENT	FRACTION	VALUE
$\frac{1}{3}$	$\frac{1}{3}^{1}$	$\frac{1}{3}$	$\frac{1}{3}$
$\frac{1}{3}\bullet\frac{1}{3}$	$\frac{1}{3}^{2}$	$\frac{1}{3\bullet 3}$	$\frac{1}{9}$
$\frac{1}{3}\cdot\frac{1}{3}\cdot\frac{1}{3}$	$\frac{1}{3}^{3}$	$\frac{1}{3\cdot 3\cdot 3}$	$\frac{1}{27}$
$\frac{1}{3}\cdot\frac{1}{3}\cdot\frac{1}{3}\cdot\frac{1}{3}$	$\frac{1}{3}^{4}$	$\frac{1}{3\cdot 3\cdot 3\cdot 3}$	$\frac{1}{81}$
$\frac{1}{3}\cdot\frac{1}{3}\cdot\frac{1}{3}\cdot\frac{1}{3}\cdot\frac{1}{3}$	$\frac{1}{3}^{5}$	$\frac{1}{3\cdot 3\cdot 3\cdot 3\cdot 3}$	$\frac{1}{243}$

Name: KEY

1. **Rewrite each expression using an exponent. Then write the value.**

EXPANDED FORM	EXPONENT	VALUE
$4 \cdot 4$	4^2	16
$4 \cdot 4 \cdot 4$	4^3	64
$4 \cdot 4 \cdot 4 \cdot 4$	4^4	256

2. **Rewrite each expression using an exponent. Then write the value.**

EXPANDED FORM	EXPONENT	VALUE
$\frac{1}{2} \cdot \frac{1}{2}$	$\frac{1}{2}^{2}$	1/4
$\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}$	$\frac{1}{2}^{3}$	1/8
$\underbrace{\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}}_{\frac{1}{8}} \cdot \underbrace{\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}}_{\frac{1}{8}}$	$\frac{1}{2}^{6}$	1/64

3. **Dr. Wiseman is researching bacteria. On Day 1, he counted 3 bacteria under the microscope. On Day 2, he noticed the bacteria tripled. The bacteria continued to triple every day.**

Complete the table.

	EXPANDED	EXPONENT	VALUE
DAY 1	3	3^1	3
DAY 2	$3 \cdot 3$	3^2	9
DAY 3	$3 \cdot 3 \cdot 3$	3^3	27
DAY 4	$3 \cdot 3 \cdot 3 \cdot 3$	3^4	81

How many times more bacteria will there be after Day 4 than Day 1?

a. 3 times
b. 4 times
c. 9 times
[✓ d. 27 times]

$81 = \_\_\_ \times \underline{3}$

4. **Dorian said the value of the expression below is 1/10.**

$$\left(\frac{1}{5}\right)^2$$

Is Dorian correct? If so, explain how you know. If she is incorrect, explain how she can find the correct answer.

Dorian is incorrect. $\frac{1}{5}^2$ means $\frac{1}{5} \times \frac{1}{5}$. She can multiply across to get a numerator of 1 and a denominator of 25. The correct answer is $\frac{1}{25}$.

G8 U5 Lesson 2

Generalize the exponent rule 10n · 10m = 10n+m and write equivalent exponential expressions of multiplication expressions with a base of 10.

G8 U5 Lesson 2 - Students will generalize the exponent rule $10^n \cdot 10^m = 10^{n+m}$ and write equivalent exponential expressions of multiplication expressions with a base of 10.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): In our last lesson, we kickstarted our unit covering all things exponents. Today, we'll continue exploring exponents, specifically thinking about what happens when we multiply exponential expressions. As we work today, I want you to see if you can predict or discover patterns that could help make our work efficient.

Let's Talk (Slide 3): Take a second to look at the expression shown here. What do you notice about it? What do you wonder? Possible Student Answers, Key Points:

- I notice there are a lot of tens being multiplied.
- I notice the first group has 4 tens and the second group has 7 tens. There are 11 tens altogether.
- I wonder if there is an easier way to write this. Maybe exponents could help us.
- I wonder what the total value is.

This expression shows two groups of tens being multiplied together. It's a pretty cumbersome expression to look at with all these tens. We can use exponents to help us think about this expression. Think back to our previous lesson. How could I write 4 factors of 10 and 6 factors of ten using exponents? Possible Student Answers, Key Points:

- Four factors of 10 can be 10 to the fourth power.
- Six factors of 10 can be 10 to the sixth power.

$$10^4 \cdot 10^7$$

(write 10 to the fourth power times 10 to the seventh power) Instead of writing out all the tens in expanded form like we were originally shown, we could write this equivalent expression using exponents.

$$10^{11}$$

We could even take it a step further. We saw that there were 11 tens being multiplied together. Instead of writing them all out, and instead of writing them as two exponential factors, we could simply write this expression as 10 to the eleventh power. *(write 10 to the 11th power)* That makes sense, because we have 11 factors of ten being multiplied. The expanded form or either of the two exponential expressions can be used to represent the same thing. We'll use this thinking today to help us multiply expressions involving exponents. Let's dive in!

Let's Think (Slide 4): Our first problem wants us to rewrite each of the expressions below using a single exponent. Before we begin, take a second to look at each problem. What do you notice about the three exponential expressions? Possible Student Answers, Key Points:

- They all have a base of 10. They each have different exponents.
- The second expression involves 3 factors.
- The last expression has really big exponents.

$$10^4 \cdot 10^2$$
$$\downarrow \qquad\qquad \downarrow$$
$$(10\cdot10\cdot10\cdot10)\cdot(10\cdot10)$$
$$\boxed{10^6}$$

Let's look at the first expression. To multiply these, it can help to write each factor in expanded form. *(write expression as you narrate)* I can write 10 to the fourth power as four factors of 10. I can write 10 to the second power as two factors of 10. How many factors of 10 do we see in all? (six factors of 10) There are six factors of 10, so we can think of the product of 10 to the fourth power and 10 to the second power as being 10 to the sixth power. *(write 10 to the sixth power)*

We wrote each factor in expanded form, then we could easily see how many total factors of 10 compose the product.

$10^3 \cdot 10^1 \cdot 10^5$

$(10\cdot10\cdot10) \cdot (10)\cdot(10\cdot10\cdot10\cdot10\cdot10)$

Let's try the next one. How could I write this expression using expanded form? Possible Student Answers, Key Points:

- 10 to the third power is 3 factors of 10. 10 to the first power is 1 factor of 10. 10 to the fifth power is 5 factors of 10.

$\boxed{10^9}$

(write expanded form as student shares) We can expand each factor to see how many total factors of 10 are in the expression. We see there are nine factors of 10 being multiplied, so we can write the product as 10 to the ninth power. *(write 10 to the ninth power)*

We noticed that the third expression has exponents that are pretty big. It would take us a really long time to write this expression in expanded form. Thinking about our last couple problems, can we think of a pattern or a rule that could help us tackle this problem more efficiently?

The first problem had 4 factors of 10 times 2 factors of 10, and we ended up with 6 factors of 10. The second problem had 3 factors of 10 times 1 factor of 10 times 5 factors of 10, and we ended up with 9 factors of 10. In a sense, we were just combining all the factors of 10. Instead of expanding the expression, is there another pattern or rule we could use to help us multiply by powers of 10? (We can add the exponents, since we're just combining the factors of 10 together.)

10^{4+2}

We can just add the exponents. In the first example, instead of expanding to see all 6 factors of 10, we could have just added the exponents of 4 and 2 to show 10 to the sixth power. *(write expression as shown here)*

10^{3+1+5}

In the second example, instead of expanding to see all 9 factors of 10, we could have just added the exponents of 3, 1, and 5 to show 10 to the 9th power. *(Write expression as shown here)* When multiplying by powers of 10, we can add the exponents. That can often be more efficient than expanding every expression.

$10^{42} \cdot 10^{19}$

10^{42+19}

$\boxed{10^{61}}$

How can we use this rule to find the value of the third expression? *(write as student shares their thinking)* Possible Student Answers, Key Points:

- We can add 42 and 19 to see how many factors of 10 there would be.
- 42 + 19 is 61, so we can think of the product as 10 to the 61st power.

42 factors of 10 times 19 more more factors of 10 would be 61 factors of 10. We can write that as 10 to the 61st power. We simply added the exponents to show all the factors of 10 being multiplied.

Let's Think (Slide 5): Let's try one more together before we move into some practice.

10^{7+0}

$\boxed{10^7}$

This problem wants us to find the product of 10 to the seventh power and 10 to the zero power. Our answer should be written as an expression with a single exponent. How could we use the rule we just learned to find the product? Possible Student Answers, Key Points:

- We can add the exponents. 7 + 0 = 7, so our answer would be 10 to the 7th power.

We can add the exponents. *(write as you narrate)* 7 plus 0 is 7, so our answer would be 10 to the 7th power.

10 to the seventh power is our answer. The rule worked! Let's pause for a second to think about any number to the 0 power, because this can be a common area for confusion if we're not careful.

$$\begin{aligned} 10^3 &= 1000 \\ 10^2 &= 100 \\ 10^1 &= 10 \\ 10^0 &= ? \end{aligned}$$

$$\begin{array}{rcll} 10^3 & = & 1000 & \\ & & & \big\downarrow \div 10 \\ 10^2 & = & 100 & \\ & & & \big\downarrow \div 10 \\ 10^1 & = & 10 & \\ & & & \big\downarrow \div 10 \\ 10^0 & = & ? & \\ & & \boxed{1} & \end{array}$$

(write an organized list of powers of 10 as you narrate) I know 10 to the 3rd power is 10 times 10 times 10, which is 1,000. I know 10 to the 2nd power is 10 times 10, which is 100. I know 10 to the first power is just one factor of 10, so it's 10. I can use the patterns I see here to help me figure out the value of 10 to the zero power.

Each value is 1/10 of the value above it. Or we can think of dividing by 10 each time to find the next value. *(draw arrows that show the dividing by 10 pattern)* If the pattern continues, we can see that 10 divided by 10 is 1. So 10 to the 0 power is 1.

If we go back to the original problem, we were asked to find 10 to the seventh power times 10 to the zero power. That means we're finding 10 the seventh power times 1. Our answer of 10 to the seventh power, makes sense!

We'll see more work with 0 exponents in future lessons. It can be helpful to know that anything to the zero power is always just 1.

Let's Try it (Slides 6 - 7): Now we'll work on a few more examples together. As we saw today, we can multiply expressions with exponents a couple different ways. What are some strategies we saw to help us?
Possible Student Answers, Key Points:

- We can write the expressions in expanded form to see how many factors of ten there are in all.
- We can add the exponents. This is helpful any time, but particularly when it would be inefficient to write the expressions in standard form.

We can use expanded form or our rule to help us as we work through the next problems. Let's go for it!

WARM WELCOME

Today we will generalize the exponent rule $10^n \cdot 10^m = 10^{n+m}$ and write equivalent exponential expressions of multiplication expressions with a base of 10.

Let's Talk:

What do you notice? What do you wonder?

$$(10 \bullet 10 \bullet 10 \bullet 10) \bullet (10 \bullet 10 \bullet 10 \bullet 10 \bullet 10 \bullet 10 \bullet 10)$$

Let's Think:

Rewrite each as an expression with a single exponent.

$10^4 \bullet 10^2$

$10^3 \bullet 10^1 \bullet 10^5$

$10^{42} \bullet 10^{19}$

Can we figure out a rule?

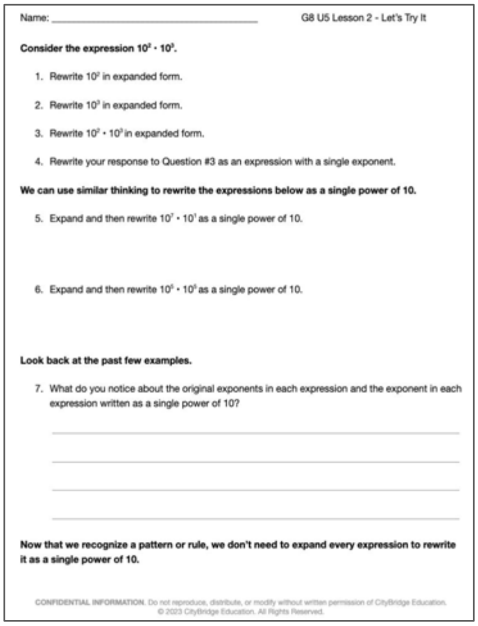
Let's Think:

Rewrite as an expression with a single exponent.

$10^7 \bullet 10^0$

Let's Try It:

Let's explore generalizing the exponent rule $10^n \bullet 10^m = 10^{n+m}$ and writing equivalent exponential expressions of multiplication expressions with a base of 10 together.



Name: ______________________________ G8 U5 Lesson 2 - Let's Try It

Consider the expression $10^2 \cdot 10^3$.

1. Rewrite 10^2 in expanded form.
2. Rewrite 10^3 in expanded form.
3. Rewrite $10^2 \cdot 10^3$ in expanded form.
4. Rewrite your response to Question #3 as an expression with a single exponent.

We can use similar thinking to rewrite the expressions below as a single power of 10.

5. Expand and then rewrite $10^7 \cdot 10^1$ as a single power of 10.
6. Expand and then rewrite $10^5 \cdot 10^5$ as a single power of 10.

Look back at the past few examples.

7. What do you notice about the original exponents in each expression and the exponent in each expression written as a single power of 10?

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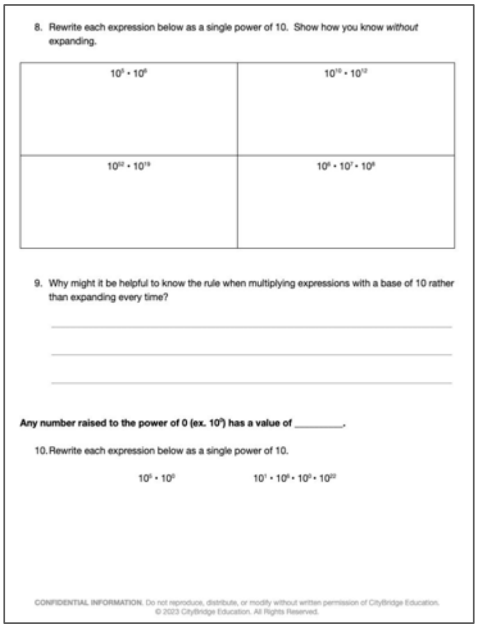
Now that we recognize a pattern or rule, we don't need to expand every expression to rewrite it as a single power of 10.



8. Rewrite each expression below as a single power of 10. Show how you know *without* expanding.

$10^5 \cdot 10^6$	$10^{10} \cdot 10^{12}$
$10^{12} \cdot 10^{19}$	$10^6 \cdot 10^7 \cdot 10^8$

9. Why might it be helpful to know the rule when multiplying expressions with a base of 10 rather than expanding every time?

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Any number raised to the power of 0 (ex. 10^0) has a value of __________.

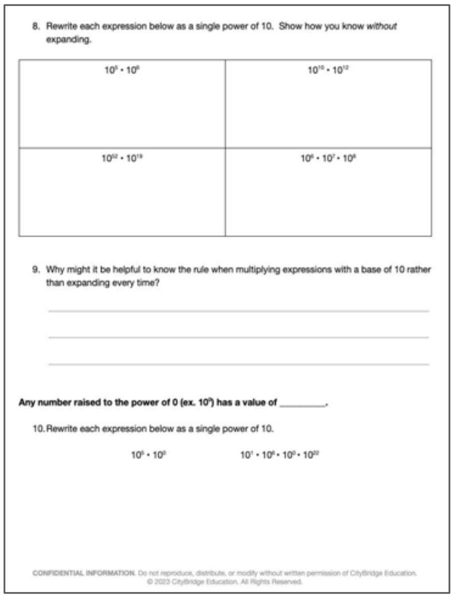
10. Rewrite each expression below as a single power of 10.

$10^5 \cdot 10^0$

$10^1 \cdot 10^6 \cdot 10^0 \cdot 10^{22}$

On your Own:

Now it's time to generalize the exponent rule $10^n \bullet 10^m = 10^{n+m}$ and write equivalent exponential expressions of multiplication expressions with a base of 10 on your own.



8. Rewrite each expression below as a single power of 10. Show how you know *without* expanding.

$10^5 \cdot 10^6$	$10^{10} \cdot 10^{12}$
$10^{12} \cdot 10^{19}$	$10^6 \cdot 10^7 \cdot 10^8$

9. Why might it be helpful to know the rule when multiplying expressions with a base of 10 rather than expanding every time?

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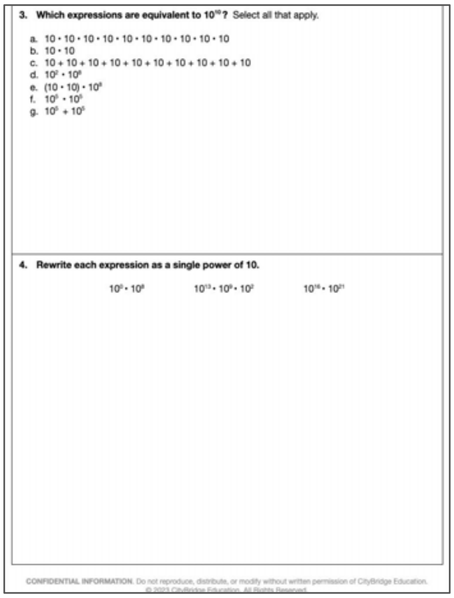
Any number raised to the power of 0 (ex. 10^0) has a value of __________.

10. Rewrite each expression below as a single power of 10.

$10^5 \cdot 10^0$ $10^1 \cdot 10^6 \cdot 10^0 \cdot 10^{22}$



3. **Which expressions are equivalent to 10^{10}?** Select all that apply.

   a. $10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$
   b. $10 \cdot 10$
   c. $10 + 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10$
   d. $10^2 \cdot 10^8$
   e. $(10 \cdot 10) \cdot 10^8$
   f. $10^5 \cdot 10^5$
   g. $10^5 + 10^5$

4. **Rewrite each expression as a single power of 10.**

$10^0 \cdot 10^8$ $10^{13} \cdot 10^9 \cdot 10^2$ $10^{16} \cdot 10^{21}$

Consider the expression $10^2 \bullet 10^3$.

1. Rewrite 10^2 in expanded form.

2. Rewrite 10^3 in expanded form.

3. Rewrite $10^2 \bullet 10^3$ in expanded form.

4. Rewrite your response to Question #3 as an expression with a single exponent.

We can use similar thinking to rewrite the expressions below as a single power of 10.

5. Expand and then rewrite $10^7 \bullet 10^1$ as a single power of 10.

6. Expand and then rewrite $10^5 \bullet 10^5$ as a single power of 10.

Look back at the past few examples.

7. What do you notice about the original exponents in each expression and the exponent in each expression written as a single power of 10?

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Now that we recognize a pattern or rule, we don't need to expand every expression to rewrite it as a single power of 10.

8. Rewrite each expression below as a single power of 10. Show how you know *without* expanding.

$10^5 \bullet 10^6$	$10^{10} \bullet 10^{12}$
$10^{52} \bullet 10^{19}$	$10^6 \bullet 10^7 \bullet 10^8$

9. Why might it be helpful to know the rule when multiplying expressions with a base of 10 rather than expanding every time?

____

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Any number raised to the power of 0 (ex. 10^0) has a value of _________.

10. Rewrite each expression below as a single power of 10.

$10^5 \bullet 10^0$

$10^1 \bullet 10^6 \bullet 10^0 \bullet 10^{22}$

1. **Complete the table.** The first example is done for you.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^5 \cdot 10^2$	10 • 10 • 10 • 10 • 10 • 10 • 10	10^7
$10^2 \cdot 10^2$		
$10^5 \cdot 10^3$		
$10^4 \cdot 10$		

2. **Maria grouped factors of ten in expanded form as shown below.**
   a. Rewrite each grouping using exponents.
   b. Then rewrite each using a single exponent.

$(10 \cdot 10 \cdot 10) \cdot (10 \cdot 10)$

$(10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)$

3. Which expressions are equivalent to 10^{10}? Select all that apply.

a. 10 • 10 • 10 • 10 • 10 • 10 • 10 • 10 • 10 • 10
b. 10 • 10
c. 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10
d. 10^2 • 10^8
e. (10 • 10) • 10^8
f. 10^5 • 10^5
g. 10^5 + 10^5

4. Rewrite each expression as a single power of 10.

$10^0 \bullet 10^8$ $10^{13} \bullet 10^9 \bullet 10^2$ $10^{16} \bullet 10^{21}$

Name: KEY

G8 U5 Lesson 2 - Let's Try It

Consider the expression $10^2 \cdot 10^3$.

1. Rewrite 10^2 in expanded form. $10 \cdot 10$

2. Rewrite 10^3 in expanded form. $10 \cdot 10 \cdot 10$

3. Rewrite $10^2 \cdot 10^3$ in expanded form. $(10 \cdot 10) \cdot (10 \cdot 10 \cdot 10)$

4. Rewrite your response to Question #3 as an expression with a single exponent. $\boxed{10^5}$

We can use similar thinking to rewrite the expressions below as a single power of 10.

5. Expand and then rewrite $10^7 \cdot 10^1$ as a single power of 10.

$(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10) \cdot (10)$

$\boxed{10^8}$

6. Expand and then rewrite $10^5 \cdot 10^5$ as a single power of 10.

$(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)$

$\boxed{10^{10}}$

Look back at the past few examples.

7. What do you notice about the original exponents in each expression and the exponent in each expression written as a single power of 10?

The exponent in the answer is the sum of the exponents in the original expression.

Now that we recognize a pattern or rule, we don't need to expand every expression to rewrite it as a single power of 10.

8. Rewrite each expression below as a single power of 10. Show how you know *without* expanding.

$10^5 \cdot 10^6$ $10^{5+6} = \boxed{10^{11}}$	$10^{10} \cdot 10^{12}$ $10^{10+12} = \boxed{10^{22}}$
$10^{52} \cdot 10^{19}$ $10^{52+19} = \boxed{10^{71}}$	$10^6 \cdot 10^7 \cdot 10^8$ $10^{6+7+8} = \boxed{10^{21}}$

Like this one!

9. Why might it be helpful to know the rule when multiplying expressions with a base of 10 rather than expanding every time?

If the exponent is a big number it would be tedious to write out in expanded form.

Any number raised to the power of 0 (ex. 10^0) has a value of 1**.**

10. Rewrite each expression below as a single power of 10.

$10^5 \cdot 10^0$

10^{6+0}

$\boxed{10^6}$

$10^1 \cdot 10^6 \cdot 10^0 \cdot 10^{22}$

$10^{1+6+0+22}$

$\boxed{10^{29}}$

Name: KEY

1. **Complete the table.** The first example is done for you.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^5 \cdot 10^2$	$10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$	10^7
$10^2 \cdot 10^2$	$10 \cdot 10 \cdot 10 \cdot 10$	10^4
$10^5 \cdot 10^3$	$10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$	10^8
$10^4 \cdot 10$	$10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$	10^5

2. **Maria grouped factors of ten in expanded form as shown below.**
   a. Rewrite each grouping using exponents.
   b. Then rewrite each using a single exponent.

$(10 \cdot 10 \cdot 10) \cdot (10 \cdot 10)$

$10^3 \cdot 10^2$

$\boxed{10^5}$

$(10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)$

$10^4 \cdot 10^5$

$\boxed{10^9}$

3. Which expressions are equivalent to 10^{10}? Select all that apply.

[✓ a.] $10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$

~~b. $10 \cdot 10$~~

~~c. $10 + 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10$~~

[✓ d.] $10^2 \cdot 10^8$

[✓ e.] $(10 \cdot 10) \cdot 10^8$

[✓ f.] $10^5 \cdot 10^5$

~~g. $10^5 + 10^5$~~

all show
10 factors
of 10

4. Rewrite each expression as a single power of 10.

$10^0 \cdot 10^8$	$10^{13} \cdot 10^9 \cdot 10^2$	$10^{16} \cdot 10^{21}$
10^{0+8}	10^{13+9+2}	10^{16+21}
10^8	10^{24}	10^{37}

G8 U5 Lesson 3

Explain and use a rule for raising a power of 10 to a power, that (10^n)^m = 10^(n•m)

G8 U5 Lesson 3 - Students will generalize the exponent rule $10^n \div 10^m = 10^{n-m}$ and write equivalent exponential expressions of division expressions with a base of 10.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): In our last lesson together, we explored different ways to multiply with powers of 10. We saw that writing the factors in expanded form could help, but we also discovered a pattern or a rule that could come in handy. Do you remember what that rule was? Possible Student Answers, Key Points:

- We don't have to use expanded form. We can just add the exponents.
- Adding the exponents works, because it tells us how many total factors of 10 we're dealing with without having to write them all out.

In today's lesson, we'll use some of this thinking. Our problems will involve taking a power of 10 to a power. If you're not sure what that means right now, don't worry. We'll see plenty of examples. As we work, try to see if you can find patterns to help us develop a rule to make our work more efficient.

Let's Talk (Slide 3): Let's look at these two expressions before we dive into our math problems. What is the same about these expressions? What is different? Possible Student Answers, Key Points:

- They both involve bases of 10. They both include exponents of 4 and 2.
- They're different colors. The first one wants us to multiply 10 to the fourth power times 10 to the second power, while the second example wants us to multiply 10 to the fourth power by itself.

$$(10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10)$$

$$10^6$$

We can look at these expressions in expanded form to further understand their similarities and differences. The first expression can be written as four factors of 10 multiplied by 2 factors of 10. *(write the expression in standard form)* We can see that we have six factors of 10 in all. We can simplify the expression by writing it as 10 to the sixth power. *(write 10 to the sixth power)* We also know we could have just added the exponents. 4 plus 2, means the exponent on the product is 6.

$$(10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10)$$

$$10^8$$

The second expression is different. It shows 10 to the fourth power to the second power. That means, we could represent it as 10 to the fourth power multiplied by 10 to the fourth power. How can we write that in expanded form?

(write as student shares, supporting as needed) Possible Student Answers, Key Points:

- I can think of it as 10^4 times 10^4.
- In expanded form, that's 10 x 10 x 10 x 10 times 10 x 10 x 10 x 10. There are 8 factors of 10.

In this expression, we see there are 8 factors of 10. We can simplify the expression by writing it as 10 to the eighth power. Notice, we did not add the exponents in this case. That's because we were thinking of multiplying two groups of 10 to the fourth power. That's 8 factors of 10, not 6 factors of 10.

We call this second example "taking a power to a power" because we're taking an exponential expression to another power. Let's look at a few more examples of problems involving taking a power to a power. Again, be on the lookout for patterns we can use to make our math easier.

Let's Think (Slide 4): This problem wants us to write each expression in expanded form, and then we'll write each as an expression using a single exponent. Let's start with expression A.

This expression can be read as 10 to the sixth power to the second power. We're taking a power to a power. I can think of this as 10 to the sixth power times itself. *(write 10 to the sixth power in expanded form multiplied by another 10 to the sixth power in expanded form)* That's a lot of factors of 10. How many? (12)

$$(10\cdot10\cdot10\cdot10\cdot10\cdot10)\cdot(10\cdot10\cdot10\cdot10\cdot10\cdot10)$$

$$\boxed{10^{12}}$$

$$10^{2\cdot6}$$

10 to the sixth power to the second power resulted in 12 factors of 10. We can write that as 10 to the twelfth power. *(write that)* We multiplied 2 groups of 6 factors of ten together. We can show that by multiplying the exponents 2 and 6 since we took 2 groups of 6 factors. *(write 10 to the "2 • 6" power)*

I wonder if multiplying the exponents works every time. Let's try on the next example.

This example can be read as 10 to the third power to the fifth power. Again, we have a power to a power. How can I write this expression in expanded form? *(write as student shares)* Possible Student Answers, Key Points:

- We need to multiply 3 groups of 10 to the fifth together.
- We can show five factors of 10 times another five factors of 10 times another five factors of 10.

$$(10\cdot10\cdot10\cdot10\cdot10)\cdot(10\cdot10\cdot10\cdot10\cdot10)\cdot(10\cdot10\cdot10\cdot10\cdot10)$$

We have 15 factors of 10 in all.

$$\boxed{10^{15}}$$

$$10^{3\cdot5}$$

That's 10 to the fifteenth power. *(write 10 to the fifteenth power)* We multiplied 3 groups together. Each group had 5 factors of 10. Like the last problem, we can think of this as multiplying the exponents. 3 times 5 is 15. *(write 10 to the "3 • 5" power)* When taking a power to a power, we can use expanded form to show how many factors are being multiplied. We can also multiply the exponents together if we want to be a bit more efficient.

Let's Think (Slide 5): Let's look at one more example. This problem wants us to write the expression using a single exponent instead of repeated multiplication.

$$(10^4)^3$$

$$10^{3\cdot4}=10^{12}$$

Here, I see 3 groups of 10 to the fourth power being multiplied together. We can rewrite that as 10 to the fourth power to the third power. *(write that)* Now we have the expression written as a power to a power.

Today we've seen how we can write a power to a power using a single exponent. How could I write this using a single exponent? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- You can expand to show 4 groups of 10 times 4 groups of 10 times 4 groups of 10.
- You can multiply 3 times 4 to get a single exponent of 12.

We can multiply the exponents to show that 3 groups of 4 factors would mean we have 12 factors of 10. The simplified expression is 10 to the 12th power.

Let's Try it (Slides 6 - 7): Now it's our chance to practice. We know that when we multiply powers of 10 together, we can add the exponents. We learned today that when we take powers of 10 to a power, we can multiply the exponents. Let’s keep this in mind as we work. If need be, we also know that expanded form can help us think carefully about how many factors of 10 are involved. Let’s get going!

WARM WELCOME

Today we will explain and use a rule for raising a power of 10 to a power, that $(10^n)^m = 10^{n \cdot m}$.

Let's Talk:

What's the same? What's different?

$10^4 \bullet 10^2$

$(10^4)^2$

Let's Think:

Write each expression in expanded form. Then write each as a single power of 10.

a. $(10^6)^2$

b. $(10^3)^5$

Can we figure out a rule?

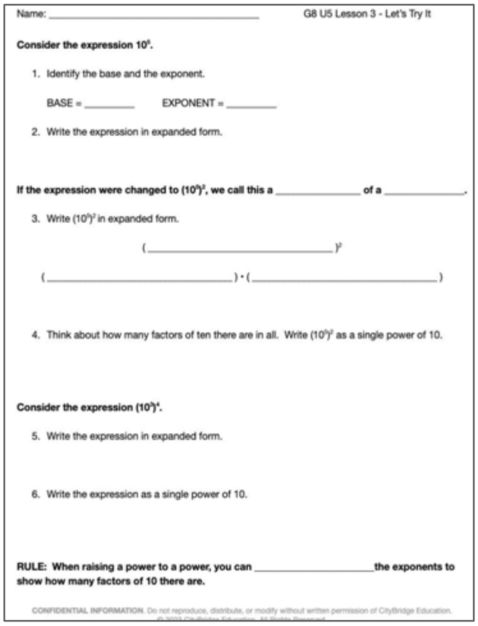
Let's Think:

Write the expression using exponents instead of repeated multiplication. Then write it using a single exponent.

$$10^4 \bullet 10^4 \bullet 10^4$$

Let's Try It:

Let's explore explaining and using a rule for raising a power to a power together.



Name: ______________________________ G8 U5 Lesson 3 - Let's Try It

Consider the expression 10^3.

1. Identify the base and the exponent.

   BASE = ________ EXPONENT = ________

2. Write the expression in expanded form.

If the expression were changed to $(10^3)^2$, we call this a ____________ of a ____________.

3. Write $(10^3)^2$ in expanded form.

   (______________________ $)^2$

   (______________________) • (______________________)

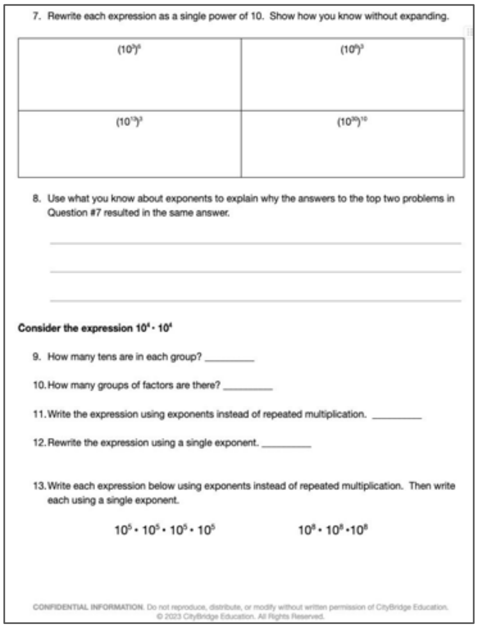
4. Think about how many factors of ten there are in all. Write $(10^3)^2$ as a single power of 10.

Consider the expression $(10^3)^4$.

5. Write the expression in expanded form.

6. Write the expression as a single power of 10.

RULE: When raising a power to a power, you can ________________ the exponents to show how many factors of 10 there are.



7. Rewrite each expression as a single power of 10. Show how you know without expanding.

$(10^3)^6$	$(10^6)^3$
$(10^{13})^3$	$(10^{30})^{10}$

8. Use what you know about exponents to explain why the answers to the top two problems in Question #7 resulted in the same answer.

Consider the expression $10^4 \cdot 10^4$

9. How many tens are in each group? ________

10. How many groups of factors are there? ________

11. Write the expression using exponents instead of repeated multiplication. ________

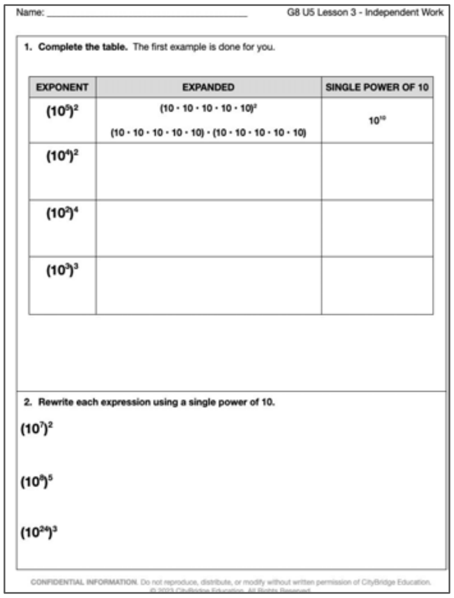
12. Rewrite the expression using a single exponent. ________

13. Write each expression below using exponents instead of repeated multiplication. Then write each using a single exponent.

$10^5 \cdot 10^5 \cdot 10^5 \cdot 10^5$ $10^8 \cdot 10^8 \cdot 10^8$

On your Own:

Now it’s time to explain and use a rule for raising a power to a power on your own.



Name: ____________________ G8 U5 Lesson 3 - Independent Work

1. Complete the table. The first example is done for you.

EXPONENT	EXPANDED	SINGLE POWER OF 10
$(10^5)^2$	$(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)^2$ $(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)$	10^{10}
$(10^4)^2$		
$(10^2)^4$		
$(10^3)^3$		

2. Rewrite each expression using a single power of 10.

$(10^7)^2$

$(10^8)^5$

$(10^{24})^3$

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3. Leticia says that the two expressions below are equivalent.

$(10^6)(10^6)$ $(10^6)^2$

Do you agree or disagree? Explain how you know.

4. Which expressions below are equivalent to 10^8? Select all that apply.

a. $10 + 10 + 10 + 10 + 10 + 10 + 10 + 10$

b. $10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$

c. $(10^2)^4$

d. $(10^2)^6$

e. $10 \cdot 8$

f. $10^2 \cdot 10^4$

g. $10^2 \cdot 10^6$

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Name: ____ G8 U5 Lesson 3 - Let's Try It

Consider the expression 10^5.

1. Identify the base and the exponent.

   BASE = _________ EXPONENT = _________

2. Write the expression in expanded form.

If the expression were changed to $(10^5)^2$, we call this a ________________ of a _______________.

3. Write $(10^5)^2$ in expanded form.

   (___________________________________ $)^2$

   (___________________________________) • (___________________________________)

4. Think about how many factors of ten there are in all. Write $(10^5)^2$ as a single power of 10.

Consider the expression $(10^3)^4$.

5. Write the expression in expanded form.

6. Write the expression as a single power of 10.

RULE: When raising a power to a power, you can ______________________the exponents to show how many factors of 10 there are.

7. Rewrite each expression as a single power of 10. Show how you know without expanding.

$(10^3)^6$	$(10^6)^3$
$(10^{13})^3$	$(10^{30})^{10}$

8. Use what you know about exponents to explain why the answers to the top two problems in Question #7 resulted in the same answer.

Consider the expression $10^4 \bullet 10^4$

9. How many tens are in each group? __________

10. How many groups of factors are there? __________

11. Write the expression using exponents instead of repeated multiplication. __________

12. Rewrite the expression using a single exponent. __________

13. Write each expression below using exponents instead of repeated multiplication. Then write each using a single exponent.

$$10^5 \bullet 10^5 \bullet 10^5 \bullet 10^5 \qquad\qquad 10^8 \bullet 10^8 \bullet 10^8$$

1. **Complete the table.** The first example is done for you.

EXPONENT	EXPANDED	SINGLE POWER OF 10
$(10^5)^2$	$(10 \bullet 10 \bullet 10 \bullet 10 \bullet 10)^2$ $(10 \bullet 10 \bullet 10 \bullet 10 \bullet 10) \bullet (10 \bullet 10 \bullet 10 \bullet 10 \bullet 10)$	10^{10}
$(10^4)^2$		
$(10^2)^4$		
$(10^3)^3$		

2. **Rewrite each expression using a single power of 10.**

$(10^7)^2$

$(10^8)^5$

$(10^{24})^3$

3. Leticia says that the two expressions below are equivalent.

$$(10^6)(10^6) \qquad\qquad (10^6)^2$$

Do you agree or disagree? Explain how you know.

4. Which expressions below are equivalent to 10^8? Select all that apply.

a. 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10

b. 10 • 10 • 10 • 10 • 10 • 10 • 10 • 10

c. $(10^2)^4$

d. $(10^2)^6$

e. 10 • 8

f. $10^2 \cdot 10^4$

g. $10^2 \cdot 10^6$

Name: KEY

G8 U5 Lesson 3 - Let's Try It

Consider the expression 10^5.

1. Identify the base and the exponent.

   BASE = 10 EXPONENT = 5

2. Write the expression in expanded form.

   $10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$

If the expression were changed to $(10^5)^2$, we call this a power of a power.

3. Write $(10^5)^2$ in expanded form.

   $(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)^2$

   $(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)$

4. Think about how many factors of ten there are in all. Write $(10^5)^2$ as a single power of 10.

   $\boxed{10^{10}}$

Consider the expression $(10^3)^4$.

5. Write the expression in expanded form.

   $(10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10)$

6. Write the expression as a single power of 10.

   $\boxed{10^{12}}$

RULE: When raising a power to a power, you can multiply the exponents to show how many factors of 10 there are.

7. Rewrite each expression as a single power of 10. Show how you know without expanding.

$(10^3)^6$ $10^{3\cdot 6} = \boxed{10^{18}}$	$(10^6)^3$ $10^{6\cdot 3} = \boxed{10^{18}}$
$(10^{13})^3$ $10^{13\cdot 3} = \boxed{10^{39}}$	$(10^{30})^{10}$ $10^{30\cdot 10} = \boxed{10^{300}}$

8. Use what you know about exponents to explain why the answers to the top two problems in Question #7 resulted in the same answer.

6 groups of 3 factors of 10 and 3 groups of 6 factors of 10 will both result in 18 factors of 10.

Consider the expression $10^4 \cdot 10^4$

9. How many tens are in each group? 4

10. How many groups of factors are there? 2

11. Write the expression using exponents instead of repeated multiplication. $(10^4)^2$

12. Rewrite the expression using a single exponent. 10^8

13. Write each expression below using exponents instead of repeated multiplication. Then write each using a single exponent.

$10^5 \cdot 10^5 \cdot 10^5 \cdot 10^5$

$(10^5)^4 = \boxed{10^{20}}$

$10^8 \cdot 10^8 \cdot 10^8$

$(10^8)^3 = \boxed{10^{24}}$

Name: KEY

1. **Complete the table.** The first example is done for you.

EXPONENT	EXPANDED	SINGLE POWER OF 10
$(10^5)^2$	$(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)^2$ $(10 \cdot 10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10 \cdot 10)$	10^{10}
$(10^4)^2$	$(10 \cdot 10 \cdot 10 \cdot 10)^2$ $(10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10 \cdot 10)$	10^8
$(10^2)^4$	$(10 \cdot 10)^4$ $(10 \cdot 10) \cdot (10 \cdot 10) \cdot (10 \cdot 10) \cdot (10 \cdot 10)$	10^8
$(10^3)^3$	$(10 \cdot 10 \cdot 10)^3$ $(10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10)$	10^9

2. **Rewrite each expression using a single power of 10.**

$(10^7)^2$ $10^{7 \cdot 2} = \boxed{10^{14}}$

$(10^8)^5$ $10^{8 \cdot 5} = \boxed{10^{40}}$

$(10^{24})^3$ $10^{24 \cdot 3} = \boxed{10^{72}}$

3. Leticia says that the two expressions below are equivalent.

$(10^6)(10^6)$ $(10^6)^2$

10^{6+6} $10^{6\cdot 2}$

Do you agree or disagree? Explain how you know.

I agree. They are both equivalent to 10^{12}. The first expression shows 2 groups of 6 factors of

4. Which expressions below are equivalent to 10^8? Select all that apply.

~~a. 10 + 10 + 10 + 10 + 10 + 10 + 10 + 10~~

[✓ b.] 10 • 10 • 10 • 10 • 10 • 10 • 10 • 10 10^8

[✓ c.] $(10^2)^4$ $10^{2\cdot 4}$

~~d. $(10^2)^6$~~ 10^{12}

~~e. 10 • 8~~ 80

~~f. $10^2 \cdot 10^4$~~ 10^6

[✓ g.] $10^2 \cdot 10^6$ $10^{2+6} = 10^8$

G8 U5 Lesson 4

Generalize the exponent rule 10m 10n = 10n-m and write equivalent exponential expressions of division expressions with a base of 10.

G8 U5 Lesson 4 - Students will generalize the exponent rule $10^n \div 10^m = 10^{n-m}$ and write equivalent exponential expressions of division expressions with a base of 10.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): Today we'll continue working with powers of 10. In previous lessons, we've learned rules to help us multiply a power of 10 by another power of 10. We've also learned how to raise a power of 10 to another power. Our focus in this lesson will be on how we can divide expressions involving powers of 10. Similar to previous lessons, we'll use expanded form to help us think about the factors. From the expanded form, we'll work to develop more efficient rules we can apply to similar problems.

Let's Talk (Slide 3): Before we jump into work with exponents, take a second to look at the four circles here. What do you notice? What do you wonder? Possible Student Answers, Key Points:

- I notice they're all fractions. I notice they all have the same numerator and denominator. I notice the third circle involves multiplication. I notice the last circle has variables instead of numbers. I notice they're all equal to 1.
- I wonder what they equal. I wonder if they're equivalent. I wonder what this has to do with our exponent work today.

We've learned in previous years that anytime a fraction has the same numerator and denominator, it's equal to 1 whole. *(point to each circle as you describe it)* For example, 2 halves is equal to 1 whole. Or 10 tenths is equal to 1 whole. The third circle would be equal to 20 twentieths which is the same as 1 whole.

This idea will come in handy as we work with our division problems today.

Let's Think (Slide 4): Our first problems want us to write each expression using a single exponent. The first example can be read as 10 to the sixth power divided by 10 to the third power.

$$\frac{10^6}{10^3} = \frac{10\cdot10\cdot10\cdot10\cdot10\cdot10}{10\cdot10\cdot10}$$

Let's rewrite the division expression in fraction form. *(write 10 to the sixth power over 10 to the third power)* From here, we can expand each set of factors. How can I write the numerator and the denominator in expanded form? Possible Student Answers, Key Points:

- The numerator can be 10 x 10 x 10 x 10 x 10 x 10.
- The denominator can be 10 x 10 x 10.

$$\frac{10\cdot10\cdot10\cdot10\cdot10\cdot10}{10\cdot10\cdot10}$$

Let's start by thinking about what the numerator and denominator have in common. I see they both have 3 factors of 10 in common. *(highlight three factors of 10 in the numerator and the denominator)*

$$\frac{10\cdot10\cdot10}{10\cdot10\cdot10}\cdot\underbrace{10\cdot10\cdot10}$$

$$1\cdot10^3$$

$$10^3$$

Let's separate that part of the expression from the leftover factors of 10. *(rewrite the expression as shown here)* We just revisited the idea that a fraction with the same numerator and denominator is always equal to 1, so I can write the three factors of 10 over three factors of 10 as simply being 1. So the expression can now be thought of as 1 times the remaining three factors of 10, or 1 times 10 to the third power. *(write 1 x 10 to the third power)* Our simplified expression is 10 to the third power. Well done! Let's look at the other example.

How can I write this division expression in fraction form? *(write as student shares)* (10 to the tenth power over 10 to the second power) Just like last time, we can expand the numerator and denominator. What would that look like? Possible Student Answers, Key Points:

- There would be 10 factors of 10 in the numerator.
- There would be 2 factors of 10 in the denominator.

$$\frac{10^{10}}{10^{2}} = \frac{10\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10}{10\cdot10}$$

We see that each expression has two factors of 10 in common. *(highlight two factors of 10 in the numerator and the denominator)* Let's write these separately from the remaining factors of 10.

$$\frac{10\cdot10}{10\cdot10}\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10$$

$$1\cdot10^{8}$$

$$10^{8}$$

What is 10 • 10 over 10 • 10 equivalent to? (1 whole) It's like 100 over 100, which would just be 1 whole. We can rewrite that part of the expression as 1. *(write as you narrate)* So, our expression now shows 1 times 8 factors of 10. We can write this as 1 times 10 to the eighth power, which is equal to 10 to the eighth power. We just rewrote the division expression as an expression with a single exponent.

Look back at both problems we just finished. Take a second to study the exponents in the problems and the exponents in each answer. Do you notice anything that could help develop an efficient rule for when we divide with powers of 10? Possible Student Answers, Key Points:

- I notice that 6 minus 3 equals 3. I notice that 10 minus 2 equals 8.
- I think we can subtract the exponents, since the matching factors of 10 cancel out.

$$10^{10-2} = 10^{8}$$

$$10^{6-3} = 10^{3}$$

When dividing with powers of 10, we can subtract the exponents. *(show subtraction of the exponents in writing as you narrate)* In our most recent problem, we can subtract 10 minus 2 to result in 8 factors of 10. In our first problem, we could subtract 6 minus 3 to result in 3 factors of 10.

This rule can help us efficiently divide with powers of 10 in any problem. Let's try out one more example.

Let's Think (Slide 5): In this problem, we see two students attempting to write the expression shown here using a single exponent. Take a moment to read each person's thinking. *(pause)* Based on the rule we just figured out, whose logic is correct? Possible Student Answers, Key Points:

- Bob is correct, because I know we can subtract the exponents when dividing with powers of 10.
- Ted is incorrect, because we don't actually divide the exponents when dealing with powers of 10.

$$\frac{10^{100}}{10^{20}} = 10^{100-20}$$

$$\downarrow$$

$$10^{80}$$

Excellent thinking. Let's show how we could arrive at the correct answer using the rule. The rule is particularly helpful for this problem, given that these numbers would take a long time to expand.

(write the expression in fraction form) We can write the division expression as a fraction. Rather than expanding both expressions out and canceling out 20 matching factors of 10, we can subtract. 100 minus 20, means we are left with an exponent of 80. The expressions would have 80 factors of 10.

Let's Try it (Slides 6 - 7): Now we'll get a chance to practice together before you work independently. What are some strategies we've seen today to help us divide powers of 10? Possible Student Answers, Key Points:

- We can write the division as a fraction.
- We can expand the expressions, and match factors of 10.
- We can subtract the exponents.

As we work, we'll want to think about which strategy best fits the given problem. Would it be an easy problem to expand? Would it maybe be easier to subtract the exponents? Let's try a few more together.

WARM WELCOME

Today we will generalize the exponent rule $10^{n} \div 10^{m} = 10^{n - m}$ and write equivalent exponential expressions of division expressions with a base of 10.

Let's Talk:

What do you notice? What do you wonder?

$\frac{2}{2}$ $\frac{10}{10}$ $\frac{4 \cdot 5}{4 \cdot 5}$ $\frac{a}{a}$

Let's Think:

Rewrite each expression using a single exponent.

$10^6 \div 10^3$

$10^{10} \div 10^2$

Can we figure out a rule?

Let's Think:

Look at each person's thinking. Who is correct? How do you know?

$10^{100} \div 10^{20}$

The answer is 10^{80} because 100 minus 20 is 80.

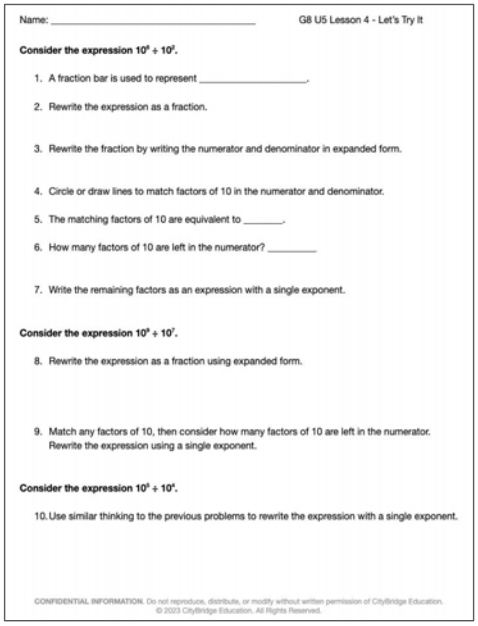
BOB

The answer is 10^{5} because 100 divided by 20 is 5.

TED

Let's Try It:

Let's explore generalizing the exponent rule $10^n \div 10^m = 10^{n-m}$ and writing equivalent exponential expressions of division expressions with a base of 10 together.



Name: ____________________ G8 U5 Lesson 4 - Let's Try It

Consider the expression $10^8 \div 10^2$.

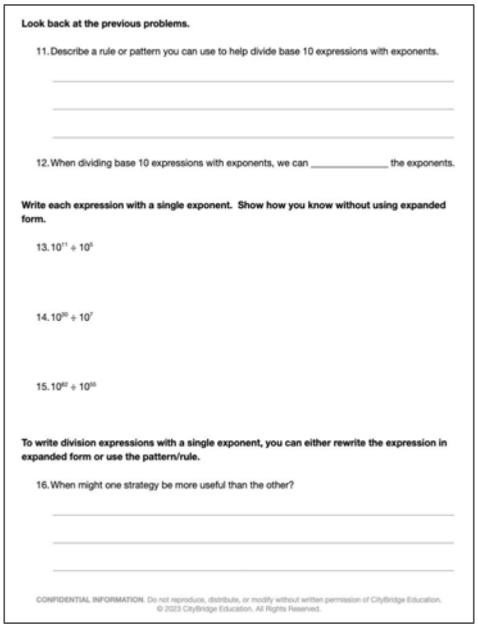
1. A fraction bar is used to represent ________________.
2. Rewrite the expression as a fraction.
3. Rewrite the fraction by writing the numerator and denominator in expanded form.
4. Circle or draw lines to match factors of 10 in the numerator and denominator.
5. The matching factors of 10 are equivalent to _______.
6. How many factors of 10 are left in the numerator? ________
7. Write the remaining factors as an expression with a single exponent.

Consider the expression $10^9 \div 10^7$.

8. Rewrite the expression as a fraction using expanded form.
9. Match any factors of 10, then consider how many factors of 10 are left in the numerator. Rewrite the expression using a single exponent.

Consider the expression $10^5 \div 10^4$.

10. Use similar thinking to the previous problems to rewrite the expression with a single exponent.



Look back at the previous problems.

11. Describe a rule or pattern you can use to help divide base 10 expressions with exponents.
12. When dividing base 10 expressions with exponents, we can ____________ the exponents.

Write each expression with a single exponent. Show how you know without using expanded form.

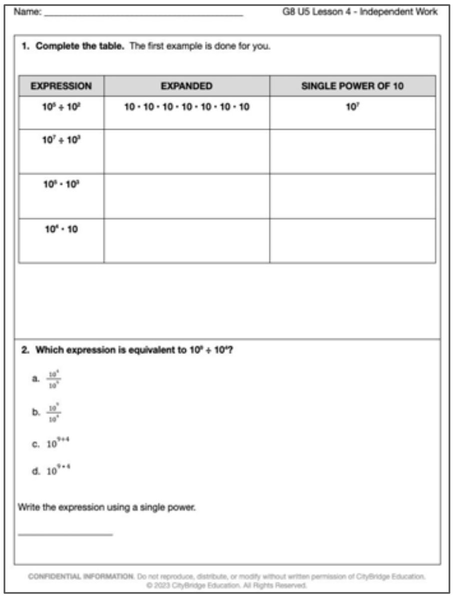
13. $10^{11} \div 10^5$
14. $10^{30} \div 10^7$
15. $10^{82} \div 10^{55}$

To write division expressions with a single exponent, you can either rewrite the expression in expanded form or use the pattern/rule.

16. When might one strategy be more useful than the other?

On your Own:

Now it’s time to generalize the exponent rule $10^n \div 10^m = 10^{n-m}$ and write equivalent exponential expressions of division expressions with a base of 10 on your own.



Name: ______________________ G8 U5 Lesson 4 - Independent Work

1. Complete the table. The first example is done for you.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^9 \div 10^2$	10 · 10 · 10 · 10 · 10 · 10 · 10	10^7
$10^7 \div 10^3$		
$10^5 \cdot 10^3$		
$10^4 \cdot 10$		

2. Which expression is equivalent to $10^9 \div 10^4$?

a. $\frac{10^4}{10^9}$

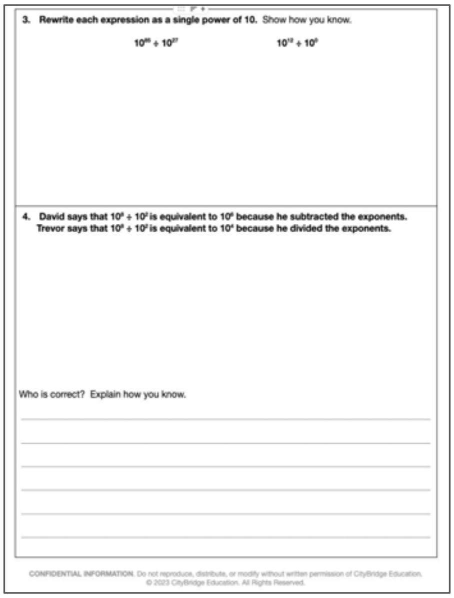
b. $\frac{10^9}{10^4}$

c. 10^{9+4}

d. 10^{9-4}

Write the expression using a single power.

____



3. Rewrite each expression as a single power of 10. Show how you know.

$10^{85} \div 10^{27}$ $10^{12} \div 10^9$

4. David says that $10^8 \div 10^2$ is equivalent to 10^6 because he subtracted the exponents. Trevor says that $10^8 \div 10^2$ is equivalent to 10^4 because he divided the exponents.

Who is correct? Explain how you know.

____

____

____

____

____

____

Consider the expression $10^6 \div 10^2$.

1. A fraction bar is used to represent _____________________.
2. Rewrite the expression as a fraction.
3. Rewrite the fraction by writing the numerator and denominator in expanded form.
4. Circle or draw lines to match factors of 10 in the numerator and denominator.
5. The matching factors of 10 are equivalent to ________.
6. How many factors of 10 are left in the numerator? __________
7. Write the remaining factors as an expression with a single exponent.

Consider the expression $10^9 \div 10^7$.

8. Rewrite the expression as a fraction using expanded form.
9. Match any factors of 10, then consider how many factors of 10 are left in the numerator. Rewrite the expression using a single exponent.

Consider the expression $10^5 \div 10^4$.

10. Use similar thinking to the previous problems to rewrite the expression with a single exponent.

Look back at the previous problems.

11. Describe a rule or pattern you can use to help divide base 10 expressions with exponents.

12. When dividing base 10 expressions with exponents, we can _______________ the exponents.

Write each expression with a single exponent. Show how you know without using expanded form.

13. $10^{11} \div 10^{5}$

14. $10^{30} \div 10^{7}$

15. $10^{82} \div 10^{55}$

To write division expressions with a single exponent, you can either rewrite the expression in expanded form or use the pattern/rule.

16. When might one strategy be more useful than the other?

1. **Complete the table.** The first example is done for you.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^5 \div 10^2$	$\frac{10 \bullet 10 \bullet 10 \bullet 10 \bullet 10}{10 \bullet 10}$	10^3
$10^7 \div 10^3$		
$10^5 \bullet 10^3$		
$10^4 \bullet 10$		

2. **Which expression is equivalent to $10^9 \div 10^4$?**

a. $\frac{10^4}{10^9}$

b. $\frac{10^9}{10^4}$

c. 10^{9+4}

d. $10^{9 \bullet 4}$

Write the expression using a single power.

____

3. **Rewrite each expression as a single power of 10.** Show how you know.

$\mathbf{10^{85} \div 10^{27}}$ $\mathbf{10^{12} \div 10^{0}}$

4. **David says that $10^8 \div 10^2$ is equivalent to 10^6 because he subtracted the exponents. Trevor says that $10^8 \div 10^2$ is equivalent to 10^4 because he divided the exponents.**

Who is correct? Explain how you know.

Name: KEY

Consider the expression $10^6 \div 10^2$.

1. A fraction bar is used to represent division.

2. Rewrite the expression as a fraction. $\frac{10^6}{10^2}$

3. Rewrite the fraction by writing the numerator and denominator in expanded form.

$$\frac{10\cdot10\cdot10\cdot10\cdot10\cdot10}{10\cdot10}$$

4. Circle or draw lines to match factors of 10 in the numerator and denominator.

5. The matching factors of 10 are equivalent to 1.

6. How many factors of 10 are left in the numerator? 4

7. Write the remaining factors as an expression with a single exponent.

10^4

Consider the expression $10^9 \div 10^7$.

8. Rewrite the expression as a fraction using expanded form.

$$\frac{\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot10\cdot10}{\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}}$$

9. Match any factors of 10, then consider how many factors of 10 are left in the numerator. Rewrite the expression using a single exponent.

10^2

Consider the expression $10^5 \div 10^4$.

10. Use similar thinking to the previous problems to rewrite the expression with a single exponent.

$$\frac{\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot10}{\cancel{10}\cdot\cancel{10}\cdot\cancel{10}\cdot\cancel{10}}$$

10

Look back at the previous problems.

11. Describe a rule or pattern you can use to help divide base 10 expressions with exponents.

Instead of writing each value in expanded form, we can subtract the exponents.

12. When dividing base 10 expressions with exponents, we can subtract the exponents.

Write each expression with a single exponent. Show how you know without using expanded form.

13. $10^{11} \div 10^{5}$ $\quad 10^{11-5} = \boxed{10^{6}}$

14. $10^{30} \div 10^{7}$ $\quad 10^{30-7} = \boxed{10^{23}}$

15. $10^{82} \div 10^{55}$ $\quad 10^{82-55} = \boxed{10^{27}}$

To write division expressions with a single exponent, you can either rewrite the expression in expanded form or use the pattern/rule.

16. When might one strategy be more useful than the other?

The rule can be more helpful when dealing with exponents that would be cumbersome to expand.

like this one!

Name: KEY

1. **Complete the table.** The first example is done for you.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^5 \div 10^2$	$\frac{10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot \cancel{10} \cdot \cancel{10}}{10 \cdot 10}$	~~10^7~~ 10^3
$10^7 \div 10^3$	$\frac{10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10}{10 \cdot 10 \cdot 10}$	10^4
$10^5 \cdot 10^3$	$\frac{10 \cdot 10 \cdot 10 \cdot 10 \cdot 10}{10 \cdot 10 \cdot 10}$	10^2
$10^4 \cdot 10$	$\frac{10 \cdot 10 \cdot 10 \cdot 10}{10}$	10^3

2. **Which expression is equivalent to $10^9 \div 10^4$?**

a. $\frac{10^4}{10^9}$

[✓ b. $\frac{10^9}{10^4}$]

c. 10^{9+4}

d. $10^{9 \cdot 4}$

$$10^9 \div 10^4 = \frac{10^9}{10^4}$$

$$10^{9-4} = 10^5$$

Write the expression using a single power.

$\boxed{10^5}$

3. Rewrite each expression as a single power of 10. Show how you know.

$10^{85} \div 10^{27}$

10^{85-27}

$\boxed{10^{58}}$

$10^{12} \div 10^{0}$

10^{12-0}

$\boxed{10^{12}}$

4. David says that $10^8 \div 10^2$ is equivalent to 10^6 because he subtracted the exponents. Trevor says that $10^8 \div 10^2$ is equivalent to 10^4 because he divided the exponents.

$$10^8 \div 10^2 = \frac{10^8}{10^2} = 10^{8-2}$$

$\boxed{10^6}$

Who is correct? Explain how you know.

David is correct. If he used expanded form, he'd have 8 factors of 10 over 2 factors of 10. Once he cancelled out factors of 10, there would be 6 factors of 10 remaining.

G8 U5 Lesson 5

Generalize the exponent rule 10-n = 10n 1 and write equivalent exponential expressions involving negative exponents.

G8 U5 Lesson 5 - Students will generalize the exponent rule $10^{-n} = 1/10^n$ and write equivalent exponential expressions involving negative exponents.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): We've been generalizing rules about exponents for the past several lessons. What rules stand out to you from what we've learned so far? Possible Student Answers, Key Points:

- When multiplying powers of 10, we can add the exponents.
- When taking a power of power, we can multiply the exponents.
- When dividing powers of 10, we can subtract the exponents.

Today, we'll continue exploring these rules and add one more rule to our toolkit. We'll specifically look at how we can work with negative exponents. Before we do that, let's refresh on the rules we've already learned.

Let's Talk (Slide 3): Look at the exponential expressions shown here. Take a few moments independently with scratch paper, and try to rewrite each using a single, positive exponent. When you're ready, we'll check your work to review our exponent rules. *(allow student a couple minutes to work, supporting as needed)*

$$10^{5+2} = 10^7$$

$$10^{5\cdot2} = 10^{10}$$

(write expressions as you narrate) The first expression has two factors that are powers of 10 being multiplied. We could write each factor in expanded form, but we also know we can add the exponents to more efficiently arrive at a single-exponent expression. 5 + 2 = 7, so our answer would be 10 to the seventh power.

What's different about the second expression? How would you write it as a single-exponent expression? Possible Student Answers, Key Points:

- The second expression is asking about a power to a power.
- We can multiply the exponents, because we're taking 2 groups of 5 factors of 10. 5 x 2 = 10, so our answer is 10 to the tenth power.

$$10^{5-2} = 10^3$$

The last example involves dividing two powers of 10. What rule can we use to write this as an expression with a single exponent? Possible Student Answers, Key Points:

- We can subtract the exponents when we divide by powers of 10.
- 5 - 2 = 3, so our answer would be 10 to the third power.

Great work! We've learned several rules that can help us efficiently work with exponential expressions. Let's explore one more.

Let's Think (Slide 4): We're going to work with negative exponents. There's a chance you've never done this before, and that's okay! Let's start by looking at patterns with what we already know: positive exponents. We'll complete this table to see how we can use familiar patterns to make sense of negative exponents.

EXPONENT	DECIMAL	FRACTION
10^2	100.0	$\frac{100}{1}$
10^1	10.0	$\frac{10}{1}$
10^0	1.0	$\frac{1}{1}$

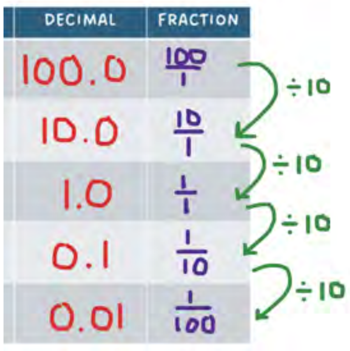
(fill in table as you narrate) We know 10 to the second power is 10 x 10, which is 100. We can write that as 100.0 in decimal form. If we want to write that as a fraction, we can write it as 100/1.

How can we write 10 to the first power as a decimal and a fraction? Possible Student Answers, Key Points:

- 10 to the first power just means one factor of 10. We can write that as 10.0 in decimal form and 10/1 in fraction form.

The next row shows 10 to the 0 power. We've learned that any base to the zero power is 1. We can write that as 1.0 for decimal form and 1/1 for fraction form.

Already, we can start to notice some place value patterns. *(trace chart with your finger as you describe the pattern)* As we move up each row, the exponent increases by 1. If we look at the values, we can see that we're multiplying each value by 10 as we move up each row. We can also think of that in reverse. As we go down each row, the exponent decreases by 1. The values are decreasing by a factor of 10. We can think of that as dividing by 10 or multiplying by 1/10 as we move down each row. These patterns can help us think about negative exponents.



DECIMAL	FRACTION
100.0	$\frac{100}{1}$
10.0	$\frac{10}{1}$
1.0	$\frac{1}{1}$
0.1	$\frac{1}{10}$
0.01	$\frac{1}{100}$

(draw arrows showing the pattern of dividing by 10 for the filled-in values) Let's keep dividing by 10 or multiplying by 1/10 as we move down the table to help us fill in the other rows. The next row is 10 to the negative first power. If 10 to the zero power is 1, we can divide that by 10 to find 10 to the negative first power. What is 1 divided by 10 as a fraction? As a decimal? *(fill in values as student shares, supporting as needed)* Possible Student Answers, Key Points:

- 1 divided by 10 is one tenth.
- We can write that as 0.1 in decimal form. As a fraction, it's 1/10.

Let's keep the pattern going to find 10 to the negative second power. We can divide by 10, or multiply by 1/10 again. One tenth divided by ten is what? We'll need a fraction and a decimal. *(fill in values as student shares, supporting as needed)* Possible Student Answers, Key Points:

- One tenth divided by 10 is one hundredth
- We can write that as 0.01 in decimal form. As a fraction, it's 1/100.

Nice work! What if the pattern were to keep going? What do you think 10 to the negative third power would be, and why? *(fill in values as student shares, supporting as needed)* Possible Student Answers, Key Points:

- We could divide 0.01 or 1/100 by 10 to find 10 to the negative third power.
- 10 to the negative third power would be one thousandth. That's 0.001 in decimal form and 1/1000 in fraction form.

$$10^3 = 10 \cdot 10 \cdot 10 = 1000$$

$$10^{-3} = \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} = \frac{1}{1000}$$

Notice, we find positive powers of 10, it's like we're multiplying by 10 that many times. *(write as you narrate)* For example, 10 to the third power is 10 x 10 x 10, or 1,000. When we find negative powers of 10, it's like we're dividing by 10 that many times. Another way to think of that is that we're multiplying by 1/10 that number of times. For example, 10 to the negative third power is 1/10 x 1/10 x 1/10, or 1/1000.

Let's Think (Slide 5): Our next problem gives us two expressions. We're asked to write each using a single, positive exponent.

$$\left(\frac{1}{10}\right)^4 \qquad \frac{1}{10 \cdot 10 \cdot 10 \cdot 10} \qquad \frac{1}{10^4}$$

Let's look at the first one. Right away, I see we have 4 factors of 1/10. *(write as you narrate)* One way we can write this is as 1/10 to the fourth power. I can also think of this expression as being 1 over 10 • 10 • 10 • 10, so I can write the expression as 1 over 10 to the fourth power. Both ways show the original expression written with a single, positive exponent.

Take a look at the next expression. This can be read as ten to the negative seventh power. Look back at the table of values we completed. How can we use the patterns from the table of values to help us rewrite this as an expression using a single positive exponent? Possible Student Answers, Key Points:

- I know 10 to a negative power is like multiplying by 1/10 that many times.
- I can think of this as 1/10 times 1/10 times 1/10…seven times over.

When the power of 10 is positive, we think of that many factors of 10 being multiplied together. When the power of 10 is negative, like in this case, we think of that many factors of 1/10 being multiplied together.

$$\left(\frac{1}{10}\right)^{7} \text{ OR } \frac{1}{10^{7}}$$

That means, we could express 10 to the negative seventh power as 1/10 multiplied by itself 7 times. *(write as you narrate)* We can write that in two ways. We could write it as 1/10 to the seventh power. Or, we can also write it as 1 over 10 to the seventh power.

Let's Try it (Slides 6 - 7): Nice work assisting with those last few examples. We were able to find helpful patterns when working with negative exponents. When our base is 10, every time our exponent increases by 1, the value of the expression is multiplied by 10. When our base is 10, every time our exponent decreases by 1, the value of the expression is multiplied by 1/10 or divided by 10. Today, we saw how this place value reasoning can apply to negative exponents. When we see a negative exponent on a base of 10, we can think of the value as 1/10 being multiplied by itself that many times. We can use the table we created to help us remember patterns as we work through a few more examples. Let's dive in!

WARM WELCOME

Today we will generalize the exponent rule $10^{-n} = 1/10^{n}$ and write equivalent exponential expressions involving negative exponents.

Let's Talk:

We've learned a few rules to help us work with powers of 10.

Rewrite each expression as a single power of 10.

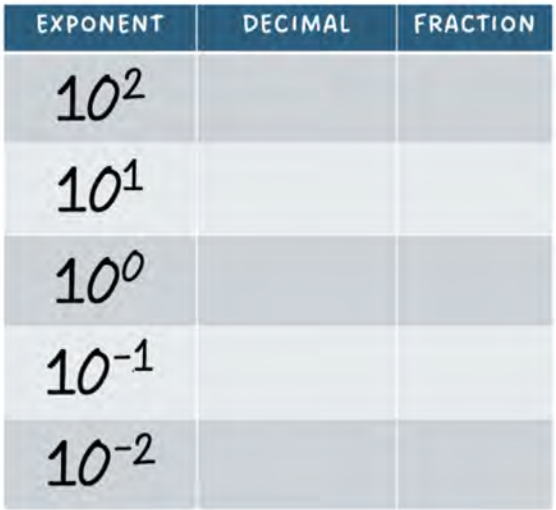
$10^5 \bullet 10^2$

$(10^5)^2$

$10^5 \div 10^2$

Let's Think:

Complete the table to identify patterns when working with negative exponents.



EXPONENT	DECIMAL	FRACTION
10^2		
10^1		
10^0		
10^{-1}		
10^{-2}		

Can we figure out a rule?

Let's Think:

Rewrite each using a single, positive power of 10.

$$\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$$

$$10^{-7}$$

Let's Try It:

Let's explore generalizing the exponent rule $10^{-n} = 1/10^{n}$ and writing equivalent exponential expressions involving negative exponents together.

Name: ____________________ G8 U5 Lesson 5 - Let's Try It

Think back to the rules and patterns we've explored with exponents so far.

1. Use the rules to write each expression in expanded form and as a single power of 10.

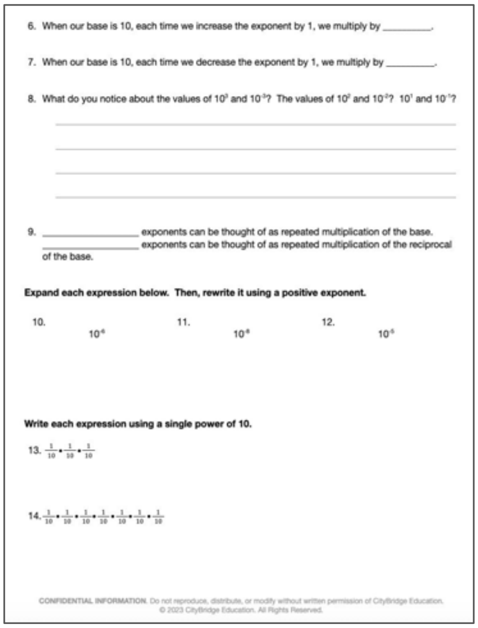
EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^{6} \cdot 10^{2}$		
$(10^{4})^{2}$		
$10^{8} \div 10^{2}$		

2. When multiplying powers of 10, we can ____________ the exponents.
3. When finding a power of a power, we can ____________ the exponents.
4. When dividing powers of 10, we can ____________ the exponents.

Let's use a table to explore expressions with *negative* exponents. The table shows exponent expressions written as decimals and fractions.

5. Complete the table. As you go, look for patterns.

EXPONENTS	10^{4}	10^{3}	10^{2}	10^{1}	10^{0}	10^{-1}	10^{-2}	10^{-3}
DECIMAL	10,000.0	1,000.0	100.0					
FRACTION	10,000/1	1,000/1	100/1					



6. When our base is 10, each time we increase the exponent by 1, we multiply by ________.
7. When our base is 10, each time we decrease the exponent by 1, we multiply by ________.
8. What do you notice about the values of 10^{3} and 10^{-3}? The values of 10^{2} and 10^{-2}? 10^{1} and 10^{-1}?

9. ____________ exponents can be thought of as repeated multiplication of the base.
____________ exponents can be thought of as repeated multiplication of the reciprocal of the base.

Expand each expression below. Then, rewrite it using a positive exponent.

10. 10^{-4}

11. 10^{-8}

12. 10^{-5}

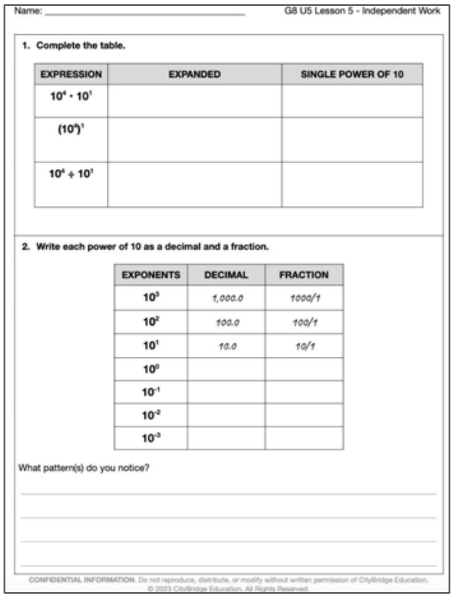
Write each expression using a single power of 10.

13. $\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$

14. $\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$

On your Own:

Now it's time to generalize the exponent rule $10^{-n} = 1/10^{n}$ and write equivalent exponential expressions involving negative exponents on your own.



Name: ______________________ G8 U5 Lesson 5 - Independent Work

1. Complete the table.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^4 \cdot 10^1$		
$(10^4)^1$		
$10^4 \div 10^1$		

2. Write each power of 10 as a decimal and a fraction.

EXPONENTS	DECIMAL	FRACTION
10^3	1,000.0	1000/1
10^2	100.0	100/1
10^1	10.0	10/1
10^0		
10^{-1}		
10^{-2}		
10^{-3}		

What pattern(s) do you notice?

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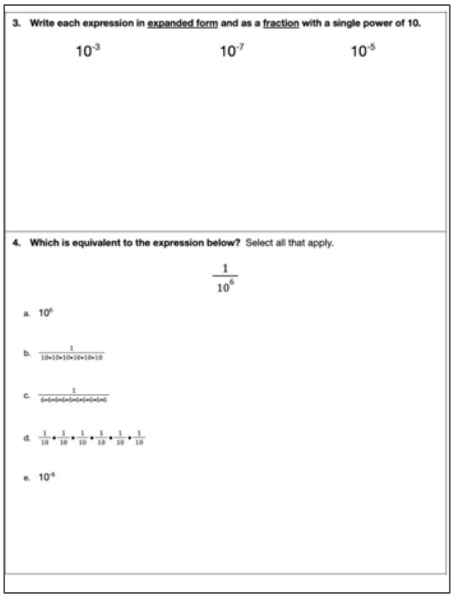

3. Write each expression in <u>expanded form</u> and as a <u>fraction</u> with a single power of 10.

10^{-3} 10^{-7} 10^{-5}

4. Which is equivalent to the expression below? Select all that apply.

$$\frac{1}{10^6}$$

a. 10^6

b. $\frac{1}{10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10}$

c. $\frac{1}{6 \cdot 6 \cdot 6 \cdot 6 \cdot 6 \cdot 6 \cdot 6 \cdot 6 \cdot 6 \cdot 6}$

d. $\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}$

e. 10^{-6}

Name: ____ G8 U5 Lesson 5 - Let’s Try It

Think back to the rules and patterns we’ve explored with exponents so far.

1. Use the rules to write each expression in expanded form and as a single power of 10.

EXPRESSION	**EXPANDED**	**SINGLE POWER OF 10**
$\mathbf{10^6 \bullet 10^2}$		
$\mathbf{(10^6)^2}$		
$\mathbf{10^6 \div 10^2}$		

2. When multiplying powers of 10, we can ___________________ the exponents.
3. When finding a power of a power, we can ___________________ the exponents.
4. When dividing powers of 10, we can ___________________ the exponents.

Let’s use a table to explore expressions with *negative* exponents. The table shows exponent expressions written as decimals and fractions.

5. Complete the table. As you go, look for patterns.

EXPONENTS	10^4	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}
DECIMAL	**10,000.0**	**1,000.0**	**100.0**					
FRACTION	**10,000/1**	**1,000/1**	**100/1**					

6. When our base is 10, each time we increase the exponent by 1, we multiply by _________.

7. When our base is 10, each time we decrease the exponent by 1, we multiply by _________.

8. What do you notice about the values of 10^3 and 10^{-3}? The values of 10^2 and 10^{-2}? 10^1 and 10^{-1}?

9. ___________________ exponents can be thought of as repeated multiplication of the base.
___________________ exponents can be thought of as repeated multiplication of the reciprocal of the base.

Expand each expression below. Then, rewrite it using a positive exponent.

10. 10^{-6}

11. 10^{-8}

12. 10^{-5}

Write each expression using a single power of 10.

13. $\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$

14. $\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$

1. Complete the table.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^4 \cdot 10^1$		
$(10^4)^1$		
$10^4 \div 10^1$		

2. Write each power of 10 as a decimal and a fraction.

EXPONENTS	DECIMAL	FRACTION
10^3	1,000.0	1000/1
10^2	100.0	100/1
10^1	10.0	10/1
10^0		
10^{-1}		
10^{-2}		
10^{-3}		

What pattern(s) do you notice?

____

____

____

____

3. Write each expression in <u>expanded form</u> and as a <u>fraction</u> with a single power of 10.

10^{-3} 10^{-7} 10^{-5}

4. Which is equivalent to the expression below? Select all that apply.

$$\frac{1}{10^{6}}$$

a. 10^{6}

b. $\frac{1}{10 \bullet 10 \bullet 10 \bullet 10 \bullet 10 \bullet 10}$

c. $\frac{1}{6 \bullet 6 \bullet 6 \bullet 6 \bullet 6 \bullet 6 \bullet 6 \bullet 6 \bullet 6 \bullet 6}$

d. $\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$

e. 10^{-6}

Name: KEY

Think back to the rules and patterns we've explored with exponents so far.

1. Use the rules to write each expression in expanded form and as a single power of 10.

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^6 \cdot 10^2$	$(10\cdot10\cdot10\cdot10\cdot10\cdot10)\cdot(10\cdot10)$	10^{6+2} $\boxed{10^8}$
$(10^6)^2$	$(10\cdot10\cdot10\cdot10\cdot10\cdot10)\cdot$ $(10\cdot10\cdot10\cdot10\cdot10\cdot10)$	$10^{6\cdot2}$ $\boxed{10^{12}}$
$10^6 \div 10^2$	$\frac{10\cdot10\cdot10\cdot10\cdot10\cdot10}{10\cdot10}$	10^{6-2} $\boxed{10^4}$

2. When multiplying powers of 10, we can add the exponents.

3. When finding a power of a power, we can multiply the exponents.

4. When dividing powers of 10, we can subtract the exponents.

Let's use a table to explore expressions with *negative* exponents. The table shows exponent expressions written as decimals and fractions.

5. Complete the table. As you go, look for patterns.

EXPONENTS	10^4	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}
DECIMAL	10,000.0	1,000.0	100.0	10.0	1.0	0.1	0.01	0.001
FRACTION	10,000/1	1,000/1	100/1	$\frac{10}{1}$	$\frac{1}{1}$	$\frac{1}{10}$	$\frac{1}{100}$	$\frac{1}{1000}$

6. When our base is 10, each time we increase the exponent by 1, we multiply by 10.

7. When our base is 10, each time we decrease the exponent by 1, we multiply by $\frac{1}{10}$.

8. What do you notice about the values of 10^3 and 10^{-3}? The values of 10^2 and 10^{-2}? 10^1 and 10^{-1}?

I notice they are multiplicative inverses.

Ex. 1000 and $\frac{1}{1000}$, 100 and $\frac{1}{100}$, 10 and $\frac{1}{10}$

9. Positive exponents can be thought of as repeated multiplication of the base.
Negative exponents can be thought of as repeated multiplication of the reciprocal of the base.

Expand each expression below. Then, rewrite it using a positive exponent.

10. 10^{-6}

$\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}$

$\frac{1}{10^6}$ OR $\left(\frac{1}{10}\right)^6$

11. 10^{-8}

$\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}$

$\frac{1}{10^8}$ OR $\left(\frac{1}{10}\right)^8$

12. 10^{-5}

$\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}$

$\frac{1}{10^5}$ OR $\left(\frac{1}{10}\right)^5$

Write each expression using a single power of 10.

13. $\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$ $\left(\frac{1}{10}\right)^3$ OR $\frac{1}{10^3}$

14. $\frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10} \bullet \frac{1}{10}$ $\left(\frac{1}{10}\right)^7$ OR $\left(\frac{1}{10^7}\right)$

Name: KEY

1. **Complete the table.**

EXPRESSION	EXPANDED	SINGLE POWER OF 10
$10^4 \cdot 10^1$	$(10 \cdot 10 \cdot 10 \cdot 10) \cdot 10$	10^5
$(10^4)^1$	$(10 \cdot 10 \cdot 10 \cdot 10)$	10^4
$10^4 \div 10^1$	$\frac{10 \cdot 10 \cdot 10 \cdot 10}{10}$	10^3

2. **Write each power of 10 as a decimal and a fraction.**

EXPONENTS	DECIMAL	FRACTION
10^3	1,000.0	1000/1
10^2	100.0	100/1
10^1	10.0	10/1
10^0	1	$\frac{1}{1}$
10^{-1}	0.1	$\frac{1}{10}$
10^{-2}	0.01	$\frac{1}{100}$
10^{-3}	0.001	$\frac{1}{1000}$

What pattern(s) do you notice?

As the exponents increase by 1 we multiply each value by 10. As exponents decrease by 1, we divide each value by 10 or multiply by 1/10.

3. Write each expression in <u>expanded form</u> and as a <u>fraction</u> with a single power of 10.

10^{-3}

$\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}$

$\boxed{\frac{1}{10^3}}$

OR $\left(\frac{1}{10}\right)^3$

10^{-7}

$\frac{1}{10\cdot10\cdot10\cdot10\cdot10\cdot10\cdot10}$

$\boxed{\left(\frac{1}{10}\right)^7}$

OR $\frac{1}{10^7}$

10^{-5}

$\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}$

$\boxed{\left(\frac{1}{10}\right)^6}$

OR $\frac{1}{10^6}$

4. Which is equivalent to the expression below? Select all that apply.

$$\frac{1}{10^6}$$

~~a. 10^6~~

[✓ b. $\frac{1}{10\cdot10\cdot10\cdot10\cdot10\cdot10}$]

~~c. $\frac{1}{6\cdot6\cdot6\cdot6\cdot6\cdot6\cdot6\cdot6\cdot6\cdot6}$~~

[✓ d. $\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}\cdot\frac{1}{10}$]

[✓ e. 10^{-6}]

G8 U5 Lesson 6

Generalize exponent rules for bases other than 10, and use exponent rules to write equivalent exponent expressions for any nonzero base.

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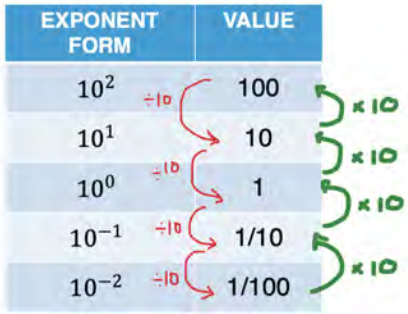
G8 U5 Lesson 6 - Students will generalize exponent rules for bases other than 10, and use the exponent rules to write equivalent exponent expressions for any nonzero base.

Warm Welcome (Slide 1): Tutor choice

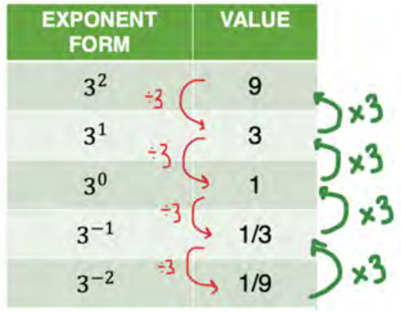
Frame the Learning/Connect to Prior Learning (Slide 2): Since the beginning of this unit, we've been working with exponents. We've found helpful rules to work with negative exponents. We've explored patterns to help us multiply exponential expressions, divide exponential expressions, and even find a power of a power. We've done all of these different things, but one thing has remained constant. Our base has always been 10. Today, we'll explore whether or not the rules we've been learning about can help us work with bases other than 10. Let me show you what I mean.

Let's Talk (Slide 3): Look over these two tables. What do you notice is the same? What's different?
Possible Student Answers, Key Points:

- They both show exponent expressions and their values. They both have exponents from 2 to -2. They are both in order.
- They are different colors. The first table involves powers of 10, and the second table shows bases of 3.



EXPONENT FORM	VALUE
10^2	100
10^1	10
10^0	1
10^{-1}	1/10
10^{-2}	1/100



EXPONENT FORM	VALUE
3^2	9
3^1	3
3^0	1
3^{-1}	1/3
3^{-2}	1/9

The first table should feel familiar. We've been working with powers of 10 for some time. We even filled out a similar table during our last lesson. *(trace with your finger or draw arrows)* We notice that as the exponents increase by 1, the value is multiplied by 10 each time. Alternately, as the exponents decrease by 1, the value is divided by 10 each time, or multiplied by 1/10.

Look at the green table that shows exponential expressions with a base of 3. Do we see the same patterns? Possible Student Answers, Key Points:

- The pattern is similar, but just with a factor of 3 or ⅓ instead of 10 or /10.
- The pattern is different. The values don't increase by multiples of 10 as the exponent goes up and multiples of 1/10 as the exponent goes down.

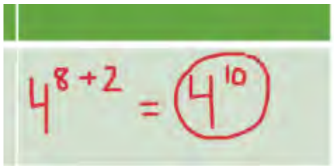
(trace with your finger or draw arrows) We notice that as the exponents increase by 1, the value is multiplied by 3 each time. Alternately, as the exponents decrease by 1, the value is divided by 3 each time, or multiplied by 1/3. The base impacts the value of the exponential expression, but the overall pattern remains similar to what we've seen with powers of 10.

So far it seems like working with powers of 10 might be similar to working with other bases. Let's explore some more.

Let's Think (Slide 4): Here, we're asked to write each expression as an expression with a single, positive exponent. Notice, none of the bases are 10. Let's use what we know to help us simplify the expressions.

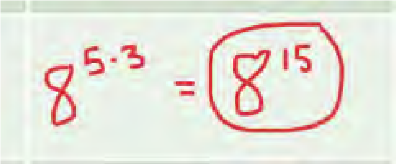
The first expression involves multiplying 4 to the eighth power times 4 to the second power. Mentally picture this expanded out. What are you picturing? Possible Student Answers, Key Points:

- I'm picturing 8 factors of 4 and then 2 more factors of 4.
- I'm picturing a long expression with 10 factors of 4 in all.



$4^{8+2} = \boxed{4^{10}}$

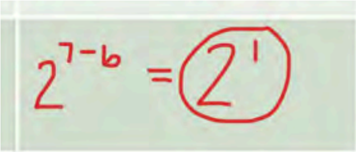
If we expanded this out, we would have 8 factors of 4 and 2 more factors of 4 being multiplied together. That means, just like we saw with powers of 10, we can add our exponents! *(write 4 to the "8+2" power)* Eight factors of 4 times 2 factors of 4 is 10 factors of 4, or 4 to the tenth power.



$8^{5 \cdot 3} = \boxed{8^{15}}$

The next expression shows 8 to the fifth power to the third power. If I picture this in expanded form, I'm visualizing 3 groups being multiplied together. Each group has 5 factors of 8 in it. That's 15 factors of 8 in all. Even though the base is 8, the rule we learned with powers of 10 holds true. We can multiply the exponents when raising a power to a power. *(write 8 to the "5 • 3" power)* The value would be 8 to the fifteenth power.

Look at the last expression. How do you think we can write this exponential expression using a single exponent? You can use scratch paper, you can think about expanded form, and you can think about the work we've done with powers of 10. Possible Student Answers, Key Points:



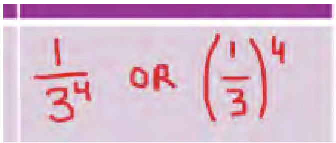
$2^{7-6} = \boxed{2^{1}}$

- I am picturing a fraction. I see 7 factors of 2 in the numerator and 6 factors of 2 in the denominator. If I match factors, I would be left with one factor of 2, or 2 to the first power.
- I can subtract the exponents. 7 - 6 = 1, so I know the answer is 2 to the first power.

We can think of this expression exactly how we'd think of it using powers of 10. If it helps, we can picture it expanded. Picture 7 factors of 2 in our numerator and 6 factors of 2 in our denominator. After matching up factors of 2, we'd have 1 factor of 2 remaining. Our answer is 2 to the first power. A more efficient way of tackling that would be to subtract the exponents. *(write 2 to the "7 - 6" power)* Either way we think of it, the value is 2 to the first power.

The rules we've used to work with bases of 10 are still helpful when the bases are other numbers.

Let's Think (Slide 5): Our last problem before we practice has us consider a negative exponent and an exponent of 0.

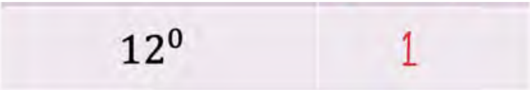


$\frac{1}{3^4}$ OR $\left(\frac{1}{3}\right)^4$

The first expression shows 3 to the negative fourth power. We can think back to our table from the beginning of the lesson. 3 to the negative first power was ⅓. 3 to the negative second power was ⅓ • ⅓, or 1/9. If we kept that pattern going, how could we think of 3 to the negative fourth power? Possible Student Answers, Key Points:

- We can think of it as ⅓ • ⅓ • ⅓ • ⅓ or 4 factors of ⅓.
- We can think of it as 1 over 3 to the fourth power.

As our exponent decreases by 1, the value is divided by 3 or multiplied by ⅓. So if we have 3 to the negative fourth power, that means we have ⅓ times ⅓ times ⅓ times ⅓. We can write that as 1 over 3 to the fourth power or as ⅓ to the fourth power. *(fill in table)*



12^0	1

Lastly, we have the expression 12 to the 0 power. Look back at our table from earlier. What was 10 to the zero power? (1) What was 3 to the zero power? (1) So, 12 to the zero power is also 1. Anything to the zero power is 1. *(fill in table)*

Let's Try it (Slides 6 - 7): We explored bases other than 10 today, and we noticed that the same rules we learned in previous lessons apply to non-ten bases. This is true, assuming the bases in a single problem are consistent like in each example we've seen so far. We know we can add the exponents when multiplying exponential expressions. We know we can subtract the exponents when dividing exponential expressions. We can multiply the exponents when taking a power to a power. And we also know that working with zero and negative exponents with non-ten bases works similar to powers of 10. Let's keep these rules in mind and try out a few more problems before you get a chance to practice on your own.

WARM WELCOME

Today we will generalize exponent rules for bases other than 10, and use the exponent rules to write equivalent exponent expressions for any nonzero base.

Let's Talk:

Look at each table of values. What's the same? What's different?

EXPONENT FORM	VALUE
10^2	100
10^1	10
10^0	1
10^{-1}	1/10
10^{-2}	1/100

EXPONENT FORM	VALUE
3^2	9
3^1	3
3^0	1
3^{-1}	1/3
3^{-2}	1/9

Let's Think:

Rewrite each expression using a single, positive exponent.

EXPONENT FORM	VALUE
$4^8 \bullet 4^2$	
$(8^5)^3$	
$2^7 \div 2^6$	

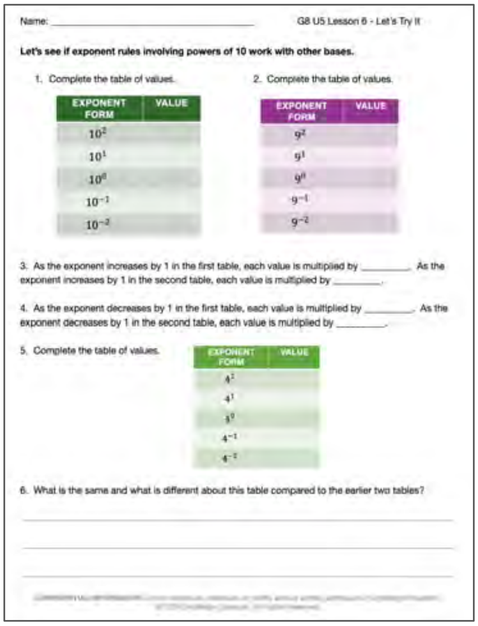
Let's Think:

Rewrite each expression using a single, positive exponent.

EXPONENT FORM	VALUE
3^{-4}	
12^0	

Let's Try It:

Let's explore generalizing exponent rules for bases other than 10, and using the exponent rules to write equivalent exponent expressions for any nonzero base together.



Name: ______________________ G8 U5 Lesson 6 - Let's Try It

Let's see if exponent rules involving powers of 10 work with other bases.

1. Complete the table of values.

EXPONENT FORM	VALUE
10^2	
10^1	
10^0	
10^{-1}	
10^{-2}	

2. Complete the table of values.

EXPONENT FORM	VALUE
9^2	
9^1	
9^0	
9^{-1}	
9^{-2}	

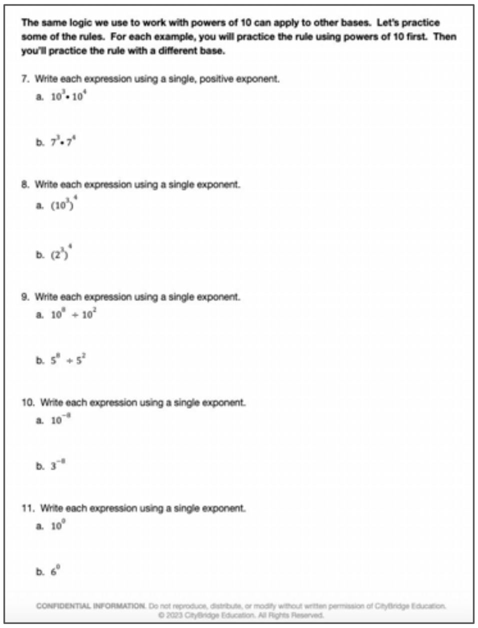
3. As the exponent increases by 1 in the first table, each value is multiplied by ________. As the exponent increases by 1 in the second table, each value is multiplied by ________.

4. As the exponent decreases by 1 in the first table, each value is multiplied by ________. As the exponent decreases by 1 in the second table, each value is multiplied by ________.

5. Complete the table of values.

EXPONENT FORM	VALUE
4^2	
4^1	
4^0	
4^{-1}	
4^{-2}	

6. What is the same and what is different about this table compared to the earlier two tables?



The same logic we use to work with powers of 10 can apply to other bases. Let's practice some of the rules. For each example, you will practice the rule using powers of 10 first. Then you'll practice the rule with a different base.

7. Write each expression using a single, positive exponent.
   a. $10^3 \cdot 10^4$
   b. $7^3 \cdot 7^4$

8. Write each expression using a single exponent.
   a. $(10^3)^4$
   b. $(2^3)^4$

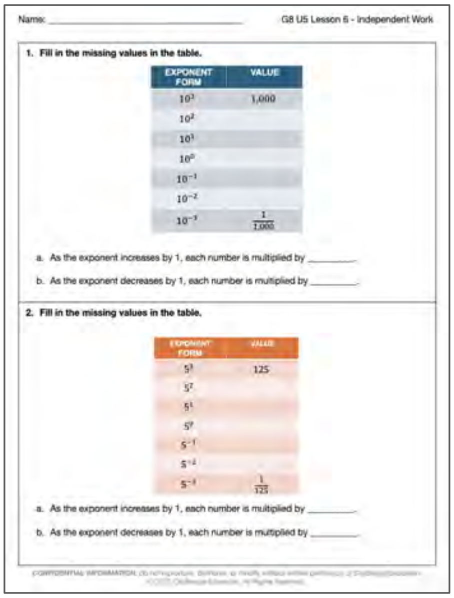
9. Write each expression using a single exponent.
   a. $10^8 \div 10^2$
   b. $5^8 \div 5^2$

10. Write each expression using a single exponent.
   a. 10^{-8}
   b. 3^{-8}

11. Write each expression using a single exponent.
   a. 10^0
   b. 6^0

On your Own:

Now it’s time to generalize exponent rules for bases other than 10, and use the exponent rules to write equivalent exponent expressions for any nonzero base on your own.



Name: ______________________ G8 U5 Lesson 6 - Independent Work

1. Fill in the missing values in the table.

EXPONENT FORM	VALUE
10^3	1,000
10^2	
10^1	
10^0	
10^{-1}	
10^{-2}	
10^{-3}	$\frac{1}{1{,}000}$

a. As the exponent increases by 1, each number is multiplied by ________.

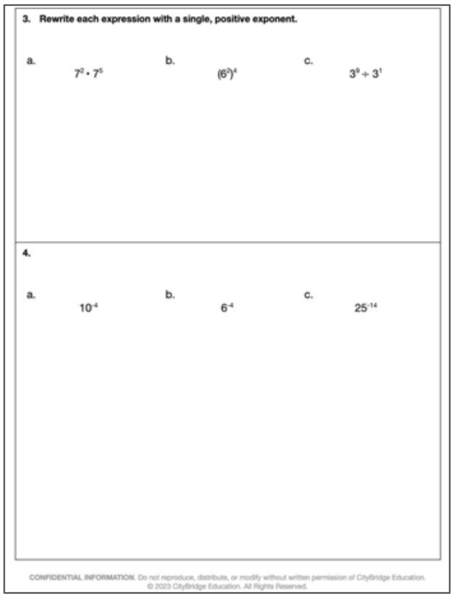
b. As the exponent decreases by 1, each number is multiplied by ________.

2. Fill in the missing values in the table.

EXPONENT FORM	VALUE
5^3	125
5^2	
5^1	
5^0	
5^{-1}	
5^{-2}	
5^{-3}	$\frac{1}{125}$

a. As the exponent increases by 1, each number is multiplied by ________.

b. As the exponent decreases by 1, each number is multiplied by ________.



3. Rewrite each expression with a single, positive exponent.

a. $7^2 \cdot 7^5$

b. $(6^2)^4$

c. $3^9 \div 3^1$

4.

a. 10^{-4}

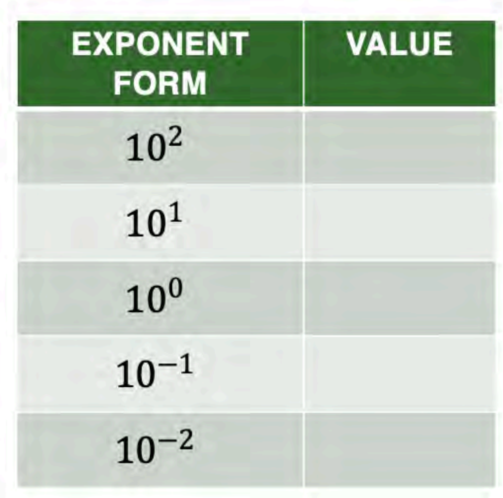
b. 6^{-4}

c. 25^{-14}

Name: ____ G8 U5 Lesson 6 - Let's Try It

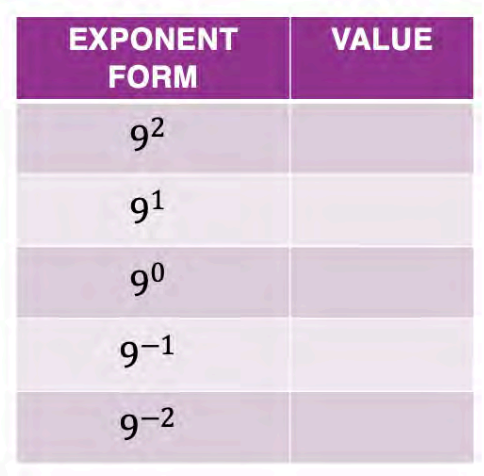
Let's see if exponent rules involving powers of 10 work with other bases.

1. Complete the table of values.



EXPONENT FORM	VALUE
10^2	
10^1	
10^0	
10^{-1}	
10^{-2}	

2. Complete the table of values.

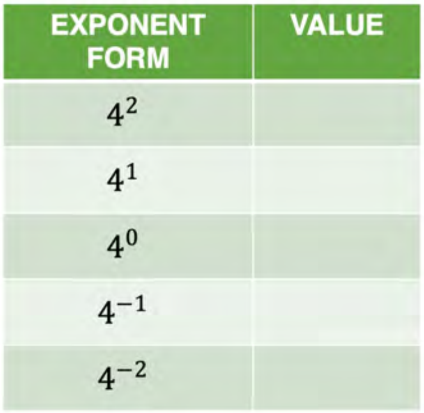


EXPONENT FORM	VALUE
9^2	
9^1	
9^0	
9^{-1}	
9^{-2}	

3. As the exponent increases by 1 in the first table, each value is multiplied by __________. As the exponent increases by 1 in the second table, each value is multiplied by __________.

4. As the exponent decreases by 1 in the first table, each value is multiplied by __________. As the exponent decreases by 1 in the second table, each value is multiplied by __________.

5. Complete the table of values.



EXPONENT FORM	VALUE
4^2	
4^1	
4^0	
4^{-1}	
4^{-2}	

6. What is the same and what is different about this table compared to the earlier two tables?

The same logic we use to work with powers of 10 can apply to other bases. Let's practice some of the rules. For each example, you will practice the rule using powers of 10 first. Then you'll practice the rule with a different base.

7. Write each expression using a single, positive exponent.
   a. $10^3 \bullet 10^4$

   b. $7^3 \bullet 7^4$

8. Write each expression using a single exponent.
   a. $(10^3)^4$

   b. $(2^3)^4$

9. Write each expression using a single exponent.
   a. $10^8 \div 10^2$

   b. $5^8 \div 5^2$

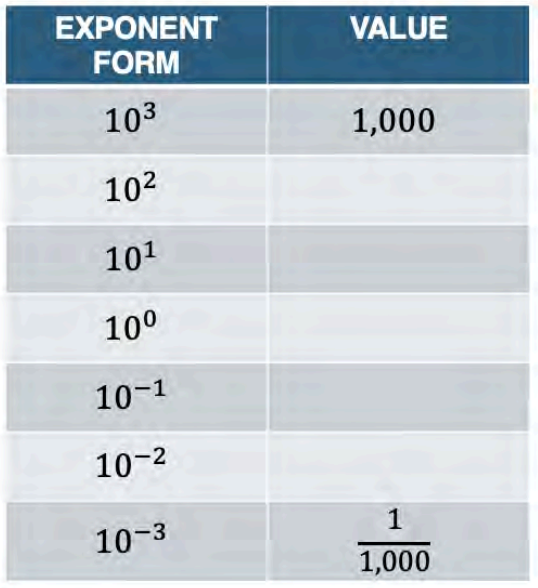
10. Write each expression using a single exponent.
    a. 10^{-8}

    b. 3^{-8}

11. Write each expression using a single exponent.
    a. 10^0

    b. 6^0

1. Fill in the missing values in the table.

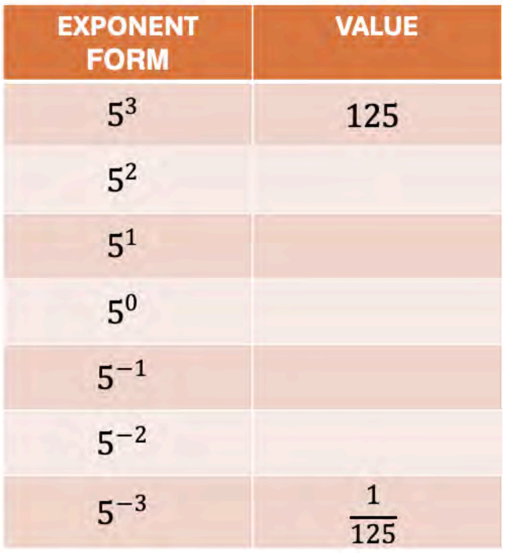


EXPONENT FORM	VALUE
10^3	1,000
10^2	
10^1	
10^0	
10^{-1}	
10^{-2}	
10^{-3}	$\frac{1}{1,000}$

a. As the exponent increases by 1, each number is multiplied by __________.

b. As the exponent decreases by 1, each number is multiplied by __________.

2. Fill in the missing values in the table.



EXPONENT FORM	VALUE
5^3	125
5^2	
5^1	
5^0	
5^{-1}	
5^{-2}	
5^{-3}	$\frac{1}{125}$

a. As the exponent increases by 1, each number is multiplied by __________.

b. As the exponent decreases by 1, each number is multiplied by __________.

3. Rewrite each expression with a single, positive exponent.

a. $7^2 \bullet 7^5$

b. $(6^2)^4$

c. $3^9 \div 3^1$

4. Rewrite each expression with a single, positive exponent.

a. 10^{-4}

b. 6^{-4}

c. 25^{-14}

Name: KEY

Let's see if exponent rules involving powers of 10 work with other bases.

1. Complete the table of values.

EXPONENT FORM	VALUE
10^2	100
10^1	10
10^0	1
10^{-1}	1/10
10^{-2}	1/100

2. Complete the table of values.

EXPONENT FORM	VALUE
9^2	81
9^1	9
9^0	1
9^{-1}	1/9
9^{-2}	1/81

3. As the exponent increases by 1 in the first table, each value is multiplied by 10. As the exponent increases by 1 in the second table, each value is multiplied by 9.

4. As the exponent decreases by 1 in the first table, each value is multiplied by 1/10. As the exponent decreases by 1 in the second table, each value is multiplied by 1/9.

5. Complete the table of values.

EXPONENT FORM	VALUE
4^2	16
4^1	4
4^0	1
4^{-1}	1/4
4^{-2}	1/16

6. What is the same and what is different about this table compared to the earlier two tables?

The base is 4. As the exponent increases the value is 4 times greater. As the exponent decreases, the value is $\frac{1}{4}$ as much as the previous.

The same logic we use to work with powers of 10 can apply to other bases. Let's practice some of the rules. For each example, you will practice the rule using powers of 10 first. Then you'll practice the rule with a different base.

7. Write each expression using a single, positive exponent.
   - a. $10^3 \cdot 10^4$ 10^{3+4} $\boxed{10^7}$
   - b. $7^3 \cdot 7^4$ 7^{3+4} $\boxed{7^7}$

8. Write each expression using a single exponent.
   - a. $(10^3)^4$ $10^{3 \cdot 4}$ $\boxed{10^{12}}$
   - b. $(2^3)^4$ $2^{3 \cdot 4}$ $\boxed{2^{12}}$

9. Write each expression using a single exponent.
   - a. $10^8 \div 10^2$ $10^{8-2} = \boxed{10^6}$
   - b. $5^8 \div 5^2$ $5^{8-2} = \boxed{5^6}$

10. Write each expression using a single exponent.
    - a. 10^{-8} $\boxed{\frac{1}{10^8}}$
    - b. 3^{-8} $\boxed{\frac{1}{3^8}}$

11. Write each expression using a single exponent.
    - a. 10^0 $\boxed{1}$
    - b. 6^0 $\boxed{1}$

Name: KEY

1. Fill in the missing values in the table.

EXPONENT FORM	VALUE
10^3	1,000
10^2	100
10^1	10
10^0	1
10^{-1}	1/10
10^{-2}	1/100
10^{-3}	$\frac{1}{1,000}$

a. As the exponent increases by 1, each number is multiplied by 10.

b. As the exponent decreases by 1, each number is multiplied by 1/10.

2. Fill in the missing values in the table.

EXPONENT FORM	VALUE
5^3	125
5^2	25
5^1	5
5^0	1
5^{-1}	5
5^{-2}	1/25
5^{-3}	$\frac{1}{125}$

a. As the exponent increases by 1, each number is multiplied by 5.

b. As the exponent decreases by 1, each number is multiplied by 1/5.

3. Rewrite each expression with a single, positive exponent.

a. $7^2 \cdot 7^5$

7^{2+5}

$\boxed{7^7}$

b. $(6^2)^4$

$6^{2 \cdot 4}$

$\boxed{6^8}$

c. $3^9 \div 3^1$

3^{9-1}

$\boxed{3^8}$

4.

a. 10^{-4}

$\boxed{\frac{1}{10^4}}$

b. 6^{-4}

$\boxed{\frac{1}{6^4}}$

c. 25^{-14}

$\boxed{\frac{1}{25^{14}}}$

G8 U5 Lesson 7

Use an appropriate exponent rule to rewrite an expression with a single, positive exponent.

G8 U5 Lesson 7 - Students will use an appropriate exponent rule to rewrite an expression with a single, positive exponent.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): Today we get to pull together all the rules we've been learning about exponents. As always, it's okay to use expanded form to help simplify exponential expressions, but it can often be more efficient to use a rule. In this lesson, we'll get a chance to practice using our rules with a variety of bases. Let's get started!

Let's Talk (Slide 3): Take a look at this statement. *(read aloud)* Based on what we've learned so far, would you say this statement is always true, sometimes true, or never true? Why? Possible Student Answers, Key Points:

- This expression is always true. We saw in our last lesson that we can apply the same rules for base 10 expressions to expressions with other bases.
- This expression is sometimes true. The bases in your expression have to be the same for the rules to apply.

[NOTE: Answers may vary depending upon student experience with exponential expressions and based upon their interpretation of the statement. The goal is to stamp that if an expression has consistent bases, then we can apply the same rules/strategies we use with base 10 expressions.]

When we have expressions with a consistent base, we can apply the same rules we use when simplifying base 10 exponential expressions. Expanded form can also be helpful in some circumstances. Let's get to some practice!

Let's Think (Slide 4): This question wants us to write each expression using a single, positive exponent. What is the base for each expression? (8) Since we have a consistent base of 8, we can use our standard exponent rules to efficiently rewrite the expressions. We've practiced these rules a lot, so I'm going to ask for your support in rewriting them.

$$8^{6+2} = \boxed{8^8}$$

How can I rewrite the expression that wants us to multiply 8 to the sixth power times 8 to the second power? Why? Possible Student Answers, Key Points:

- We can add the exponents.
- We have 6 factors of 8 times 2 more factors of 8, so we know there will be 8 factors of 8 in all.

(write as you narrate) We can add the exponents to show we are combining 6 factors of 8 times 2 more factors of 8. 6 + 2 = 8, so our rewritten expression is 8 to the eighth power.

$$8^{6-4} = \boxed{8^2}$$

How can I rewrite the expression that wants us to divide 8 to the sixth power by 8 to the fourth power? Why? Possible Student Answers, Key Points:

- We can subtract the exponents.
- We have 6 factors of 8 over 4 factors of 8. We can match up 4 factors of 8 in the numerator and denominator, leaving us with 2 factors of 8 remaining.

(write as you narrate) We can subtract the exponents. 6 minus 4 equals 2. Picturing expanded form, we'd have 6 factors of 8 over 4 factors of 8. We could isolate 4 factors of 8 over 4 factors of 8, which would be equal to 1. That would leave us with 2 factors of 8 left. Our rewritten expression is 8 to the second power.

$$8^{-5} = \boxed{\frac{1}{8^5} \text{ OR } \left(\frac{1}{8}\right)^5}$$

How can I rewrite the expression that shows 8 to the negative fifth power? Why? Possible Student Answers, Key Points:

- We can think of it as dividing by 8 five times, or multiplying by ⅛ five times.
- We could write it as 1 over 8 to the fifth power or as ⅛ to the fifth power.

(write as you narrate) If this were a positive exponent, we'd think of it as 8 x 8 x 8 x 8 x 8. Since it's a negative exponent, we can think of it as ⅛ x ⅛ x ⅛ x ⅛ x ⅛. Our rewritten expression could be 1 over 8 to the fifth power. We could also write it as ⅛ to the fifth power. Either form is acceptable.

$$8^{3\cdot 3} = \boxed{8^9}$$

How can I rewrite the last expression? Why? Possible Student Answers, Key Points:

- We can multiply the exponents.
- If you picture expanded form, we'd have 3 groups being multiplied together. In each group, there would be 3 factors of 8. That's nine factors of 8.

(write as you narrate) We can multiply the exponents to show we are multiplying 3 groups of 3 factors of 8. 3 • 3 = 9, so our rewritten expression is 8 to the ninth power.

We just used exponent rules to rewrite various expressions with a non-10 base efficiently. Great work!

Let's Think (Slide 5): Our final problem wants us to look at each equation and determine whether the equation is true or false. If it's false, we'll fix it. Each of these examples involves negative exponents, so we'll want to work carefully when applying our exponent rules.

The first equation involves multiplying to factors that have bases of 5. Since they both have the same base, what rule can we apply to the exponents? What would the expression be if rewritten with a single exponent? Possible Student Answers, Key Points:

- We can add the exponents.
- 4 plus -2 is positive 2. The rewritten expression would be 5 to the second power.

$$5\cdot5\cdot5\cdot5\cdot\frac{1}{5\cdot5}$$

(write as you narrate) Let's see if you're right. I'll start by writing each in expanded form, just to be safe. I can write 5 to the fourth power as 5 x 5 x 5 x 5. I can write 5 to the negative second power as 1 over 5 x 5.

$$\frac{5\cdot5\cdot5\cdot5}{5\cdot5} = \boxed{5^2}$$

If we multiply these, that would give us a numerator of 5 x 5 x 5 x 5 and a denominator of 5 x 5. We can match up two factors of 5 in the numerator and denominator, which is equivalent to 1. That leaves us with two factors of 5. We can rewrite this as 5 to the second power.

$$5^{4+-2} = \boxed{5^2}$$

That makes sense with our rule! We know we can add the exponents. 4 + -2 is equivalent to 2, so 5 to the second power makes sense. Whether we use expanded form or our exponent rule, we can see that this equation is true.

$$6^{4\cdot -2}=6^{-8}$$

$$(6^{-2})^4=6^{-8}$$

$$\left(\frac{1}{6}\times\frac{1}{6}\right)^4$$

(write as you narrate) Look at the second equation. What rule can we apply to the exponents when taking a power to a power? (We can multiply the exponents.) If we multiply 4 x -2, we get -8. We could rewrite this expression as 6 to the negative eighth power. Is this equation true? (No, it's false.)

We can rewrite it using the correct rewritten expression to make it true.

Our answer also makes sense if we consider expanded form. We can think of 6 to the negative second power as being ⅙ times ⅙. We can think of the expression as being (⅙ x ⅙) to the fourth power. *(write that)* If we were to picture 4 factors that each looked like ⅙ x ⅙, we'd have eight factors of ⅙, which we know we can write as 6 to the negative eighth power.

Once again, we see that whether we think about expanded form our our exponent rules, we can arrive at an answer that makes sense.

Take a second to consider the last example on your own. When you're ready to share your thinking, let me know. Is the equation true or false? *(provide wait time)* Possible Student Answers, Key Points:

- The equation is false.
- I can subtract the exponents, since we're dividing. I can think of 4 minus -2 as 4 + 2, so the exponent should be 6.

$$8^{4--2}=8^{4+2}=8^{6}$$

$$8^4\div 8^{-2}=8^6$$

(write as you narrate) When dividing exponential expressions with similar bases, we know we can subtract the exponents. 4 minus 2 would result in an exponent of 2, but this problem needs us to do 4 minus *negative* 2. 4 minus -2 is the same as 4 + 2. Our exponent in the rewritten expression would be 6. 8 to the fourth power divided by 8 to the negative second power is 8 to the sixth power.

Let's Try it (Slides 6 - 7): Now we'll get a chance to do some more practice. After we complete the next few examples, you'll get a chance to show what you know independently. As we saw in the previous problems, we can use the efficient exponent rules we've already explored and apply them to non-ten bases. If necessary, it can also be helpful to think about our expressions in expanded form. Let's keep both tactics in mind as we look at the next examples.

WARM WELCOME

Today we will use an appropriate exponent rule to rewrite an expression with a single, positive exponent.

Let's Talk:

Is the statement below ALWAYS, SOMETIMES, or NEVER true?

"The rules for evaluating exponential expressions with base 10 work for expressions with other bases."

Let's Think:

Rewrite each expression with a single, positive exponent.

$8^6 \bullet 8^2$

$\frac{8^6}{8^4}$

8^{-5}

$(8^3)^3$

Let's Think:

Is the expression below true or false? If false, rewrite to make a true statement.

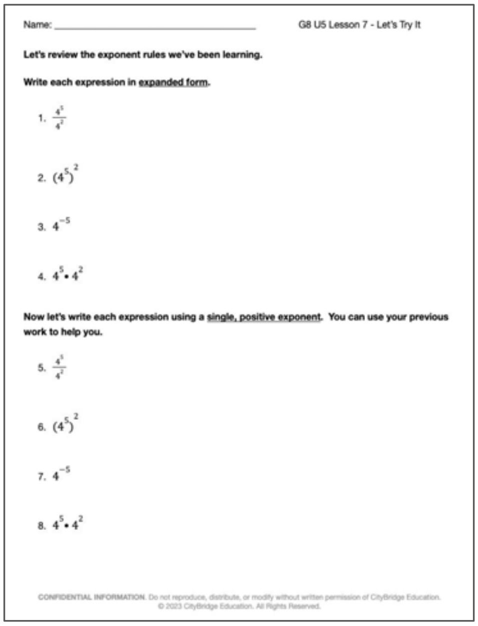
$5^4 \bullet 5^{-2} = 5^{-8}$

$(6^{-2})^4 = 6^8$

$8^4 \div 8^{-2} = 8^2$

Let's Try It:

Let's explore using an appropriate exponent rule to rewrite an expression with a single, positive exponent together.



Name: ______________________________ G8 U5 Lesson 7 - Let's Try It

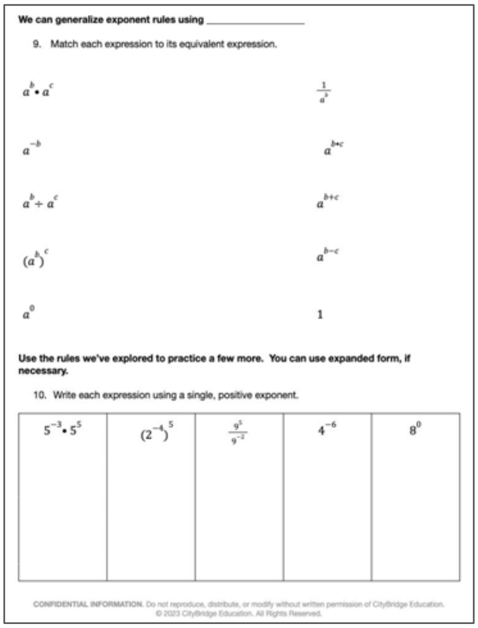
Let's review the exponent rules we've been learning.

Write each expression in expanded form.

1. $\frac{4^5}{4^2}$
2. $(4^5)^2$
3. 4^{-5}
4. $4^5 \bullet 4^2$

Now let's write each expression using a single, positive exponent. You can use your previous work to help you.

5. $\frac{4^5}{4^2}$
6. $(4^5)^2$
7. 4^{-5}
8. $4^5 \bullet 4^2$



We can generalize exponent rules using ________________

9. Match each expression to its equivalent expression.

$a^b \bullet a^c$	$\frac{1}{a^b}$
a^{-b}	$a^{b \bullet c}$
$a^b \div a^c$	a^{b+c}
$(a^b)^c$	a^{b-c}
a^0	1

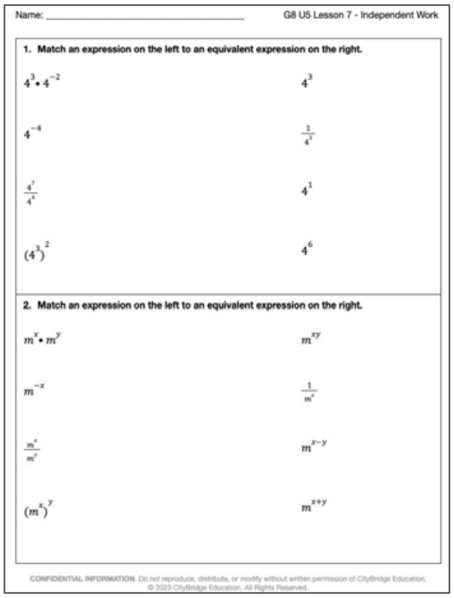
Use the rules we've explored to practice a few more. You can use expanded form, if necessary.

10. Write each expression using a single, positive exponent.

$5^{-3} \bullet 5^5$	$(2^{-4})^5$	$\frac{9^5}{9^{-2}}$	4^{-6}	8^0

On your Own:

Now it's time to use an appropriate exponent rule to rewrite an expression with a single, positive exponent on your own.



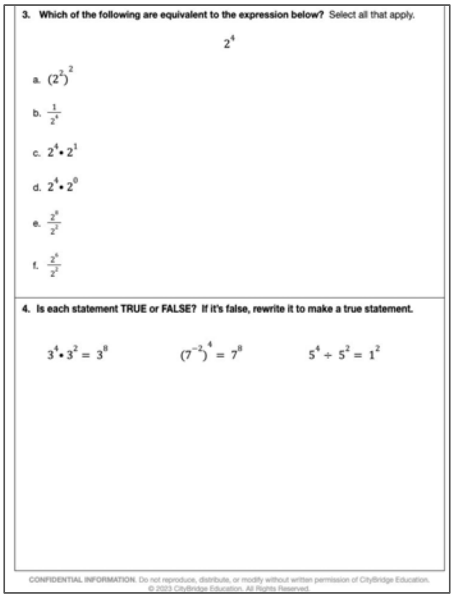
Name: ______________________________ G8 U5 Lesson 7 - Independent Work

1. Match an expression on the left to an equivalent expression on the right.

$4^3 \bullet 4^{-2}$	4^3
4^{-4}	$\frac{1}{4^3}$
$\frac{4^7}{4^4}$	4^1
$(4^3)^2$	4^6

2. Match an expression on the left to an equivalent expression on the right.

$m^x \bullet m^y$	m^{xy}
m^{-x}	$\frac{1}{m^x}$
$\frac{m^x}{m^y}$	m^{x-y}
$(m^x)^y$	m^{x+y}



3. Which of the following are equivalent to the expression below? Select all that apply.

$$2^4$$

a. $(2^2)^2$

b. $\frac{1}{2^4}$

c. $2^4 \bullet 2^1$

d. $2^4 \bullet 2^0$

e. $\frac{2^8}{2^2}$

f. $\frac{2^6}{2^2}$

4. Is each statement TRUE or FALSE? If it's false, rewrite it to make a true statement.

$3^4 \bullet 3^2 = 3^8$ $(7^{-2})^4 = 7^8$ $5^4 \div 5^2 = 1^2$

Let's review the exponent rules we've been learning.

Write each expression in expanded form.

1. $\frac{4^5}{4^2}$

2. $(4^5)^2$

3. 4^{-5}

4. $4^5 \bullet 4^2$

Now let's write each expression using a single, positive exponent. You can use your previous work to help you.

5. $\frac{4^5}{4^2}$

6. $(4^5)^2$

7. 4^{-5}

8. $4^5 \bullet 4^2$

We can generalize exponent rules using ___________________

9. Match each expression to its equivalent expression.

$a^b \bullet a^c$

a^{-b}

$a^b \div a^c$

$(a^b)^c$

a^0

$\frac{1}{a^b}$

$a^{b \bullet c}$

a^{b+c}

a^{b-c}

1

Use the rules we've explored to practice a few more. You can use expanded form, if necessary.

10. Write each expression using a single, positive exponent.

$5^{-3} \bullet 5^5$	$(2^{-4})^5$	$\frac{9^5}{9^{-2}}$	4^{-6}	8^0

Name: ____

1. Match an expression on the left to an equivalent expression on the right.

$4^3 \bullet 4^{-2}$

4^{-3}

$\frac{4^7}{4^4}$

$(4^3)^2$

4^3

$\frac{1}{4^3}$

4^1

4^6

2. Match an expression on the left to an equivalent expression on the right.

$m^x \bullet m^y$

m^{-x}

$\frac{m^x}{m^y}$

$(m^x)^y$

m^{xy}

$\frac{1}{m^x}$

m^{x-y}

m^{x+y}

3. Which of the following are equivalent to the expression below? Select all that apply.

$$2^4$$

a. $(2^2)^2$

b. $\frac{1}{2^4}$

c. $2^4 \bullet 2^1$

d. $2^4 \bullet 2^0$

e. $\frac{2^8}{2^2}$

f. $\frac{2^6}{2^2}$

4. Is each statement TRUE or FALSE? If it's false, rewrite it to make a true statement.

$3^4 \bullet 3^2 = 3^8$

$(7^{-2})^4 = 7^8$

$5^4 \div 5^2 = 1^2$

Name: KEY

G8 U5 Lesson 7 - Let's Try It

Let's review the exponent rules we've been learning.

Write each expression in expanded form.

1. $\frac{4^5}{4^2}$ $\frac{4\cdot4\cdot4\cdot4\cdot4}{4\cdot4}$

2. $(4^5)^2$ $(4\cdot4\cdot4\cdot4\cdot4)\cdot(4\cdot4\cdot4\cdot4\cdot4)$

3. 4^{-5} $\frac{1}{4\cdot4\cdot4\cdot4\cdot4}$

4. $4^5 \bullet 4^2$ $(4\cdot4\cdot4\cdot4\cdot4)\cdot(4\cdot4)$

Now let's write each expression using a single, positive exponent. You can use your previous work to help you.

5. $\frac{4^5}{4^2}$ $4^{5-2} = \boxed{4^3}$

6. $(4^5)^2$ $4^{5\cdot2} = \boxed{4^{10}}$

7. 4^{-5} $\boxed{\frac{1}{4^5}}$

8. $4^5 \bullet 4^2$ $4^{5+2} = \boxed{4^7}$

We can generalize exponent rules using Variables

9. Match each expression to its equivalent expression.

$a^b \cdot a^c$	$\frac{1}{a^b}$
a^{-b}	$a^{b \cdot c}$
$a^b \div a^c$	a^{b+c}
$(a^b)^c$	a^{b-c}
a^0	1

$a^b \cdot a^c \rightarrow a^{b+c}$

$a^{-b} \rightarrow \frac{1}{a^b}$

$a^b \div a^c \rightarrow a^{b-c}$

$(a^b)^c \rightarrow a^{b \cdot c}$

$a^0 \rightarrow 1$

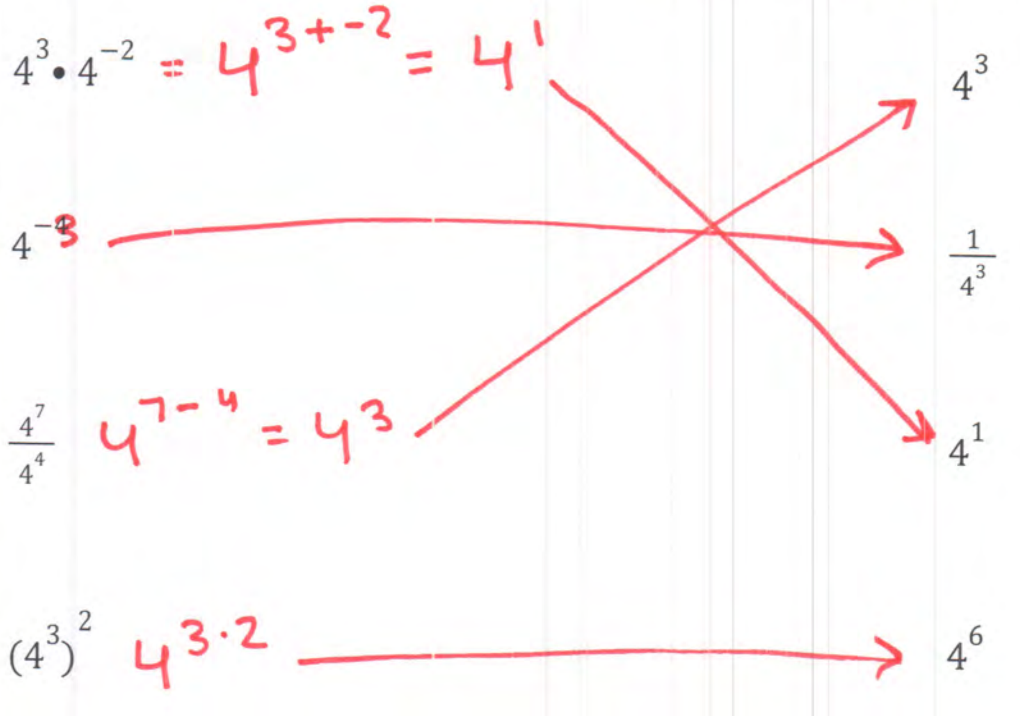
Use the rules we've explored to practice a few more. You can use expanded form, if necessary.

10. Write each expression using a single, positive exponent.

$5^{-3} \cdot 5^5$	$(2^{-4})^5$	$\frac{9^5}{9^{-2}}$	4^{-6}	8^0
5^{-3+5} $\boxed{5^2}$	$2^{-4 \cdot 5}$ 2^{-20} $\boxed{\frac{1}{2^{20}}}$	9^{5--2} 9^{5+2} $\boxed{9^7}$	$\boxed{\frac{1}{4^6}}$	$\boxed{1}$

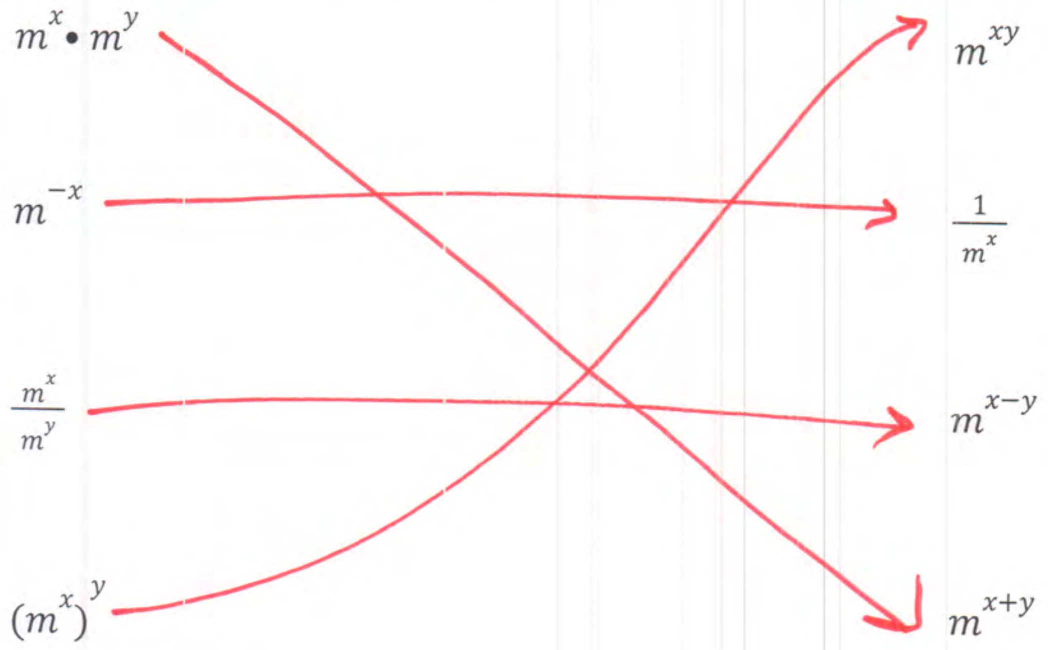
Name: KEY

1. Match an expression on the left to an equivalent expression on the right.



$4^{3} \cdot 4^{-2} = 4^{3+-2} = 4^{1}$	4^{3}
4^{-3}	$\frac{1}{4^{3}}$
$\frac{4^{7}}{4^{4}}$ $4^{7-4} = 4^{3}$	4^{1}
$(4^{3})^{2}$ $4^{3 \cdot 2}$	4^{6}

2. Match an expression on the left to an equivalent expression on the right.



$m^{x} \cdot m^{y}$	m^{xy}
m^{-x}	$\frac{1}{m^{x}}$
$\frac{m^{x}}{m^{y}}$	m^{x-y}
$(m^{x})^{y}$	m^{x+y}

3. Which of the following are equivalent to the expression below? Select all that apply.

2^4

$2 \cdot 2 \cdot 2 \cdot 2$

[✓ a.] $(2^2)^2$ $2^{2 \cdot 2} = 2^4$

~~b.~~ $\frac{1}{2^4}$ $= 2^{-4}$

~~c.~~ $2^4 \bullet 2^1$ $2^{4+1} = 2^5$

[✓ d.] $2^4 \bullet 2^0$ $2^{4+0} = 2^4$

~~e.~~ $\frac{2^8}{2^2}$ $2^{8-2} = 2^6$

[✓ f.] $\frac{2^6}{2^2}$ 2^{6-2} [illegible] $= 2^4$

4. Is each statement TRUE or FALSE? If it's false, rewrite it to make a true statement.

FALSE

$3^4 \bullet 3^2 = 3^8$

$3^{4+2} = 3^6$

FALSE

$(7^{-2})^4 = 7^8$

$7^{-2 \cdot 4} = 7^{-8}$

FALSE

$5^4 \div 5^2 = 1^2$

$\frac{5^4}{5^2} = 5^{4-2}$

5^2

G8 U5 Lesson 8

Generalize a process for multiplying expressions with different bases having the same exponent.

G8 U5 Lesson 8 - Students will generalize a process for multiplying expressions with different bases having the same exponent.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): We are becoming exponent experts one lesson at a time! Up until now, we've explored rules we can apply when an exponential expression has a consistent base. But, what if the bases are different? What if the bases *and* the exponents are different? Can we still use the same rules or not? At the end of our time together today, we'll be able to start answering those questions. Let's get started.

Let's Talk (Slide 3): Look at the expressions shown here. What's the same? What's different? Possible Student Answers, Key Points:

- They all involve multiplication. They all involve bases of either 4 or 10. They all have at least one exponent that's a three.
- The first two look like problems we've solved before. The last two have different bases. The last one has different bases and different exponents.

Some of these problems look different than what we're used to. We're used to seeing exponential expressions where the base is consistent. For example, the first expression involves bases of 10. The second expression involves bases of 4. We already know how to rewrite expressions like that efficiently.

$$10^{3+3} = 10^6$$

$$4^{3+3} = 4^6$$

How could we rewrite the first two examples using a single, positive exponent? *(write as student shares, supporting as necessary)* Possible Student Answers, Key Points:

- We can add the exponents.
- The first expression could be rewritten as 10 to the 6th power, because 3 + 3 equals 6. The second expression could be rewritten as 4 to the 6th power, because 3 + 3 equals 6.

The same rules don't automatically apply to the other examples, because if you mentally picture them in expanded form, you have a number of different factors being multiplied. All is not lost, however! We can still use concepts we know about exponents to help us rewrite the expressions. It just requires a bit more strategic thinking. Let me show you what I mean.

Let's Think (Slide 4): Let's consider the third expression of 10 to the third power times 4 to the third power. We already noted that the expression involves different bases. We see a base of 10, and a base of 4. Let's expand the expression. What would this expression look like in expanded form? *(write expanded form as students shares)* Possible Student Answers, Key Points:

- 10 to the third power would be 10 x 10 x 10. We would multiply that by 4 x 4 x 4.
- We'd have 3 factors of 10 and 3 factors of 4.

$$(10\cdot10\cdot10)\bullet(4\cdot4\cdot4)$$

$$(10\cdot4)\bullet(10\cdot4)\bullet(10\cdot4)$$

Since we have three of each factor, we can use the commutative property to rearrange them and pair up factors. I'm going to pair up factors of 10 and 4. Watch! *(write (10 x 4) x (10 x 4) x (10 x 4))* Now I have three identical factors of 10 x 4. I can write that as 10 x 4 to the third power. *(write it)* What is 10 x 4? (40) I have three identical factors of 40, which I can write as 40 to the third power.

$$(10\cdot4)^3$$

$$\boxed{40^3}$$

We were able to expand each exponential factor and then rearrange and combine factors to write a simpler expression with a single exponent. Let's try another one.

Let's Think (Slide 5): What's the same about this problem compared to the previous problem? What's different? Possible Student Answers, Key Points:

- It's the same in that we have a base of 10 and a base of 4. It's also the same in that we're multiplying the exponential factors.
- It's different, because the exponents aren't identical like last time. We have an exponent of 3 and an exponent of 4.

This problem is almost the same as the last problem, but we see there are different exponents. That's not a problem. We can use similar thinking to last time.

$$(10 \cdot 10 \cdot 10) \cdot (4 \cdot 4 \cdot 4 \cdot 4)$$

Let's start by writing each factor in expanded form. *(expand both factors as shown)* I have three factors of 10 and four factors of 4. If I think about rearranging and combining factors, I know I'll be able to match up a 10 to a 4 three times, but I'll have one leftover factor of 4 that can't be matched. *(highlight or circle one factor of 4)* This 4 won't have a factor partner.

$$(10 \cdot 4) \cdot (10 \cdot 4) \cdot (10 \cdot 4) \cdot 4$$

$$40^3 \cdot 4$$

I'll rewrite the expression using the commutative property to rearrange factors so that each 10 is paired with a factor of 4. *(rewrite as shown)* We have one extra 4, as expected.

I know 10 x 4 is 40, so I have 3 equal factors of 40 and a factor of 4. If I want to simplify this expression, I can write it as 40 to the third power times 4.

Even if we don't have a matching set of factors, like 4 tens and 4 fours, we can still rearrange factors to write a simpler exponential expression.

Let's Try it (Slides 6 - 7): Now we'll practice working with different bases before you get a chance to try some on your own. If our problems have consistent bases, we can use the rules we've been practicing for several lessons. If we notice a problem has different bases, we'll want to think through the strategy we applied today. We can expand the expression, rearrange and match factors, and then rewrite the expressions using a single exponent. Let's go for it!

WARM WELCOME

Today we will generalize a process for multiplying expressions with different bases having the same exponent.

Let's Talk:

What's the same? What's different?

$$10^3 \bullet 10^3$$

$$4^3 \bullet 4^3$$

$$10^3 \bullet 4^3$$

$$10^3 \bullet 4^4$$

Let's Think:

Rewrite the expression using a single, positive exponent if possible.

$$10^3 \bullet 4^3$$

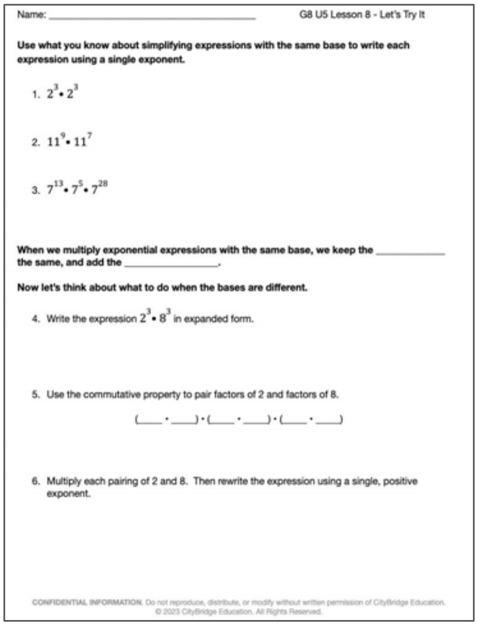
Let's Think:

Rewrite the expression using a single, positive exponent if possible.

$$10^3 \bullet 4^4$$

Let's Try It:

Let's explore generalizing a process for multiplying expressions with different bases having the same exponent together.



Name: ______________________ G8 U5 Lesson 8 - Let's Try It

Use what you know about simplifying expressions with the same base to write each expression using a single exponent.

1. $2^3 \bullet 2^3$
2. $11^9 \bullet 11^7$
3. $7^{13} \bullet 7^5 \bullet 7^{28}$

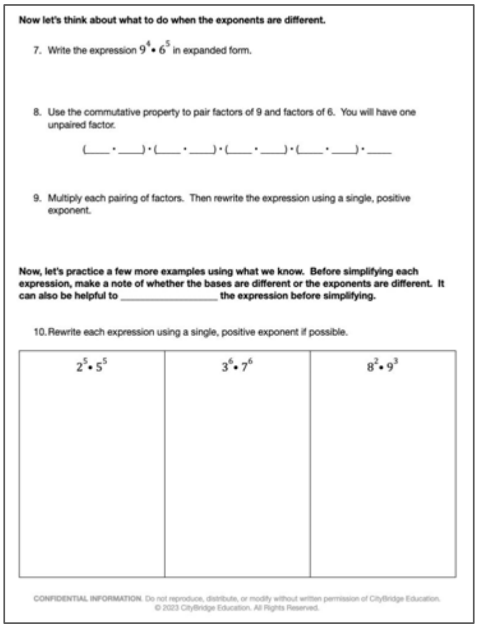
When we multiply exponential expressions with the same base, we keep the ____________ the same, and add the ______________.

Now let's think about what to do when the bases are different.

4. Write the expression $2^3 \bullet 8^3$ in expanded form.
5. Use the commutative property to pair factors of 2 and factors of 8.

(____ • ____) • (____ • ____) • (____ • ____)

6. Multiply each pairing of 2 and 8. Then rewrite the expression using a single, positive exponent.



Now let's think about what to do when the exponents are different.

7. Write the expression $9^4 \bullet 6^5$ in expanded form.
8. Use the commutative property to pair factors of 9 and factors of 6. You will have one unpaired factor.

(____ • ____) • (____ • ____) • (____ • ____) • (____ • ____) • ____

9. Multiply each pairing of factors. Then rewrite the expression using a single, positive exponent.

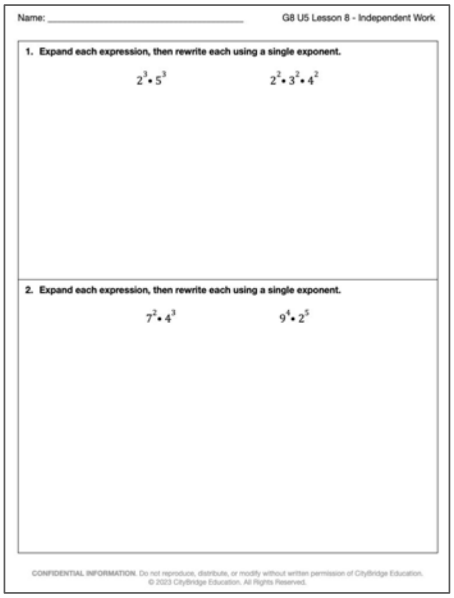
Now, let's practice a few more examples using what we know. Before simplifying each expression, make a note of whether the bases are different or the exponents are different. It can also be helpful to ______________ the expression before simplifying.

10. Rewrite each expression using a single, positive exponent if possible.

$2^5 \bullet 5^5$	$3^6 \bullet 7^6$	$8^2 \bullet 9^3$

On your Own:

Now it's time to generalize a process for multiplying expressions with different bases having the same exponent on your own.



Name: ______________________ G8 U5 Lesson 8 - Independent Work

1. Expand each expression, then rewrite each using a single exponent.

$2^3 \cdot 5^3$ $2^2 \cdot 3^2 \cdot 4^2$

2. Expand each expression, then rewrite each using a single exponent.

$7^2 \cdot 4^3$ $9^4 \cdot 2^5$

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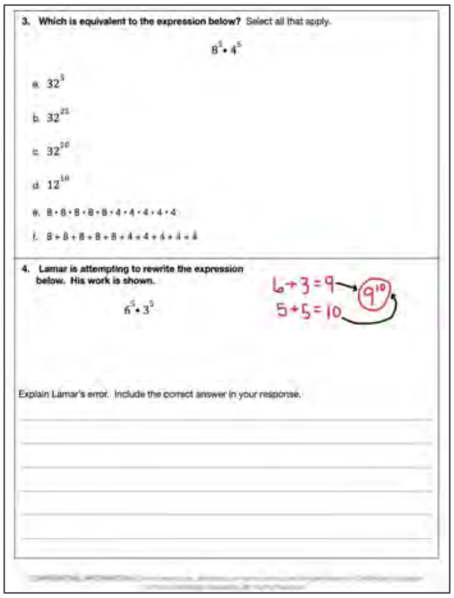


3. Which is equivalent to the expression below? Select all that apply.

$8^5 \cdot 4^5$

a. 32^5

b. 32^{25}

c. 32^{10}

d. 12^{10}

e. $8 \cdot 8 \cdot 8 \cdot 8 \cdot 8 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot 4$

f. $8 + 8 + 8 + 8 + 8 + 4 + 4 + 4 + 4 + 4$

4. Lamar is attempting to rewrite the expression below. His work is shown.

$6^5 \cdot 3^5$

$6+3=9 \rightarrow \boxed{9^{10}}$

$5+5=10$

Explain Lamar's error. Include the correct answer in your response.

Use what you know about simplifying expressions with the same base to write each expression using a single exponent.

1. $2^3 \bullet 2^3$
2. $11^9 \bullet 11^7$
3. $7^{13} \bullet 7^5 \bullet 7^{28}$

When we multiply exponential expressions with the same base, we keep the _____________ the same, and add the __________________.

Now let's think about what to do when the bases are different.

4. Write the expression $2^3 \bullet 8^3$ in expanded form.
5. Use the commutative property to pair factors of 2 and factors of 8.

(_____ • _____) • (_____ • _____) • (_____ • _____)

6. Multiply each pairing of 2 and 8. Then rewrite the expression using a single, positive exponent.

Now let's think about what to do when the exponents are different.

7. Write the expression $9^{4} \bullet 6^{5}$ in expanded form.

8. Use the commutative property to pair factors of 9 and factors of 6. You will have one unpaired factor.

(_____ • _____) • (_____ • _____) • (_____ • _____) • (_____ • _____) • _____

9. Multiply each pairing of factors. Then rewrite the expression using a single, positive exponent.

Now, let's practice a few more examples using what we know. Before simplifying each expression, make a note of whether the bases are different or the exponents are different. It can also be helpful to ___________________ the expression before simplifying.

10. Rewrite each expression using a single, positive exponent if possible.

$2^{5} \bullet 5^{5}$	$3^{6} \bullet 7^{6}$	$8^{2} \bullet 9^{3}$

1. **Expand each expression, then rewrite each using a single exponent.**

$2^3 \bullet 5^3$ $2^2 \bullet 3^2 \bullet 4^2$

2. **Expand each expression, then rewrite each using a single exponent.**

$7^2 \bullet 4^3$ $9^4 \bullet 2^5$

3. Which is equivalent to the expression below? Select all that apply.

$$8^5 \bullet 4^5$$

a. 32^5

b. 32^{25}

c. 32^{10}

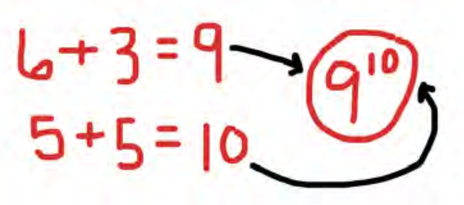
d. 12^{10}

e. 8 • 8 • 8 • 8 • 8 • 4 • 4 • 4 • 4 • 4

f. 8 + 8 + 8 + 8 + 8 + 4 + 4 + 4 + 4 + 4

4. Lamar is attempting to rewrite the expression below. His work is shown.

$$6^5 \bullet 3^5$$



$6+3=9 \rightarrow \boxed{9^{10}}$

$5+5=10$

Explain Lamar's error. Include the correct answer in your response.

Name: KEY

Use what you know about simplifying expressions with the same base to write each expression using a single exponent.

1. $2^3 \bullet 2^3$ $\quad 2^{3+3} = 2^6$

2. $11^9 \bullet 11^7$ $\quad 11^{9+7} = 11^{16}$

3. $7^{13} \bullet 7^5 \bullet 7^{28}$ $\quad 7^{13+5+28} = 7^{46}$

When we multiply exponential expressions with the same base, we keep the base **the same, and add the** exponents**.**

Now let's think about what to do when the bases are different.

4. Write the expression $2^3 \bullet 8^3$ in expanded form.

   $(2 \cdot 2 \cdot 2) \cdot (8 \cdot 8 \cdot 8)$

5. Use the commutative property to pair factors of 2 and factors of 8.

   $(2 \cdot 8) \cdot (2 \cdot 8) \cdot (2 \cdot 8)$

6. Multiply each pairing of 2 and 8. Then rewrite the expression using a single, positive exponent.

   $16 \cdot 16 \cdot 16$

   16^3

Now let's think about what to do when the exponents are different.

7. Write the expression $9^4 \bullet 6^5$ in expanded form.

$(9\cdot9\cdot9\cdot9)\cdot(6\cdot6\cdot6\cdot6\cdot6)$

8. Use the commutative property to pair factors of 9 and factors of 6. You will have one unpaired factor.

$(9 \cdot 6)\cdot(9 \cdot 6)\cdot(9 \cdot 6)\cdot(9 \cdot 6)\cdot 6$

9. Multiply each pairing of factors. Then rewrite the expression using a single, positive exponent.

$\underbrace{54\cdot54\cdot54\cdot54}\cdot 6$

$\boxed{54^4\cdot 6}$

Now, let's practice a few more examples using what we know. Before simplifying each expression, make a note of whether the bases are different or the exponents are different. It can also be helpful to expand **the expression before simplifying.**

10. Rewrite each expression using a single, positive exponent if possible.

$2^5 \bullet 5^5$	$3^6 \bullet 7^6$	$8^2 \bullet 9^3$
$\boxed{10^5}$	$\boxed{21^6}$	$(8\cdot8)\cdot(9\cdot9\cdot9)$ $\boxed{72^2\cdot 9}$

Name: KEY

1. Expand each expression, then rewrite each using a single exponent.

$2^3 \bullet 5^3$

$(2 \cdot 2 \cdot 2) \cdot (5 \cdot 5 \cdot 5)$

$\boxed{10^3}$

$2^2 \bullet 3^2 \bullet 4^2$

$2 \cdot 2 \cdot 3 \cdot 3 \cdot 4 \cdot 4$

$(2 \cdot 3 \cdot 4) \cdot (2 \cdot 3 \cdot 4)$

$\boxed{24^2}$

2. Expand each expression, then rewrite each using a single exponent.

$7^2 \bullet 4^3$

$7 \cdot 7 \cdot 4 \cdot 4 \cdot 4$

$\boxed{28^2 \cdot 4}$

$9^4 \bullet 2^5$

$9 \cdot 9 \cdot 9 \cdot 9 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$

$\boxed{18^4 \cdot 2}$

3. Which is equivalent to the expression below? Select all that apply.

$$8^5 \cdot 4^5$$

$$(8 \cdot 8 \cdot 8 \cdot 8 \cdot 8) \cdot (4 \cdot 4 \cdot 4 \cdot 4 \cdot 4)$$

$$32^5$$

[✓ a. 32^5]

~~b. 32^{25}~~

~~c. 32^{10}~~

~~d. 12^{10}~~

[✓ e. 8 • 8 • 8 • 8 • 8 • 4 • 4 • 4 • 4 • 4]

~~f. 8 + 8 + 8 + 8 + 8 + 4 + 4 + 4 + 4 + 4~~

4. Lamar is attempting to rewrite the expression below. His work is shown.

$$6^5 \cdot 3^5$$

$$6+3=9 \rightarrow \boxed{9^{10}}$$

$$5+5=10$$

Explain Lamar's error. Include the correct answer in your response.

Lamar added his bases and added his exponents. He has ~~4~~ 5 factors of 6 and 3. That means he has 5 factors of 18. He can write that as 18^5.

G8 U5 Lesson 9

Describe large and small numbers as multiples of powers of 10.

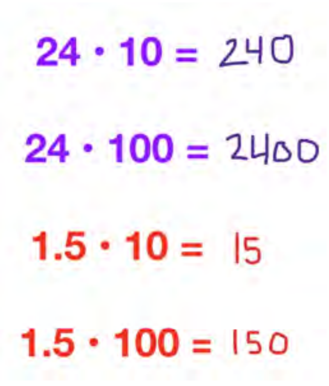
G8 U5 Lesson 9 - Students will describe large and small numbers as multiples of powers of 10.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): We've been working with exponents since the beginning of this unit. We're getting stronger and stronger at applying exponent rules. Sometimes when we get deep in the weeds of computation, we can forget why we're even doing the things we're doing. Today's lesson is a reminder of one major reason we use exponents in everyday life, and that's to express large and small numbers efficiently. Astronomers use exponents to express the massive distance between planets. Biologists use exponents to express miniscule lengths of microscopic cells. Businesses use exponents to express large profits. Today, our goal is to describe large and small numbers as multiples of powers of 10.

Let's Talk (Slide 3): You've likely been multiplying and dividing by tens since 3rd or 4th grade. People often consider tens as being fairly friendly numbers to compute with. What rules or patterns do we know to help us multiply by tens? Feel free to use your own experience or the equations below to help explain your thinking.
Possible Student Answers, Key Points:

- Multiplying a whole number by 10 is easy, because we can just annex a zero on the right-side of the number. If we multiply by 100, we can annex two zeroes. The pattern continues.
- For every 10 we multiply by, we can shift the digits of a number left one place value. Place value patterns make multiplying by tens easy.



$24 \cdot 10 = 240$

$24 \cdot 100 = 2400$

$1.5 \cdot 10 = 15$

$1.5 \cdot 100 = 150$

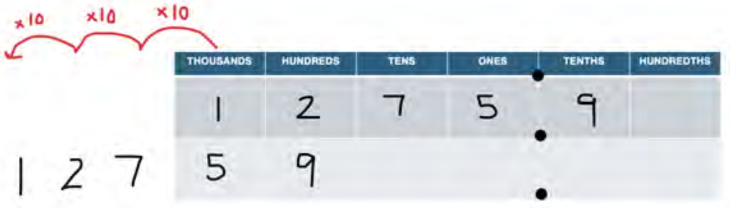
We can use patterns to help us easily find the products of multiples of 10. When dealing with whole numbers, we can annex a zero for every 10 we multiply by. We can also think about the placement of digits when we multiply by tens. Every ten we multiply shifts the digits of a number one place value left.

Let's use this thinking to find each product here. What would each product be, and how did you figure it out? *(write as student shares)* Possible Student Answers, Key Points:

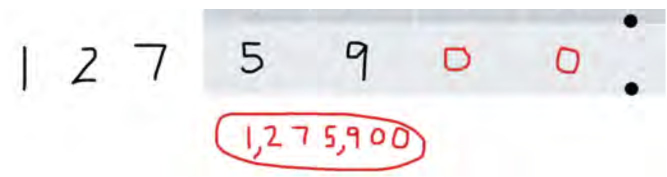
- 24 x 10 is 240, because I could just add a zero. 24 x 100 is 2400, because I could just add two zeros. Multiplying by 100 is like multiplying by 10 twice.
- 1.5 x 10 is 15, because I can just shift the digits one place value left. 1.5 x 100 is 150, because I can shift the digits two place values left.

Let's keep these efficient patterns in mind. This thinking will come in handy as we work on today's problems.

Let's Think (Slide 4): Our first set of problems asks us to find the value of two numbers multiplied by powers of 10. The first problem wants us to find the value of 1,275.9 times 10 to the third power. That means we're multiplying the number by 10 three times. As we just practiced, we know that means we can shift the digits three places values to the left. A tool we can use to help us organize our work is a place value chart.



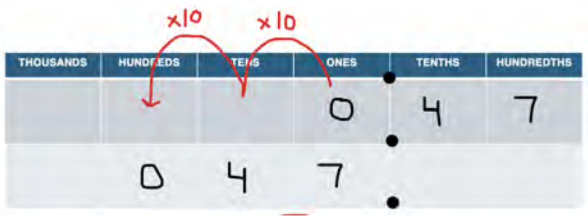
(fill in place value chart as you narrate) I'll start by writing 1,275.9 in the place value chart. Multiplying by 10 to the third power, means each digit will shift left three place values. *(draw 3 hops with arrows, labeling each as "x10")* Now the 1 is in the millions, the 2 is in the hundred thousands, the 7 is in the ten thousands, the 5 is in the thousand, and the 9 is in the hundreds place.



I'll fill in placeholder zeros in the empty place values, and we'll have our answer. *(fill in a zero in the tens and ones places)* After filling in the place holder zeros, we can see that 1,275.9 times ten to the third power is 1,275,900.

Let's try the next problem. The problem wants us to find the value of 0.47 times 10 to the second power. How can we use what we did in the previous problem in this problem? Possible Student Answers, Key Points:

- We can put 0.47 in a place value chart. Since we're multiplying by 10 to the second power, each digit will shift left two place values.



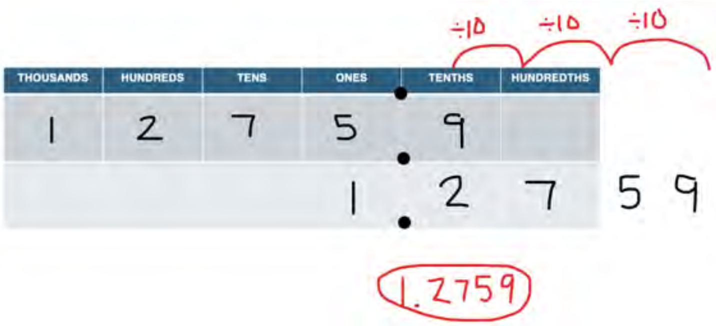
(fill in place value chart as you narrate) We know that each digit will shift two place values. We don't always *need* to use a place value chart to show this work, but it's helpful to keep everything organized. I'll start by putting 0.47 in the place value chart. Each digit will shift two place values, because each place value shift represents multiplying by 10. We'll end up with a zero in the hundreds place, a 4 in the tens place, and a 7 in the ones place. What number does this represent? (47)

The value of 0.47 times ten to the second power is 47. *(write 47)* Knowing patterns when multiplying numbers by ten really came in handy. We also see how helpful it can be to keep track of digits in a place value chart. Let's look at two more examples that have a bit of a twist.

Let's Think (Slide 5): Take a look at these two problems. What do you notice? Possible Student Answers, Key Points:

- The problems involve the same numbers as our last two examples.
- The exponents are now negative.

We can use a place value chart and patterns with tens to help us find the value of expressions involving negative exponents, too.



For the first example, let's start by writing the number in a place value chart. *(fill in place value chart as you narrate)* Multiplying by 10 to the negative third power is the same as multiplying by 1/10 x `1/10 x 1/10. We can also think of that as dividing by 10 then by 10 then by 10 again. Since division is the inverse of multiplication, the only difference in our work will be the direction our digits shift along the place value chart. I'll show three hops to the right along the place value chart to show that each digit in 1,275.9 is shifting three place values right. When I rewrite my digits, each three places over, we end up with an answer of 1.2759.

I think you can help me complete the next problem. Take a second to look it over, and then walk me through how you could use a place value chart to find the value of 0.47 times ten to the negative second power. *(fill in place value chart as student shares, supporting as needed)*

Possible Student Answers, Key Points:

- First, we can write 0.47 in the place value chart. The 4 is in the tenths place and the 7 is in the hundredths place.
- Since we're multiplying by 10 to the negative second power, that's like multiplying by 1/10 and 1/10. We can also think of that as dividing by 10 and then by 10 again.
- If each digit shifts two place values right, the value of the expression is 0.0047.

Each digit shifts two place values right, and the value of the expression is 0.0047.

Let's Try it (Slides 6 - 7): Now we'll get a chance to practice a few more problems before you work on a few of your own. Knowing that each place value is 10 times greater than the place value to its right can help us efficiently multiply by powers of 10. If the exponent is negative, we can use similar thinking, but we understand that our digits will shift a different direction. If we find it helpful, we can continue to use the place value chart as a way to organize our thinking.

WARM WELCOME

Today we will describe large and small numbers as multiples of powers of 10.

Let’s Talk:

What patterns or rules do we know to help us multiply by powers of ten?

$24 \cdot 10 = ?$

$24 \cdot 100 = ?$

$1.5 \cdot 10 = ?$

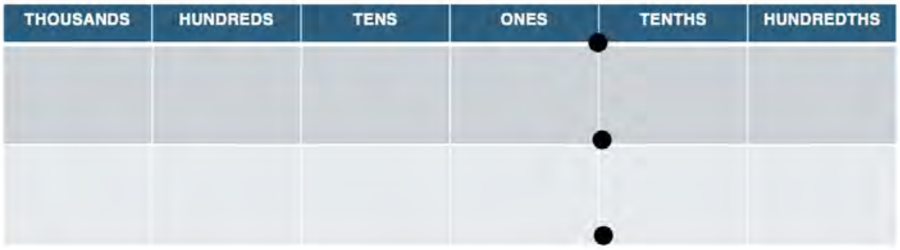
$1.5 \cdot 100 = ?$

Let’s Think:

Find the value of each expression.

a. $1{,}275.9 \cdot 10^3$

b. $0.47 \cdot 10^2$



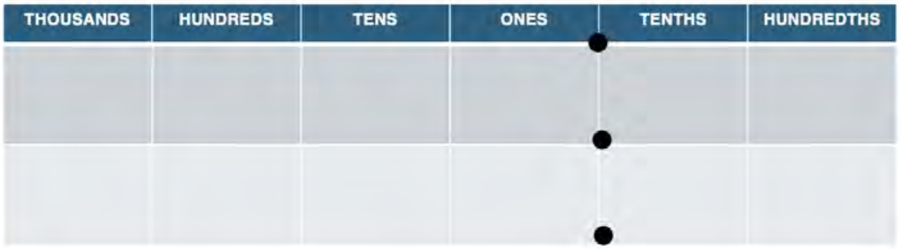
THOUSANDS	HUNDREDS	TENS	ONES	TENTHS	HUNDREDTHS

Let's Think:

Find the value of each expression.

a. $1{,}275.9 \bullet 10^{-3}$

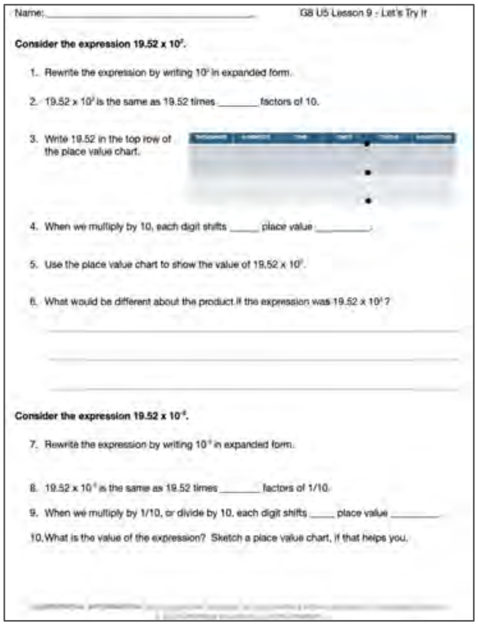
b. $0.47 \bullet 10^{-2}$



THOUSANDS	HUNDREDS	TENS	ONES	TENTHS	HUNDREDTHS

Let's Try It:

Let's explore describing large and small numbers as multiples of powers of 10 together.



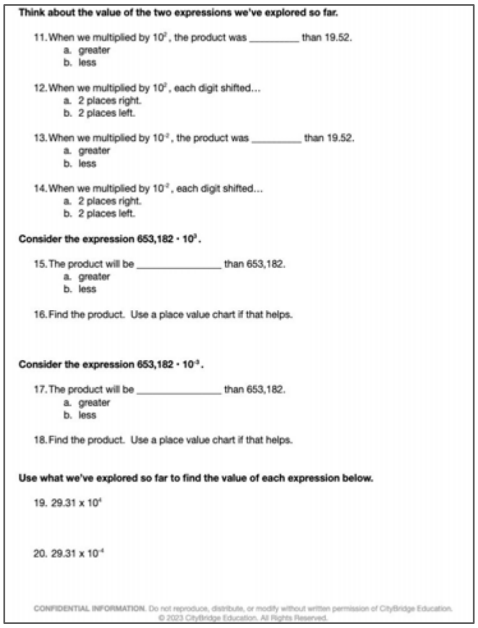
Name:____________________ G8 U5 Lesson 9 - Let's Try It

Consider the expression 19.52 x 10^2.

1. Rewrite the expression by writing 10^2 in expanded form.
2. 19.52 x 10^2 is the same as 19.52 times _______ factors of 10.
3. Write 19.52 in the top row of the place value chart.
4. When we multiply by 10, each digit shifts _____ place value ________.
5. Use the place value chart to show the value of 19.52 x 10^2.
6. What would be different about the product if the expression was 19.52 x 10^3 ?

Consider the expression 19.52 x 10^{-2}.

7. Rewrite the expression by writing 10^{-2} in expanded form.
8. 19.52 x 10^{-2} is the same as 19.52 times _______ factors of 1/10.
9. When we multiply by 1/10, or divide by 10, each digit shifts _____ place value ________.
10. What is the value of the expression? Sketch a place value chart, if that helps you.



Think about the value of the two expressions we've explored so far.

11. When we multiplied by 10^2, the product was _________ than 19.52.
    a. greater
    b. less
12. When we multiplied by 10^2, each digit shifted...
    a. 2 places right.
    b. 2 places left.
13. When we multiplied by 10^{-2}, the product was _________ than 19.52.
    a. greater
    b. less
14. When we multiplied by 10^{-2}, each digit shifted...
    a. 2 places right.
    b. 2 places left.

Consider the expression 653,182 · 10^3.

15. The product will be _______________ than 653,182.
    a. greater
    b. less
16. Find the product. Use a place value chart if that helps.

Consider the expression 653,182 · 10^{-3}.

17. The product will be _______________ than 653,182.
    a. greater
    b. less
18. Find the product. Use a place value chart if that helps.

Use what we've explored so far to find the value of each expression below.

19. 29.31 x 10^4
20. 29.31 x 10^{-4}

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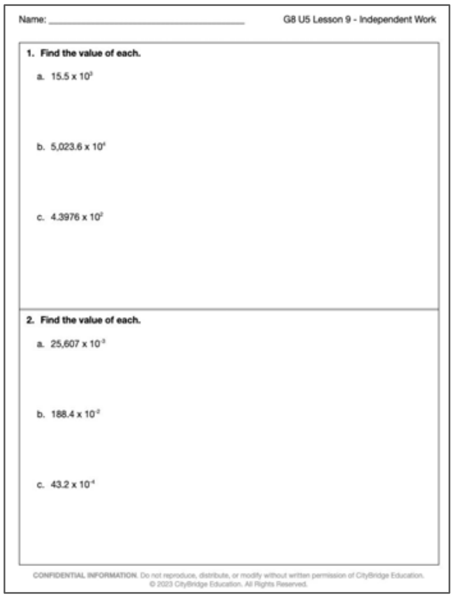
On your Own:

Now it’s time to describe large and small numbers as multiples of powers of 10 on your own.



Name: ______________________________ G8 U5 Lesson 9 - Independent Work

1. Find the value of each.

a. 15.5×10^3

b. $5{,}023.6 \times 10^4$

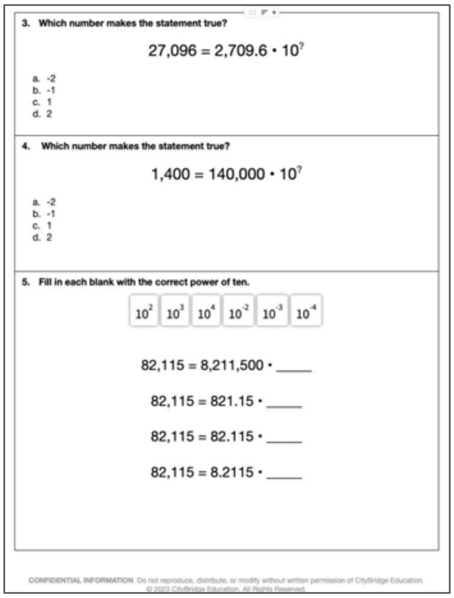
c. 4.3976×10^2

2. Find the value of each.

a. $25{,}607 \times 10^{-3}$

b. 188.4×10^{-2}

c. 43.2×10^{-4}



3. Which number makes the statement true?

$$27{,}096 = 2{,}709.6 \cdot 10^?$$

a. -2
b. -1
c. 1
d. 2

4. Which number makes the statement true?

$$1{,}400 = 140{,}000 \cdot 10^?$$

a. -2
b. -1
c. 1
d. 2

5. Fill in each blank with the correct power of ten.

10^2 10^3 10^4 10^{-2} 10^{-3} 10^{-4}

82,115 = 8,211,500 • _____

82,115 = 821.15 • _____

82,115 = 82.115 • _____

82,115 = 8.2115 • _____

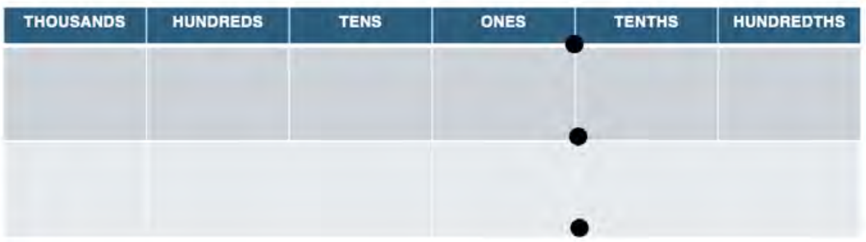
Name: ____ G8 U5 Lesson 9 - Let's Try It

Consider the expression 19.52 x 10^2.

1. Rewrite the expression by writing 10^2 in expanded form.

2. 19.52 x 10^2 is the same as 19.52 times _______ factors of 10.

3. Write 19.52 in the top row of the place value chart.



THOUSANDS	HUNDREDS	TENS	ONES	TENTHS	HUNDREDTHS

4. When we multiply by 10, each digit shifts ______ place value __________.

5. Use the place value chart to show the value of 19.52 x 10^2.

6. What would be different about the product if the expression was 19.52 x 10^3 ?

____

____

____

Consider the expression 19.52 x 10^{-2}.

7. Rewrite the expression by writing 10^{-2} in expanded form.

8. 19.52 x 10^{-2} is the same as 19.52 times _______ factors of 1/10.

9. When we multiply by 1/10, or divide by 10, each digit shifts _____ place value _________.

10. What is the value of the expression? Sketch a place value chart, if that helps you.

Think about the value of the two expressions we've explored so far.

11. When we multiplied by 10^2, the product was _________ than 19.52.
    a. greater
    b. less

12. When we multiplied by 10^2, each digit shifted…
    a. 2 places right.
    b. 2 places left.

13. When we multiplied by 10^{-2}, the product was _________ than 19.52.
    a. greater
    b. less

14. When we multiplied by 10^{-2}, each digit shifted…
    a. 2 places right.
    b. 2 places left.

Consider the expression 653,182 • 10^3.

15. The product will be _______________ than 653,182.
    a. greater
    b. less

16. Find the product. Use a place value chart if that helps.

Consider the expression 653,182 • 10^{-3}.

17. The product will be _______________ than 653,182.
    a. greater
    b. less

18. Find the product. Use a place value chart if that helps.

Use what we've explored so far to find the value of each expression below.

19. 29.31 x 10^4

20. 29.31 x 10^{-4}

1. Find the value of each.

a. 15.5×10^3

b. $5{,}023.6 \times 10^4$

c. 4.3976×10^2

2. Find the value of each.

a. $25{,}607 \times 10^{-3}$

b. 188.4×10^{-2}

c. 43.2×10^{-4}

3. Which number makes the statement true?

$$27{,}096 = 2{,}709.6 \bullet 10^{?}$$

a. -2
b. -1
c. 1
d. 2

4. Which number makes the statement true?

$$1{,}400 = 140{,}000 \bullet 10^{?}$$

a. -2
b. -1
c. 1
d. 2

5. Fill in each blank with the correct power of ten.

10^{2} 10^{3} 10^{4} 10^{-2} 10^{-3} 10^{-4}

$$82{,}115 = 8{,}211{,}500 \bullet \underline{\qquad}$$

$$82{,}115 = 821.15 \bullet \underline{\qquad}$$

$$82{,}115 = 82.115 \bullet \underline{\qquad}$$

$$82{,}115 = 8.2115 \bullet \underline{\qquad}$$

Name: KEY

G8 U5 Lesson 9 - Let's Try It

Consider the expression 19.52×10^2.

1. Rewrite the expression by writing 10^2 in expanded form. $10 \cdot 10$

2. 19.52×10^2 is the same as 19.52 times 2 factors of 10.

3. Write 19.52 in the top row of the place value chart.

THOUSANDS	HUNDREDS	TENS	ONES	TENTHS	HUNDREDTHS
		1	9	5	2
1	9	5	2		

4. When we multiply by 10, each digit shifts 1 place value left.

5. Use the place value chart to show the value of 19.52×10^2. 1,952

6. What would be different about the product if the expression was 19.52×10^3?

Each digit would shift one more place left. The answer would be 19,520.

Consider the expression 19.52×10^{-2}.

7. Rewrite the expression by writing 10^{-2} in expanded form.

$\frac{1}{10} \cdot \frac{1}{10}$ OR $\frac{1}{10 \cdot 10}$

8. 19.52×10^{-2} is the same as 19.52 times 2 factors of 1/10.

9. When we multiply by 1/10, or divide by 10, each digit shifts 1 place value right.

10. What is the value of the expression? Sketch a place value chart, if that helps you.

0.1952

Think about the value of the two expressions we've explored so far.

11. When we multiplied by 10^2, the product was __________ than 19.52.
    - [✓ a. greater]
    - b. less

12. When we multiplied by 10^2, each digit shifted…
    - a. 2 places right.
    - [✓ b. 2 places left.]

13. When we multiplied by 10^{-2}, the product was __________ than 19.52.
    - a. greater
    - [✓ b. less]

14. When we multiplied by 10^{-2}, each digit shifted…
    - [✓ a. 2 places right.]
    - b. 2 places left.

Consider the expression $653{,}182 \cdot 10^3$.

15. The product will be ________________ than 653,182.
    - [✓ a. greater]
    - b. less

16. Find the product. Use a place value chart if that helps.

    653,182,000

Consider the expression $653{,}182 \cdot 10^{-3}$.

17. The product will be ________________ than 653,182.
    - a. greater
    - [✓ b. less]

18. Find the product. Use a place value chart if that helps.

    653.182

Use what we've explored so far to find the value of each expression below.

19. 29.31 x 10^4 293,100

20. 29.31 x 10^{-4} 0.002931

Name: KEY

1. **Find the value of each.**

   a. 15.5×10^3

   15,500

   b. $5,023.6 \times 10^4$

   50,236,000

   c. 4.3976×10^2

   439.76

2. **Find the value of each.**

   a. $25,607 \times 10^{-3}$

   25.607

   b. 188.4×10^{-2}

   1.884

   c. 43.2×10^{-4}

   0.00432

3. Which number makes the statement true?

$$27{,}096 = 2{,}709.6 \cdot 10^{?}$$

- a. -2
- b. -1
- [✓ c. 1]
- d. 2

×10

2709.6

27096

4. Which number makes the statement true?

$$1{,}400 = 140{,}000 \cdot 10^{?}$$

- [✓ a. -2]
- b. -1
- c. 1
- d. 2

140000.

1400.

$\times\frac{1}{10}$

$\times\frac{1}{10}$

5. Fill in each blank with the correct power of ten.

10^{2} 10^{3} 10^{4} 10^{-2} 10^{-3} 10^{-4}

$82{,}115 = 8{,}211{,}500 \cdot$ 10^{-2}

$82{,}115 = 821.15 \cdot$ 10^{2}

$82{,}115 = 82.115 \cdot$ 10^{3}

$82{,}115 = 8.2115 \cdot$ 10^{4}

G8 U5 Lesson 10

Compare large numbers using powers of 10.

G8 U5 Lesson 10 - Students will compare large numbers using powers of 10.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): In our previous lesson, we worked to represent really large numbers and really small numbers using powers of 10. That's one critical reason why we use exponents. Today, we're going to continue with that work. Our goal is to compare large numbers using powers of 10. Let's get started!

Let's Talk (Slide 3): Before we work directly with powers of ten, let's get on the same page about some ideas around comparison. Let's look at the examples of comparison here.

How many times greater is 10 than 5? How do you know? Possible Student Answers, Key Points:

- 10 is 2 times greater than 5.
- I know because 5 x 2 is 10. 10 is twice as much as 5. I know 10 divided by 5 is 2.

$10 = \_\_ \times 5$

$10 \div 5 = 2$

There are many ways to think of this. We can think "10 is how many times as much as 5?" *(write 10 = _____ x 5)* One way to solve this equation is to divide 10 by 5. That gives us 2, so we know 10 is 2 times greater than 5.

$30 = \_\_ \times 5$

$30 \div 5 = 6$

We can use similar thinking for the next example. We can think "30 is how many times as much as 5?" *(write 30 = _____ x 5)* One way to solve this equation is to divide 30 by 5. That gives us 6, so we know 30 is 6 times greater than 5.

$5000 = \_\_\_ \times 5$

$5000 \div 5 = 1000$

How could we use this logic with the next example? *(write equations as student shares, supporting as needed)* Possible Student Answers, Key Points:

- We can think 5,000 is how many times 5 by writing 5000 = _____ x 5.
- We can divide 5,000 by 5. 5,000 is 1,000 times greater than 5.

$42 = \_\_ \times 5$

$42 \div 5 = 8.4$

5,000 divided by 5 shows us that 5,000 is 1,000 times as much as 5. This thinking even works when the numbers aren't compatible. Look at the last example. If we want to know how many times greater is 42 than 5, we can think about what times 5 is equal to 42, and we can write 42 = ____ x 5. If we divide 42 by 5, we get 8.4 So, we can say 42 is 8.4 times greater than 5.

Let's keep this comparison thinking in mind as we look at numbers involving powers of 10.

Let's Think (Slide 4): For our first problem, it wants to know whose number is greater. Once we figure that out, they want to know how many times greater that number is than the other number.

Take a look at Maria's number. Take a look at Angel's number. Whose is greater? How do you know? Possible Student Answers, Key Points:

- Maria's number is greater, because they both have the same power of 10, but Maria's leading factor is 32 and Angel's is only 8.
- Maria's number is greater, because it is 320,000,000 and Angel's is 80,000,000.

$32 > 8$

I notice both numbers use the same power of 10, so we can think of the leading factors 32 and 8 as being in the same place value. Since 32 is greater than 8, *(write 32 > 8)* then Maria's number is greater.

Now, let's work to determine how many times greater Maria's number is than Angel's number. Just like we saw in our earlier examples, we can divide the larger quantity by the smaller quantity to see how many times bigger it is than the smaller quantity.

$$\frac{32 \cdot 10^7}{8 \cdot 10^7} = \frac{32}{8} \cdot \frac{10^7}{10^7}$$

$$4 \cdot 1$$

$$\boxed{4}$$

Let's start by writing the division in fraction form. *(write Maria's number in the numerator and Angel's number in the denominator)* To evaluate this, we can divide the leading factors first, and then we can divide the powers of 10. *(write leading factors and powers of 10 separately as shown)*

What is 32 divided by 8? (4)

What is 10 to the seventh power divided by 10 to the seventh power? (1) It's 1, because any number over itself in fraction form is equivalent to 1 whole. *(write 4 • 1)*

4 times 1 is equal to 4. We can say Maria's number is 4 times greater than Angel's number. We used division to help us find how many times greater Maria's number is than Angel's number. Dividing the leading factors first and then the powers of 10 kept the math manageable.

Let's try another example.

Let's Think (Slide 5): *(read the problem aloud)*   This problem wants us to find how many times faster light travels through copper wire than through diamonds. I notice these values don't have the same power of 10. It can be helpful, although not 100% necessary, to compare numbers if they involve the same power of 10.

$$2.5 \times 10^8$$

$$2.5 \times 10^2 \times 10^6$$

$$250 \times 10^6$$

Let's think about how we can rewrite 2.5 x 10 to the eighth power using 10 to the sixth power instead. I know 10 to the eighth power can be written as 10 to the sixth power times 10 to the second power. I can decompose 10 to the eighth power using a number bond. *(show a number bond decomposing 10 to the eighth power into 10 to the second power and 10 to the sixth power)* I know 2.5 x 10 to the second power is the same as 250. 2.5 times 10 to the eighth power is equivalent to 250 times 10 to the sixth power. *(write 250 x 10 to the sixth power)*

$$\frac{250 \times 10^6}{160 \times 10^6} = \frac{250}{160} \times \frac{10^6}{10^6}$$

Now we can use division to find how many times faster light travels through copper wire than through diamonds. I'll write the value for the speed of light through copper wire in the numerator. I'll write the value for the speed of light through diamonds in the denominator. *(write the values in fraction form)* Think back to our last example. How can we break apart this problem to make the division more manageable? How could we write the quotient? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- We can divide the leading factors first, and then we can divide the powers of 10.
- 250 divided by 160 is 1.5625. 10 to the sixth divided by 10 to the sixth is just 1 whole.

$$1.5625 \times 1$$

$$\boxed{1.5625}$$

We're left with 1.5625 times 1, which is 1.5625. This tells us the speed light waves travel through copper wire is 1.5625 times faster than the speed at which light waves travel through diamonds.

Let's Try it (Slides 6 - 7): Now we get a chance to try a few more comparison problems together. As we've seen, we can use division to help us compare how many times greater one value is than another. When dividing with powers of 10, it can be helpful to have the same power of 10 in both quantities. We can also make dividing efficient by dividing leading factors and powers of 10 separately. Let's keep all this in mind for the next few examples. When we're done, you'll get a chance to show what you know independently.

WARM WELCOME

Today we will compare large numbers using powers of 10.

Let’s Talk:

How many times greater is 10 than 5?

How many times greater is 30 than 5?

How many times greater is 5,000 than 5?

How many times greater is 42 than 5?

Let’s Think:

Whose number is greater?

How many times greater is it than the other number?

MARIA

$32 \cdot 10^7$

ANGEL

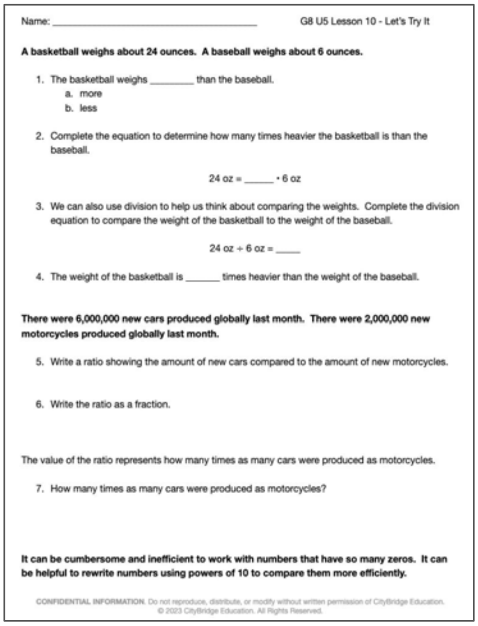
$8 \cdot 10^7$

Let's Think:

Light waves travel through copper wire at a speed of 2.5 • 10^8 meters per second. Light waves travel through diamonds at 160 • 10^6 meters per second. How many times faster does light travel through copper wire than through diamonds?

Let's Try It:

Let's explore comparing large numbers using powers of 10 together.



Name: ______________________________ G8 U5 Lesson 10 - Let's Try It

A basketball weighs about 24 ounces. A baseball weighs about 6 ounces.

1. The basketball weighs ________ than the baseball.
   a. more
   b. less
2. Complete the equation to determine how many times heavier the basketball is than the baseball.

   24 oz = _____ • 6 oz

3. We can also use division to help us think about comparing the weights. Complete the division equation to compare the weight of the basketball to the weight of the baseball.

   24 oz ÷ 6 oz = _____

4. The weight of the basketball is _______ times heavier than the weight of the baseball.

There were 6,000,000 new cars produced globally last month. There were 2,000,000 new motorcycles produced globally last month.

5. Write a ratio showing the amount of new cars compared to the amount of new motorcycles.
6. Write the ratio as a fraction.

The value of the ratio represents how many times as many cars were produced as motorcycles.

7. How many times as many cars were produced as motorcycles?

It can be cumbersome and inefficient to work with numbers that have so many zeros. It can be helpful to rewrite numbers using powers of 10 to compare them more efficiently.

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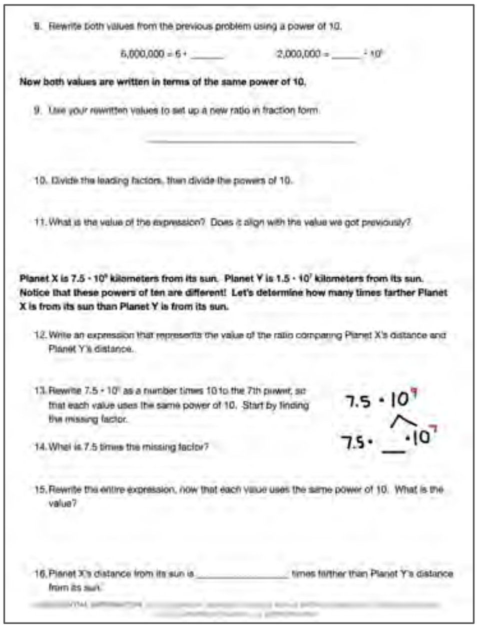


8. Rewrite both values from the previous problem using a power of 10.

   6,000,000 = 6 • ______ 2,000,000 = ______ • 10^6

Now both values are written in terms of the same power of 10.

9. Use your rewritten values to set up a new ratio in fraction form.

10. Divide the leading factors, then divide the powers of 10.

11. What is the value of the expression? Does it align with the value we got previously?

Planet X is 7.5 • 10^9 kilometers from its sun. Planet Y is 1.5 • 10^7 kilometers from its sun. Notice that these powers of ten are different! Let's determine how many times farther Planet X is from its sun than Planet Y is from its sun.

12. Write an expression that represents the value of the ratio comparing Planet X's distance and Planet Y's distance.

13. Rewrite 7.5 • 10^9 as a number times 10 to the 7th power, so that each value uses the same power of 10. Start by finding the missing factor.

14. What is 7.5 times the missing factor?

$7.5 \cdot 10^9$

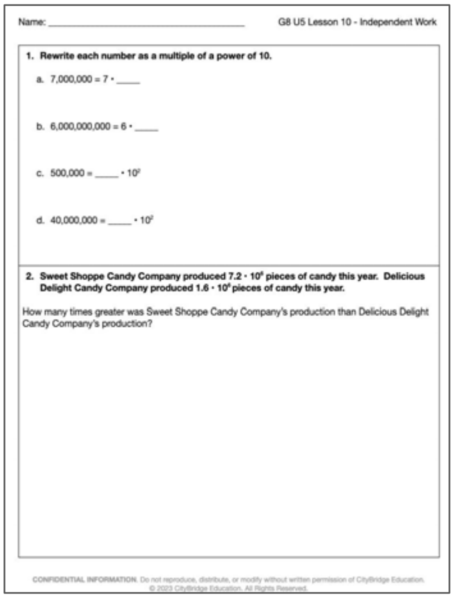
$7.5 \cdot \_\_ \cdot 10^7$

15. Rewrite the entire expression, now that each value uses the same power of 10. What is the value?

16. Planet X's distance from its sun is ______________ times farther than Planet Y's distance from its sun.

On your Own:

Now it’s time to compare large numbers using powers of 10 on your own.



Name: ______________________ G8 U5 Lesson 10 - Independent Work

1. Rewrite each number as a multiple of a power of 10.

a. 7,000,000 = 7 • _____

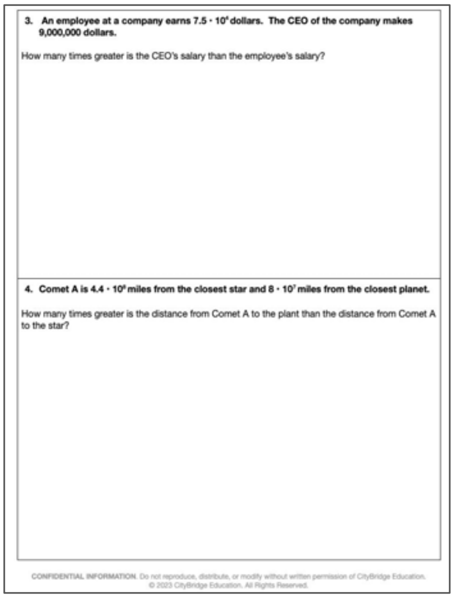
b. 6,000,000,000 = 6 • _____

c. 500,000 = _____ • $10^?$

d. 40,000,000 = _____ • $10^?$

2. Sweet Shoppe Candy Company produced 7.2 · 10^8 pieces of candy this year. Delicious Delight Candy Company produced 1.6 · 10^6 pieces of candy this year.

How many times greater was Sweet Shoppe Candy Company’s production than Delicious Delight Candy Company’s production?



3. An employee at a company earns 7.5 · 10^4 dollars. The CEO of the company makes 9,000,000 dollars.

How many times greater is the CEO’s salary than the employee’s salary?

4. Comet A is 4.4 · 10^8 miles from the closest star and 8 · 10^7 miles from the closest planet.

How many times greater is the distance from Comet A to the plant than the distance from Comet A to the star?

A basketball weighs about 24 ounces. A baseball weighs about 6 ounces.

1. The basketball weighs _________ than the baseball.
    a. more
    b. less

2. Complete the equation to determine how many times heavier the basketball is than the baseball.

24 oz = ______ • 6 oz

3. We can also use division to help us think about comparing the weights. Complete the division equation to compare the weight of the basketball to the weight of the baseball.

24 oz ÷ 6 oz = _____

4. The weight of the basketball is _______ times heavier than the weight of the baseball.

There were 6,000,000 new cars produced globally last month. There were 2,000,000 new motorcycles produced globally last month.

5. Write a ratio showing the amount of new cars compared to the amount of new motorcycles.

6. Write the ratio as a fraction.

The value of the ratio represents how many times as many cars were produced as motorcycles.

7. How many times as many cars were produced as motorcycles?

It can be cumbersome and inefficient to work with numbers that have so many zeros. It can be helpful to rewrite numbers using powers of 10 to compare them more efficiently.

8. Rewrite both values from the previous problem using a power of 10.

6,000,000 = 6 • _______ 2,000,000 = ______ • 10^6

Now both values are written in terms of the same power of 10.

9. Use your rewritten values to set up a new ratio in fraction form.

____

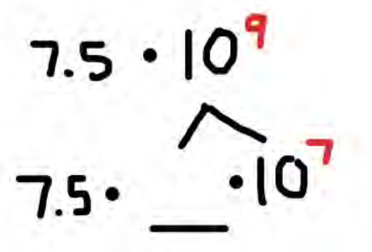
10. Divide the leading factors, then divide the powers of 10.

11. What is the value of the expression? Does it align with the value we got previously?

Planet X is 7.5 • 10^9 kilometers from its sun. Planet Y is 1.5 • 10^7 kilometers from its sun. Notice that these powers of ten are different! Let's determine how many times farther Planet X is from its sun than Planet Y is from its sun.

12. Write an expression that represents the value of the ratio comparing Planet X's distance and Planet Y's distance.

13. Rewrite 7.5 • 10^9 as a number times 10 to the 7th power, so that each value uses the same power of 10. Start by finding the missing factor.



14. What is 7.5 times the missing factor?

15. Rewrite the entire expression, now that each value uses the same power of 10. What is the value?

16. Planet X's distance from its sun is __________________ times farther than Planet Y's distance from its sun.

1. **Rewrite each number as a multiple of a power of 10.**

   a. 7,000,000 = 7 • _____

   b. 6,000,000,000 = 6 • _____

   c. 500,000 = _____ • 10^2

   d. 40,000,000 = _____ • 10^2

2. **Sweet Shoppe Candy Company produced 7.2 • 10^6 pieces of candy this year. Delicious Delight Candy Company produced 1.6 • 10^6 pieces of candy this year.**

How many times greater was Sweet Shoppe Candy Company's production than Delicious Delight Candy Company's production?

3. An employee at a company earns 7.5 • 10^4 dollars. The CEO of the company makes 9,000,000 dollars.

How many times greater is the CEO's salary than the employee's salary?

4. Comet A is 4.4 • 10^8 miles from the closest star and 8 • 10^7 miles from the closest planet.

How many times greater is the distance from Comet A to the plant than the distance from Comet A to the star?

Name: KEY

G8 U5 Lesson 10 - Let's Try It

A basketball weighs about 24 ounces. A baseball weighs about 6 ounces.

1. The basketball weighs ________ than the baseball.
   - [✓ a. more]
   - b. less

2. Complete the equation to determine how many times heavier the basketball is than the baseball.

   24 oz = 4 • 6 oz

3. We can also use division to help us think about comparing the weights. Complete the division equation to compare the weight of the basketball to the weight of the baseball.

   24 oz ÷ 6 oz = 4

4. The weight of the basketball is 4 times heavier than the weight of the baseball.

There were 6,000,000 new cars produced globally last month. There were 2,000,000 new motorcycles produced globally last month.

5. Write a ratio showing the amount of new cars compared to the amount of new motorcycles.

   6000000 : 2000000

6. Write the ratio as a fraction.

   $$\frac{6000000}{2000000}$$

The value of the ratio represents how many times as many cars were produced as motorcycles.

7. How many times as many cars were produced as motorcycles?

   $\cancel{\frac{6 \times 10}{2 \times 10}}$ $\cancel{\frac{6}{2} \times \frac{10}{10}}$ $\cancel{3 \times 1}$ 3

It can be cumbersome and inefficient to work with numbers that have so many zeros. It can be helpful to rewrite numbers using powers of 10 to compare them more efficiently.

8. Rewrite both values from the previous problem using a power of 10.

6,000,000 = 6 • 10^6 2,000,000 = 2 • 10^6

Now both values are written in terms of the same power of 10.

9. Use your rewritten values to set up a new ratio in fraction form.

$$\frac{6 \cdot 10^6}{2 \cdot 10^6}$$

10. Divide the leading factors, then divide the powers of 10.

$6 \div 2 = 3$ $10^6 \div 10^6 = 1$

11. What is the value of the expression? Does it align with the value we got previously?

$3 \times 1 = \boxed{3}$ ↳ Yes! It's the same answer.

Planet X is 7.5 • 10^9 kilometers from its sun. Planet Y is 1.5 • 10^7 kilometers from its sun. Notice that these powers of ten are different! Let's determine how many times farther Planet X is from its sun than Planet Y is from its sun.

12. Write an expression that represents the value of the ratio comparing Planet X's distance and Planet Y's distance.

$$\frac{7.5 \times 10^9}{1.5 \times 10^7}$$

13. Rewrite 7.5 • 10^9 as a number times 10 to the 7th power, so that each value uses the same power of 10. Start by finding the missing factor.

$7.5 \cdot 10^9$

$7.5 \cdot \underline{10^2} \cdot 10^7$

14. What is 7.5 times the missing factor?

750

15. Rewrite the entire expression, now that each value uses the same power of 10. What is the value?

$\frac{750 \times 10^7}{1.5 \times 10^7}$ $\frac{750}{1.5} \times \frac{10^7}{10^7}$ 500×1

16. Planet X's distance from its sun is $\boxed{500}$ times farther than Planet Y's distance from its sun.

Name: KEY

G8 U5 Lesson 10 - Independent Work

1. Rewrite each number as a multiple of a power of 10.

a. 7,000,000 = 7 · 10^6

b. 6,000,000,000 = 6 · 10^9

c. 500,000 = 5000 · 10^2

d. 40,000,000 = 400,000 · 10^2

2. Sweet Shoppe Candy Company produced $7.2 \cdot 10^6$ pieces of candy this year. Delicious Delight Candy Company produced $1.6 \cdot 10^6$ pieces of candy this year.

How many times greater was Sweet Shoppe Candy Company's production than Delicious Delight Candy Company's production?

$$\frac{7.2\times10^6}{1.6\times10^6} \longrightarrow \frac{7.2}{1.6}\times\frac{10^6}{10^6}$$

$$4.5\times1$$

$$4.5$$

3. An employee at a company earns $7.5 \cdot 10^4$ dollars. The CEO of the company makes 9,000,000 dollars.

How many times greater is the CEO's salary than the employee's salary?

$$\frac{9 \times 10^6}{7.5 \times 10^4}$$

$$\frac{9}{7.5} \times \frac{10^6}{10^4}$$

$$1.2 \times 10^2$$

$$\boxed{120}$$

4. Comet A is $4.4 \cdot 10^8$ miles from the closest star and $8 \cdot 10^7$ miles from the closest planet.

How many tirnes greater is the distance from Comet A to the plant than the distance from Comet A to the star?

$$\frac{4.4 \times 10^8}{8 \times 10^7}$$

$$\frac{4.4}{8} \times \frac{10^8}{10^7}$$

$$0.55 \times 10^1$$

$$\boxed{5.5}$$

G8 U5 Lesson 11

Represent small numbers as multiples of powers of 10, and compare numbers using powers of 10.

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G8 U5 Lesson 11 - Students will represent small numbers as multiples of powers of 10, and compare numbers using powers of 10.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): In our last lesson, we represented large numbers using powers of 10, and we spent time comparing those numbers. Today, we'll do the same thing, but we'll be working with small numbers. What scenarios can you think of that might necessitate the need to represent really small numbers? Possible Student Answers, Key Points:

- Scientists might need to use small numbers to think about really tiny things like atoms or cells under a microscope.
- Statisticians might need to use small numbers to determine probability or analyze data.
- Anyone who works with really precise measurements like an engineer or an architect or an artist might need to think about miniscule measurements.

Those are great ideas. There are many cases where representing really small numbers is necessary. Let's see how we can represent and compare small numbers using what we know about powers of 10.

Let's Talk (Slide 3): Before we jump into really small numbers, let's revisit some thinking around multiplicative comparison. Help me think about the first question. How many times as long is 10 inches compared to 5 inches? How do you know? Possible Student Answers, Key Points:

- 10 inches is 2 times as long as 5 inches, because 5 x 2 = 10.
- We can divide to compare. I know 10 divided by 5 is 2, so 10 inches is 2 times as long as 5 inches.

$10 = \_\_ \times 5$

$10 \div 5 = 2$

Like we've done before, we can think 10 is equal to what times 5? Or how many times longer than 5 is 10. *(write 10 = _____ x 5)* We've also explored how we can use division to think about comparison and find the unknown in this case. 10 divided by 5 equals 2. *(write that equation)* So 10 inches is 2 times as long as 5 inches.

What if we reversed this? The second question says how many times as long is 5 inches compared to 10 inches. Is the answer still 2? How do you know? Possible Student Answers, Key Points:

- The answer can't be 2, because 5 is not equal to 2 x 10.
- 5 inches is shorter than 10 inches, so it doesn't make sense that 5 inches would be 2 times as long as 10 inches.

$5 = \_\_ \times 10$

$5 \div 10 = \frac{1}{2}$

5 is not 2 times as long as 10 inches, because 2 times 10 is 20. So how can we think about this comparison? We can use the same structure we used in the last example. I can think: "5 is equal to what number times 10?" *(write 5 = ____ x 10)* Like before, we can use division to help find the unknown. 5 divided by 10 is 5/10 or ½ or 0.5 So we can say 5 inches is ½ times as long as 10 inches. Or 5 inches is 0.5 times as long as 10 inches. This value being less than 1 makes sense, because we already noted how 5 is shorter than 10.

Let's continue using this thinking throughout this lesson.

Let's Think (Slide 4): *(read problem aloud)* This problem wants us to determine how many times as long the diameter of the grain of salt is compared to the diameter of the plant cell. We can write the ratio comparing those two quantities as a fraction. We'll put 0.02 in the numerator, since that represents the diameter of the grain of salt. We'll put 0.00064 in the denominator, since that represents the diameter of the plant cell.

$$\frac{0.02}{0.00064} = \frac{20 \times 10^{-3}}{6.4 \times 10^{-4}}$$

(set up ratio as a fraction as stated) I'll write each of these using a power of 10 to help me divide efficiently. I can say 0.02 is 20 times 10 to the negative third power. *(rewrite the ratio with this new numerator)*

I'll rewrite 0.00064 as being 6.4 times a power of 10. What power of ten makes sense? How do you know? *(rewrite numerator as student shares, supporting as needed)* Possible Student Answers, Key Points:

- It should be 10 to the negative fourth power.
- If I shift the digits in 6.4 four place values right, I end back up with 0.00064.

$$3.125 \times 10^{1}$$
$$\boxed{31.25}$$

Now we can divide the leading factors separate from the powers of 10. 20 divided by 6.4 is 3.125. If we subtract the exponents -3 - -4, we can think of that as -3 + 4. The power of 10 when we divide is 10 to the first power. *(write 3.125 x 10 to the first power)* 3.125 times 10 is equal to 31.25.

The diameter of the grain of salt is 31.25 times as long as the diameter of the plant cell. Now let's reverse this comparison, and see if we can work it out.

Let's Think (Slide 5): Read the problem to yourself. *(pause as student reads)* What do you notice? Possible Student Answers, Key Points:

- This problem has the same information as the previous example.
- Instead of comparing how many times longer the diameter of the grain of salt is to the diameter of the plant cell, we're asked to compare the other way around. It's like the comparison is reversed.

This is like when we compared how many times as long 5 inches was compared to 10 inches. We can use the same logic.

$$\frac{0.00064}{0.02} = \frac{6.4 \times 10^{-4}}{2 \times 10^{-2}}$$

Since we're comparing how many times as long the plant cell is as the grain of salt, we'll put the plant cell's length in the numerator and the grain of salt in the denominator. *(write ratio in fraction form as stated)* We can rewrite each value using a power of 10. We'll use 6.4 times 10 to the negative fourth power to represent 0.00064. Instead of using 20 times 10 to the -3 power, I'll use 2 times 10 to the -2 power. That will just make it easier to divide the leading factors. *(rewrite ratio in fraction form using powers of 10 as described)*

Divide the leading factors. Divide the powers of 10. What's the result? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- When we divide the leading factors we can think of 6.4 divided by 2. That's 3.2.
- To divide the powers of 10, we can subtract the exponents. -4 minus -2 is the same as -4 plus 2, so the exponent is -2.
- The quotient is 3.2 x 10 to the -2 power.

$$3.2 \times 10^{-2} = \boxed{0.032}$$

The quotient is 3.2 times 10 to the -2 power. If we rewrite that in standard form, it's 0.032. That means the length of the plant cell's diameter is 0.032 times as long as the length of the grain of salt's diameter. This makes sense, because we know the plant cell's diameter is shorter than the grain of salt's diameter.

Let's Try it (Slides 6 - 7): Now let's try a few more together before you get a chance to try some out independently. When asked to compare, we saw that we can compare larger quantities to smaller quantities or smaller quantities to larger quantities multiplicatively. We'll want to pay attention to exactly what the question is asking us to compare. Once we know that, we can set up a ratio using powers of 10 to efficiently divide. Let's jump into our next examples.

WARM WELCOME

Today we will represent small numbers as multiples of powers of 10, and compare numbers using powers of 10.

Let’s Talk:

How many times as long is 10” compared to 5”?

How many times as long is 5” compared to 10”?

Let’s Think:

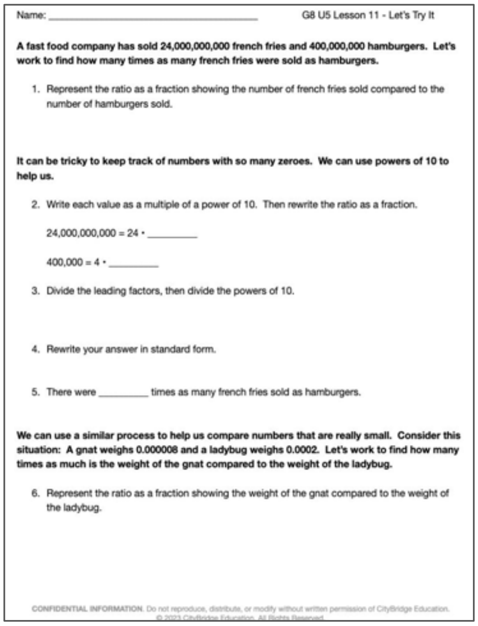
The diameter of a plant cell is 0.00064 cm. The diameter of a grain of salt is 0.02 cm. How many times as long is the diameter of the grain of salt compared to the diameter of the plant cell?

Let's Think:

The diameter of a plant cell is 0.00064 cm. The diameter of a grain of salt is 0.02 cm. How many times as long is the diameter of the plant cell compared to the diameter of the grain of salt?

Let's Try It:

Let's explore representing small numbers as multiples of powers of 10, and comparing numbers using powers of 10 together.



Name: ______________________ G8 U5 Lesson 11 - Let's Try It

A fast food company has sold 24,000,000,000 french fries and 400,000,000 hamburgers. Let's work to find how many times as many french fries were sold as hamburgers.

1. Represent the ratio as a fraction showing the number of french fries sold compared to the number of hamburgers sold.

It can be tricky to keep track of numbers with so many zeroes. We can use powers of 10 to help us.

2. Write each value as a multiple of a power of 10. Then rewrite the ratio as a fraction.

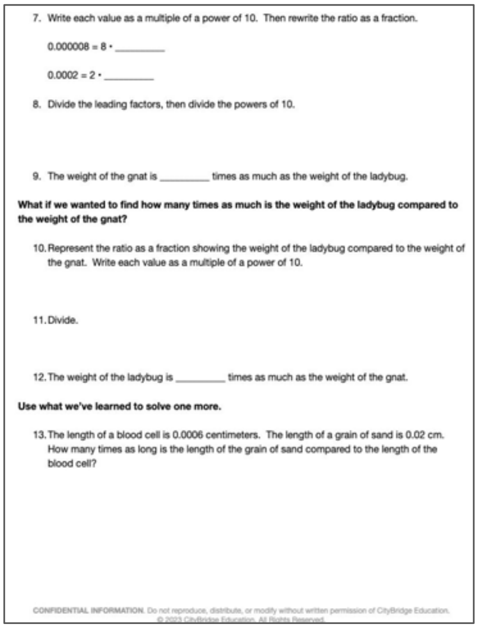
   24,000,000,000 = 24 • _________

   400,000 = 4 • _________

3. Divide the leading factors, then divide the powers of 10.
4. Rewrite your answer in standard form.
5. There were _________ times as many french fries sold as hamburgers.

We can use a similar process to help us compare numbers that are really small. Consider this situation: A gnat weighs 0.000008 and a ladybug weighs 0.0002. Let's work to find how many times as much is the weight of the gnat compared to the weight of the ladybug.

6. Represent the ratio as a fraction showing the weight of the gnat compared to the weight of the ladybug.



7. Write each value as a multiple of a power of 10. Then rewrite the ratio as a fraction.

   0.000008 = 8 • _________

   0.0002 = 2 • _________

8. Divide the leading factors, then divide the powers of 10.
9. The weight of the gnat is _________ times as much as the weight of the ladybug.

What if we wanted to find how many times as much is the weight of the ladybug compared to the weight of the gnat?

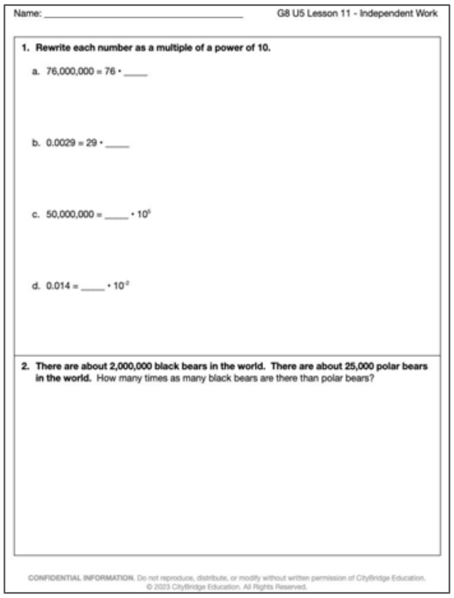
10. Represent the ratio as a fraction showing the weight of the ladybug compared to the weight of the gnat. Write each value as a multiple of a power of 10.
11. Divide.
12. The weight of the ladybug is _________ times as much as the weight of the gnat.

Use what we've learned to solve one more.

13. The length of a blood cell is 0.0006 centimeters. The length of a grain of sand is 0.02 cm. How many times as long is the length of the grain of sand compared to the length of the blood cell?

On your Own:

Now it's time to represent small numbers as multiples of powers of 10, and compare numbers using powers of 10 on your own.



Name: ______________________________ G8 U5 Lesson 11 - Independent Work

1. Rewrite each number as a multiple of a power of 10.

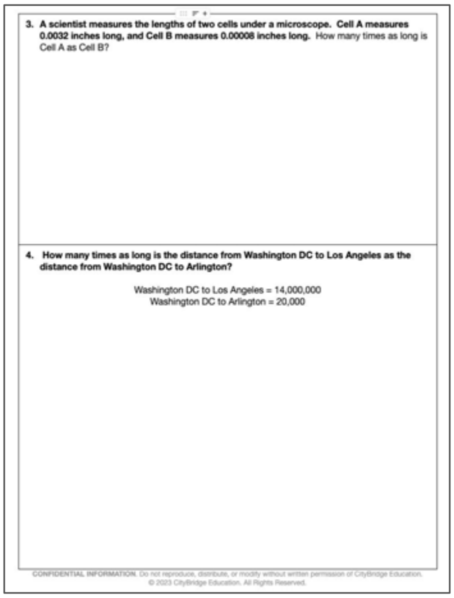
a. 76,000,000 = 76 • _____

b. 0.0029 = 29 • _____

c. 50,000,000 = _____ • 10^5

d. 0.014 = _____ • 10^{-2}

2. There are about 2,000,000 black bears in the world. There are about 25,000 polar bears in the world. How many times as many black bears are there than polar bears?



3. A scientist measures the lengths of two cells under a microscope. Cell A measures 0.0032 inches long, and Cell B measures 0.00008 inches long. How many times as long is Cell A as Cell B?

4. How many times as long is the distance from Washington DC to Los Angeles as the distance from Washington DC to Arlington?

Washington DC to Los Angeles = 14,000,000
Washington DC to Arlington = 20,000

Name: ____ G8 U5 Lesson 11 - Let's Try It

A fast food company has sold 24,000,000,000 french fries and 400,000,000 hamburgers. Let's work to find how many times as many french fries were sold as hamburgers.

1. Represent the ratio as a fraction showing the number of french fries sold compared to the number of hamburgers sold.

It can be tricky to keep track of numbers with so many zeroes. We can use powers of 10 to help us.

2. Write each value as a multiple of a power of 10. Then rewrite the ratio as a fraction.

   24,000,000,000 = 24 • __________

   400,000,000 = 4 • __________

3. Divide the leading factors, then divide the powers of 10.

4. Rewrite your answer in standard form.

5. There were __________ times as many french fries sold as hamburgers.

We can use a similar process to help us compare numbers that are really small. Consider this situation: A gnat weighs 0.000008 and a ladybug weighs 0.0002. Let's work to find how many times as much is the weight of the gnat compared to the weight of the ladybug.

6. Represent the ratio as a fraction showing the weight of the gnat compared to the weight of the ladybug.

7. Write each value as a multiple of a power of 10. Then rewrite the ratio as a fraction.

   0.000008 = 8 • _________

   0.0002 = 2 • _________

8. Divide the leading factors, then divide the powers of 10.

9. The weight of the gnat is _________ times as much as the weight of the ladybug.

What if we wanted to find how many times as much is the weight of the ladybug compared to the weight of the gnat?

10. Represent the ratio as a fraction showing the weight of the ladybug compared to the weight of the gnat. Write each value as a multiple of a power of 10.

11. Divide.

12. The weight of the ladybug is _________ times as much as the weight of the gnat.

Use what we've learned to solve one more.

13. The length of a blood cell is 0.0006 centimeters. The length of a grain of sand is 0.02 cm. How many times as long is the length of the grain of sand compared to the length of the blood cell?

1. Rewrite each number as a multiple of a power of 10.

a. 76,000,000 = 76 • _____

b. 0.0029 = 29 • _____

c. 50,000,000 = _____ • 10^5

d. 0.014 = _____ • 10^{-2}

2. There are about 2,000,000 black bears in the world. There are about 25,000 polar bears in the world. How many times as many black bears are there than polar bears?

3. **A scientist measures the lengths of two cells under a microscope. Cell A measures 0.0032 inches long, and Cell B measures 0.00008 inches long.** How many times as long is Cell A as Cell B?

4. **How many times as long is the distance from Washington DC to Los Angeles as the distance from Washington DC to Arlington?**

Washington DC to Los Angeles = 14,000,000
Washington DC to Arlington = 20,000

Name: KEY

A fast food company has sold 24,000,000,000 french fries and 400,000,000 hamburgers. Let's work to find how many times as many french fries were sold as hamburgers.

1. Represent the ratio as a fraction showing the number of french fries sold compared to the number of hamburgers sold.

$$\frac{24,000,000,000}{400,000,000}$$

It can be tricky to keep track of numbers with so many zeroes. We can use powers of 10 to help us.

2. Write each value as a multiple of a power of 10. Then rewrite the ratio as a fraction.

24,000,000,000 = 24 • 10^9

400,000,000 ~~400,000~~ = 4 • 10^8

3. Divide the leading factors, then divide the powers of 10.

$\frac{24}{4} \times \frac{10^9}{10^8}$ 6×10^1

4. Rewrite your answer in standard form.

60

5. There were 60 times as many french fries sold as hamburgers.

We can use a similar process to help us compare numbers that are really small. Consider this situation: A gnat weighs 0.000008 and a ladybug weighs 0.0002. Let's work to find how many times as much is the weight of the gnat compared to the weight of the ladybug.

6. Represent the ratio as a fraction showing the weight of the gnat compared to the weight of the ladybug.

$$\frac{0.000008}{0.0002}$$

7. Write each value as a multiple of a power of 10. Then rewrite the ratio as a fraction.

0.000008 = 8 • 10^{-6}

0.0002 = 2 • 10^{-4}

8. Divide the leading factors, then divide the powers of 10.

$$\frac{8}{2} \times \frac{10^{-6}}{10^{-4}} \qquad \boxed{4 \times 10^{-2}}$$

9. The weight of the gnat is $\boxed{0.04}$ times as much as the weight of the ladybug.

What if we wanted to find how many times as much is the weight of the ladybug compared to the weight of the gnat?

10. Represent the ratio as a fraction showing the weight of the ladybug compared to the weight of the gnat. Write each value as a multiple of a power of 10.

$$\frac{2 \times 10^{-4}}{8 \times 10^{-6}}$$

11. Divide.

$$\frac{1}{4} \times 10^{2} \qquad 0.25 \times 10^{2} = 25$$

12. The weight of the ladybug is $\boxed{25}$ times as much as the weight of the gnat.

Use what we've learned to solve one more.

13. The length of a blood cell is 0.0006 centimeters. The length of a grain of sand is 0.02 cm. How many times as long is the length of the grain of sand compared to the length of the blood cell?

$$\frac{0.02}{0.0006} \longrightarrow \frac{2 \times 10^{-2}}{6 \times 10^{-4}} \qquad \frac{2}{6} \times \frac{10^{-2}}{10^{-4}}$$

$$\approx 0.33 \times 10^{2}$$

$$\boxed{\approx 33}$$

Name: KEY

G8 U5 Lesson 11 - Independent Work

1. Rewrite each number as a multiple of a power of 10.

a. 76,000,000 = 76 • 10^6

b. 0.0029 = 29 • 10^{-4}

c. 50,000,000 = 500 • 10^5

d. 0.014 = 1.4 • 10^{-2}

2. There are about 2,000,000 black bears in the world. There are about 25,000 polar bears in the world. How many times as many black bears are there than polar bears?

$$\frac{2\,000\,000}{25\,000} \longrightarrow \frac{2 \times 10^6}{2.5 \times 10^4} \qquad \frac{2}{2.5} \times \frac{10^6}{10^4}$$

$$0.8 \times 10^2$$

$$80$$

3. **A scientist measures the lengths of two cells under a microscope. Cell A measures 0.0032 inches long, and Cell B measures 0.00008 inches long.** How many times as long is Cell A as Cell B?

$$\frac{0.0032}{0.00008} \rightarrow \frac{32 \times 10^{-4}}{8 \times 10^{-5}} \quad \frac{32}{8} \times \frac{10^{-4}}{10^{-5}}$$

$$4 \times 10^{1}$$

$$\boxed{40}$$

4. **How many times as long is the distance from Washington DC to Los Angeles as the distance from Washington DC to Arlington?**

Washington DC to Los Angeles = 14,000,000
Washington DC to Arlington = 20,000

$$\frac{140 \times 10^{5}}{20 \times 10^{3}} \rightarrow \frac{140}{20} \times \frac{10^{5}}{10^{3}}$$

$$7 \times 10^{2}$$

$$\boxed{700}$$

G8 U5 Lesson 12
Use exponent rules and powers of 10 to solve problems in context.

CITYTUTOR DC

G8 U5 Lesson 12 - Students will use exponent rules and powers of 10 to solve problems in context.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): Today, our goal is to use exponent rules and powers of 10 to solve real-world problems. We've actually done a lot of this already in previous lessons, so today might not feel brand new. One thing we'll focus on specifically is how we can use estimation to find approximate answers when working with exponents and powers of 10. When, either in math class or the world around us, might it be useful to use an approximation or an estimate rather than an exact answer? Possible Student Answers, Key Points:

- We estimate if we need to get a quick idea. Usually when we estimate we use compatible, or friendly, numbers that are easy to calculate with.
- If I'm setting up for a party, I might use an estimation to know how many cake slices I need and how many balloons to order. The numbers don't have to be exact in situations like that.

Let's use approximations to help us think about applying exponent rules and powers of 10 to the world around us.

Let's Talk (Slide 3): Consider the following scenario. Your teacher asks you to solve the problem shown here. They want to know the approximate value. Which path would you take, and why? Possible Student Answers, Key Points:

- Since the teacher asked for an approximation, I'd choose the path on the right. The actual dividend is close to 600,000 and the actual divisor is close to 20,000. The numbers would be easy to work with in my head.
- I might choose the left hand one if I wanted to be really accurate.

Either path would get you to an answer that the teacher would likely find acceptable, but if they just asked for an approximate answer, the path on the right would be most efficient. The right hand path used approximations of the dividend and divisor that were compatible, or friendly to work with. It's much easier to think about 600,000 divided by 20,000 than to find the exact answer.

Today, we'll estimate like this to help us find approximations of answers. Let's look at our first problem.

Let's Think (Slide 4): *(read the problem aloud once all the way through)* This is asking us how many times more brain cells are in the human's brain than the mosquito's brain.

$$\frac{161,654,209,118}{244,975}$$

We've tackled many comparison problems like this before. We can start by setting up a ratio comparing the number of cells in the human brain to the number of cells in the mosquito's brain. *(write ratio with the human brain cell value in the numerator and the mosquito brain cell value in the denominator)*

Is this problem asking us for an exact answer or an estimate, and how do you know? Possible Student Answers, Key Points:

- It's asking for an estimate.
- We'll estimate, because it says "approximately how many times" in the problem.

$$\frac{160,000,000,000}{200,000}$$

Since we're being asked for an approximation, we can think of compatible numbers that are relatively close to the original numbers. I'll use 160,000,000,000 and 200,000 because they're not too far from the actual numbers and their leading digits will be easy to manipulate. *(rewrite ratio)*

Now let's compare. All these zeros can be a bit tricky to look at and work with. How can I write each of these numbers using a power of 10 that will be easy to divide with? Possible Student Answers, Key Points:

- 160,000,000,000 is 16 times 10 to the 10 power. I know because if I shift the digits in 16 ten places values left, I end up with 160,000,000,000.
- 200,000 is 2 times 10 to the 5 power. I know, because I can shift 2 to the left five place values and end up with 200,000.

$$\frac{16 \times 10^{10}}{2 \times 10^{5}}$$

(write ratio with powers of 10 as shown or as student stated if they chose another form with powers of 10 that could also easily be divided) We can now divide the leading factors and the powers of 10 in isolation. *(highlight or circle leading factors and powers of 10 as shown)*

$$8 \times 10^{5}$$

$$\boxed{800{,}000}$$

I quickly know that 16 divided by 2 is 8. I also can quickly determine that 10 to the 10 power divided by 10 to the 5 power is 10 to the 5 power, because I can subtract the exponents. We end up with 8 times 10 to the 5 power. *(write that)* What is the value of our answer in standard form? (800,000) So we can say that the human brain has *about* 800,000 times more cells than the mosquito's brain.

Since the teacher asked us to find an approximate answer, we were able to use compatible numbers to more efficiently arrive at an answer that's close to what the actual answer would be.

Why might we find it helpful or unhelpful to find an estimate in a given problem like this? Possible Student Answers, Key Points:

- It's helpful, because we can more efficiently arrive at a general sense of what the answer should be. We don't have to calculate as precisely.
- It might be unhelpful, because we don't get an exact answer. If the situation required precision, an estimate might be misleading or less helpful.

Let's Try it (Slides 5 - 6): Now is our chance to collaborate on a few more problems. Most problems today will ask us to approximate. We can look for that word or similar language like "about how much" as clues to tell us a question does not require an exact answer. When estimating using powers of 10, we want to find leading factors that are easy to calculate in our heads. Sometimes that means changing one value or both values, depending on the numbers in the problem. We'll keep these estimation strategies in mind as we work. After these examples, you'll get to try some out independently.

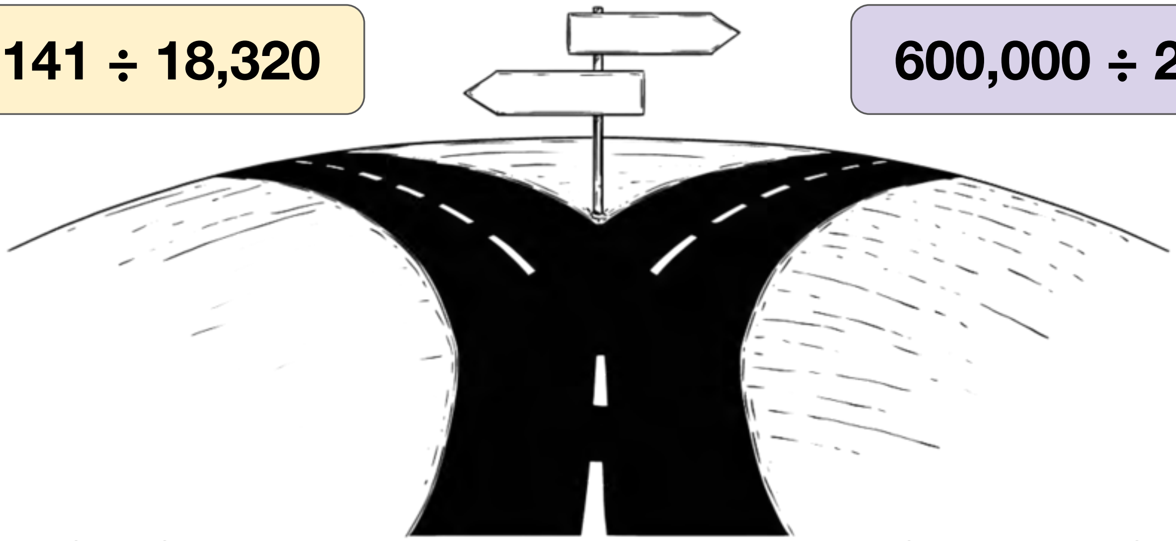
WARM WELCOME

Today we will use exponent rules and powers of 10 to solve problems in context.

Let's Talk:

Your teacher asks to know the approximate value of 589,141 ÷ 18,320. Which path will you take?

589,141 ÷ 18,320



600,000 ÷ 20,000

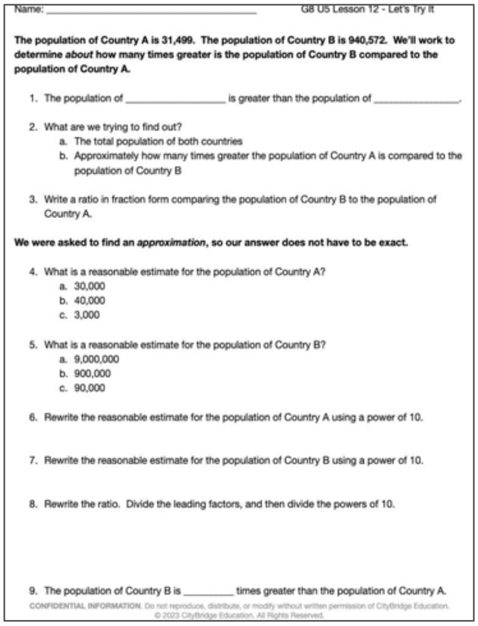
Let's Think:

A human's brain is composed of 161,654,209,118 cells. A mosquito's brain is composed of 244,975 cells.

Approximately how many times more brain cells are in the human's brain than the mosquito's brain?

Let's Try It:

Let's explore using exponent rules and powers of 10 to solve problems in context together.



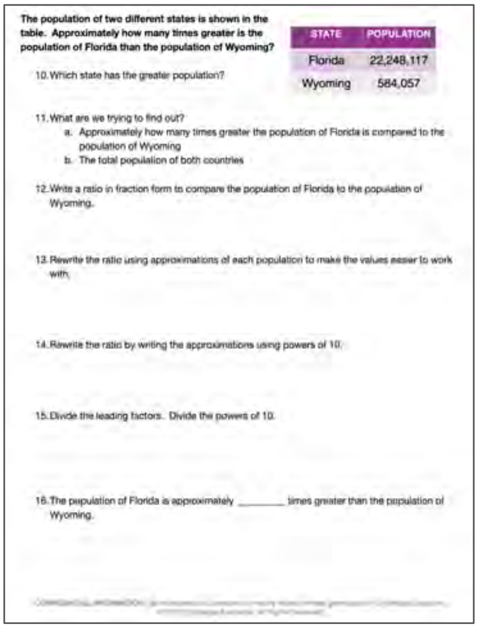
Name: ______________________ G8 U5 Lesson 12 - Let's Try It

The population of Country A is 31,499. The population of Country B is 940,572. We'll work to determine *about* how many times greater is the population of Country B compared to the population of Country A.

1. The population of ______________ is greater than the population of ______________.
2. What are we trying to find out?
   a. The total population of both countries
   b. Approximately how many times greater the population of Country A is compared to the population of Country B
3. Write a ratio in fraction form comparing the population of Country B to the population of Country A.

We were asked to find an *approximation*, so our answer does not have to be exact.

4. What is a reasonable estimate for the population of Country A?
   a. 30,000
   b. 40,000
   c. 3,000
5. What is a reasonable estimate for the population of Country B?
   a. 9,000,000
   b. 900,000
   c. 90,000
6. Rewrite the reasonable estimate for the population of Country A using a power of 10.
7. Rewrite the reasonable estimate for the population of Country B using a power of 10.
8. Rewrite the ratio. Divide the leading factors, and then divide the powers of 10.
9. The population of Country B is _________ times greater than the population of Country A.



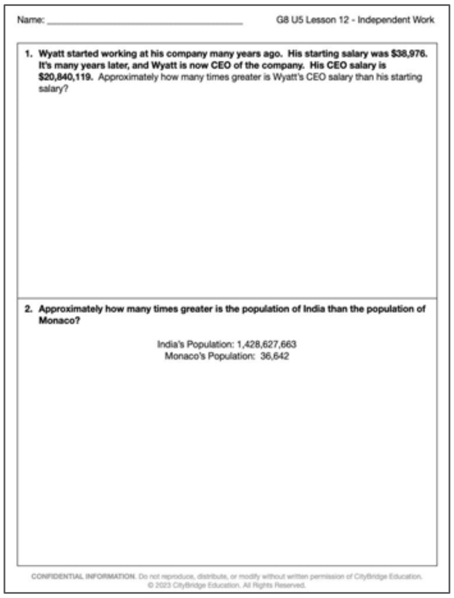
The population of two different states is shown in the table. Approximately how many times greater is the population of Florida than the population of Wyoming?

STATE	POPULATION
Florida	22,248,117
Wyoming	584,057

10. Which state has the greater population?
11. What are we trying to find out?
    a. Approximately how many times greater the population of Florida is compared to the population of Wyoming
    b. The total population of both countries
12. Write a ratio in fraction form to compare the population of Florida to the population of Wyoming.
13. Rewrite the ratio using approximations of each population to make the values easier to work with.
14. Rewrite the ratio by writing the approximations using powers of 10.
15. Divide the leading factors. Divide the powers of 10.
16. The population of Florida is approximately _________ times greater than the population of Wyoming.

On your Own:

Now it's time to use exponent rules and powers of 10 to solve problems in context on your own.

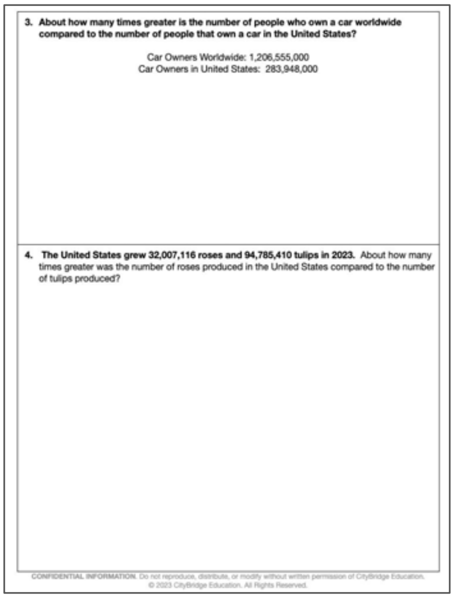


Name: ______________________ G8 U5 Lesson 12 - Independent Work

1. **Wyatt started working at his company many years ago. His starting salary was $38,976. It's many years later, and Wyatt is now CEO of the company. His CEO salary is $20,840,119.** Approximately how many times greater is Wyatt's CEO salary than his starting salary?

2. **Approximately how many times greater is the population of India than the population of Monaco?**

   India's Population: 1,428,627,663
   Monaco's Population: 36,642



3. **About how many times greater is the number of people who own a car worldwide compared to the number of people that own a car in the United States?**

   Car Owners Worldwide: 1,206,555,000
   Car Owners in United States: 283,948,000

4. **The United States grew 32,007,116 roses and 94,785,410 tulips in 2023.** About how many times greater was the number of roses produced in the United States compared to the number of tulips produced?

The population of Country A is 31,499. The population of Country B is 940,572. We'll work to determine *about* how many times greater is the population of Country B compared to the population of Country A.

1. The population of ___________________ is greater than the population of ________________.

2. What are we trying to find out?
    a. The total population of both countries
    b. Approximately how many times greater the population of Country A is compared to the population of Country B

3. Write a ratio in fraction form comparing the population of Country B to the population of Country A.

We were asked to find an *approximation*, so our answer does not have to be exact.

4. What is a reasonable estimate for the population of Country A?
    a. 30,000
    b. 40,000
    c. 3,000

5. What is a reasonable estimate for the population of Country B?
    a. 9,000,000
    b. 900,000
    c. 90,000

6. Rewrite the reasonable estimate for the population of Country A using a power of 10.

7. Rewrite the reasonable estimate for the population of Country B using a power of 10.

8. Rewrite the ratio. Divide the leading factors, and then divide the powers of 10.

9. The population of Country B is _________ times greater than the population of Country A.

The population of two different states is shown in the table. Approximately how many times greater is the population of Florida than the population of Wyoming?

STATE	POPULATION
Florida	22,248,117
Wyoming	584,057

10. Which state has the greater population?

11. What are we trying to find out?
    a. Approximately how many times greater the population of Florida is compared to the population of Wyoming
    b. The total population of both countries

12. Write a ratio in fraction form to compare the population of Florida to the population of Wyoming.

13. Rewrite the ratio using approximations of each population to make the values easier to work with.

14. Rewrite the ratio by writing the approximations using powers of 10.

15. Divide the leading factors. Divide the powers of 10.

16. The population of Florida is approximately __________ times greater than the population of Wyoming.

1. **Wyatt started working at his company many years ago. His starting salary was $38,976. It's many years later, and Wyatt is now CEO of the company. His CEO salary is $20,840,119.** Approximately how many times greater is Wyatt's CEO salary than his starting salary?

2. **Approximately how many times greater is the population of India than the population of Monaco?**

India's Population: 1,428,627,663
Monaco's Population: 36,642

3. **About how many times greater is the number of people who own a car worldwide compared to the number of people that own a car in the United States?**

Car Owners Worldwide: 1,206,555,000
Car Owners in United States: 283,948,000

4. **The United States grew 32,007,116 roses and 94,785,410 tulips in 2023.** About how many times greater was the number of tulips produced in the United States compared to the number of roses produced?

Name: KEY

The population of Country A is 31,499. The population of Country B is 940,572. We'll work to determine *about* how many times greater is the population of Country B compared to the population of Country A.

1. The population of Country B is greater than the population of Country A.

2. What are we trying to find out?
   - a. The total population of both countries
   - [✓ b.] Approximately how many times greater the population of Country A is compared to the population of Country B

3. Write a ratio in fraction form comparing the population of Country B to the population of Country A. $\frac{940,572}{31,499}$

We were asked to find an *approximation*, so our answer does not have to be exact.

4. What is a reasonable estimate for the population of Country A?
   - [✓ a. 30,000]
   - b. 40,000
   - c. 3,000

5. What is a reasonable estimate for the population of Country B?
   - a. 9,000,000
   - [✓ b. 900,000]
   - c. 90,000

6. Rewrite the reasonable estimate for the population of Country A using a power of 10.

   3×10^4

7. Rewrite the reasonable estimate for the population of Country B using a power of 10.

   9×10^5

8. Rewrite the ratio. Divide the leading factors, and then divide the powers of 10.

   $\frac{9\times10^5}{3\times10^4}$ $\frac{9}{3}\times\frac{10^5}{10^4}$ $\boxed{3\times10^1}$

9. The population of Country B is 30 times greater than the population of Country A.

The population of two different states is shown in the table. Approximately how many times greater is the population of Florida than the population of Wyoming?

STATE	POPULATION
Florida	22,248,117
Wyoming	584,057

10. Which state has the greater population?

Florida

11. What are we trying to find out?
    [✓ a.] Approximately how many times greater the population of Florida is compared to the population of Wyoming
    b. The total population of both countries

12. Write a ratio in fraction form to compare the population of Florida to the population of Wyoming.

$$\frac{22,248,117}{584,057}$$

13. Rewrite the ratio using approximations of each population to make the values easier to work with.

$$\frac{24,000,000}{600,000}$$

14. Rewrite the ratio by writing the approximations using powers of 10.

$$\frac{24 \times 10^6}{6 \times 10^5}$$

15. Divide the leading factors. Divide the powers of 10.

4×10^1

16. The population of Florida is approximately 40 times greater than the population of Wyoming.

Name: KEY

G8 U5 Lesson 12 - Independent Work

1. **Wyatt started working at his company many years ago. His starting salary was $38,976. It's many years later, and Wyatt is now CEO of the company. His CEO salary is $20,840,119.** Approximately how many times greater is Wyatt's CEO salary than his starting salary?

$$\frac{20{,}840{,}119}{38{,}976} \approx \frac{20{,}000{,}000}{40{,}000}$$

$$\frac{20 \times 10^6}{4 \times 10^4} \rightarrow \frac{20}{4} \times \frac{10^6}{10^4}$$

$$5 \times 10^2$$

$$\boxed{500}$$

2. **Approximately how many times greater is the population of India than the population of Monaco?**

India's Population: 1,428,627,663
Monaco's Population: 36,642

$$\frac{1{,}428{,}627{,}663}{36{,}642} \approx \frac{1{,}500{,}000{,}000}{30{,}000}$$

$$\frac{15 \times 10^8}{3 \times 10^4} \rightarrow \frac{15}{3} \times \frac{10^8}{10^4}$$

$$5 \times 10^4 \quad \boxed{50{,}000}$$

3. About how many times greater is the number of people who own a car worldwide compared to the number of people that own a car in the United States?

Car Owners Worldwide: 1,206,555,000 → 1,200,000,000
Car Owners in United States: 283,948,000 → 300,000,000

$$\frac{12\times10^8}{3\times10^8}$$

$$\frac{12}{3}\times\frac{10^8}{10^8}$$

$$4\times1=\boxed{4}$$

4. The United States grew 32,007,116 roses and 94,785,410 tulips in 2023. About how many times greater was the number of ~~roses~~ tulips produced in the United States compared to the number of ~~tulips~~ roses produced?

$\approx$ 30,000,000

$\approx$ 90,000,000

$$\frac{9\times10^7}{3\times10^7}$$

$$\frac{9}{3}\times\frac{10^7}{10^7}$$

$$3\times1=\boxed{3}$$

G8 U5 Lesson 13

Identify numbers written in scientific notation, and rewrite numbers written in different forms in scientific notation.

G8 U5 Lesson 13 - Students will identify numbers written in scientific notation, and rewrite numbers written in different forms in scientific notation.

Warm Welcome (Slide 1): Tutor choice

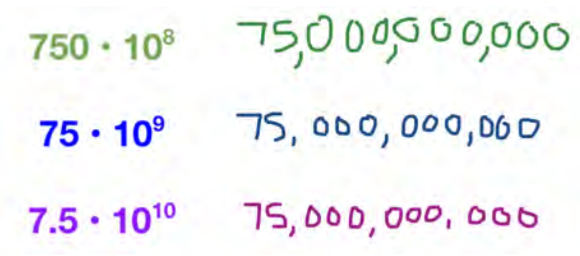
Frame the Learning/Connect to Prior Learning (Slide 2): We've been working with exponents and powers of 10 for several lessons. More recently we've been applying this thinking to everyday contexts, including using approximations of larger and small numbers. Scientists have to work with large and small numbers often, and so thousands of years ago scientists developed a uniform, agreed-upon way to represent them called scientific notation. We'll learn more about scientific notation in a few moments. Before we do, why do you think it's important for mathematicians, scientists, and other experts to have a uniform way of representing large and small numbers? Possible Student Answers, Key Points:

- It can make reading and writing the numbers simpler.
- There are many ways to represent numbers, as we've seen with exponents and powers of 10, so it might help them compare and discuss numbers if they're represented in a familiar way.

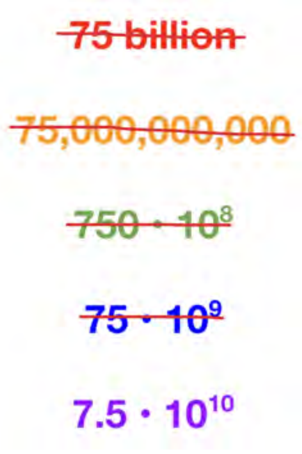
Interesting ideas. Let's keep that thinking in mind, and jump into a quick warm-up thinking exercise.

Let's Talk (Slide 3): Take a look at the numbers shown here. What's the same? What's different? Possible Student Answers, Key Points:

- They all start with 7 and 5. They all represent the same amount.
- One uses words. One is in standard form. Some have exponents. They are different colors.



These are all different ways to represent the number 75 billion or 75,000,000,000. Just to be certain, let's write the last three numbers in standard form. *(write as you narrate)* 750 times 10 the 8 power means each digit will shift 8 places left. That's 75,000,000,000. 75 times 10 to the 9 power means each digit shifts 9 places left. That's 75,000,000,000. Lastly, 7.5 times 10 to the 10 power means each digit shifts 10 places left. That's, again, 75,000,000,000.



These are all valid ways to write the number, however only one of them is written in what is called scientific notation. In order for a number to be written in scientific notation, it must be written as the product of two factors. *(cross out the first two examples)*

The second factor must be a power of 10 with an integer exponent, and the first term must be greater than or equal to 1 and less than 10. *(Cross out the green and blue expressions)* These aren't in scientific notation because the leading factors are greater than 10. The last example is the only one written in scientific notation.

As we work with numbers in scientific notation, remember the criteria. The number must be a written as a product of two factors. The first factor must be greater than or equal to 1 and less than 10, and the second factor must be an integer power of 10.

Let's Think (Slide 4): To start off, let's take a look at the four numbers shown here in various forms. We're tasked with finding which ones are in scientific notation, and which ones are not.

a. $3.1 \cdot 10^8$ ✓

b. 0.00945

c. $9 \cdot 10^{-7}$ ✓

d. $62 \cdot 10^4$

Since we just reviewed the criteria for scientific notation, see if you can identify the two numbers here that are already in scientific notation. *(circle or put a check next to A and C as student identifies them, supporting as needed)* Possible Student Answers, Key Points:

- I know A is in scientific notation. 3.1 is greater than or equal to 1, it's less than 10, and the other factor is an integer power of 10.
- I know C is in scientific notation. 9 is greater than or equal to 1, it's less than 10, and the other factor is an integer power of 10.

Answers A and C are already in scientific notation. Let's focus on the other two numbers to think about why they are not in scientific notation, and what we can do to get them there. Let's start with B. Why is B not in scientific notation? Possible Student Answers, Key Points:

- B is not in scientific notation, because it's not written as two factors. In scientific notation, the leading factor should also be greater than or equal to 1, which 0.00945 is not.
- B is not in scientific notation, because it does not use a power of 10.

To write 0.00945 in scientific notation, we'll start by shifting the digits to produce a leading factor that is 1 or more, but less than 10. If we shift the digits three places left, we end up with 9.45, which meets our criteria.

b. 0.00945 $\quad 9.45 \times 10^{-3}$

(use arrows to show shifting) Some people might also think of this shifting as moving the decimal three place values right. Either way, we end up with a leading factor of 9.45. Since we shifted 3 place values left, or moved the decimal three place values right, we can write this as 9.45 times 10 to the -3 power. *(write scientific notation)*

What about D? Why is D not in scientific notation? Possible Student Answers, Key Points:

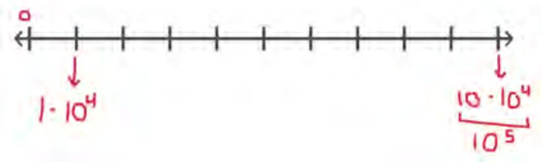
- At first glance it almost looks like it is in scientific notation, because it has two factors, one of which is an integer power of 10.
- It's not in scientific notation, because 62 is not between 1 and 10.

Let's shift digits so that the 62 becomes 6.2 This will also impact the power of 10. I can shift digits right one place value, or I can think of this change as moving the decimal left one place value. *(use arrows to show the shift)* Either way, we now have a leading factor of 6.2. Since we shifted our digits right one place, we'll increase the exponent by 1 to make sure the value of the entire number remains constant. *(write scientific notation)*

d. $62 \cdot 10^4 \quad 6.2 \times 10^5$

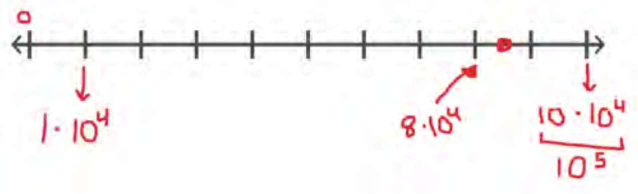
We just determined whether a set of numbers were in scientific notation or not. Those that weren't, we were able to use our understanding of powers of 10 to write them in scientific notation. We know that to be in scientific notation, the numbers must have a leading factor between 1 and 10 (inclusive of 1) and an integer power of 10.

Let's Think (Slide 5): One of the benefits of using scientific notation is that it can quickly tell us what place value the leading factor is in. This problem will help us see that. It wants us to use the number line to determine which two powers of 10 this number is between. We'll then plot the location of our number on the line.



I'll start by marking the first tick mark as 0, just to give us a starting point. *(label 0 at the first tick mark)* Our number is 8.5 times 10 to the 4 power. That means our number is in between 1 x 10 to the 4 power and 10 times 10 to the 4 power *(label the second tick mark and last tick mark accordingly)* Another way to think of 10 times 10 to the 4 power is as 10 to the 5 power. If you weren't sure about that, you could picture what 10 times 10 to the 4 power would look like expanded. *(use bracket to show that 10 times 10 to the 4 power is the same as 10 to the 5 power)*

We know that our number is somewhere between these two values. Essentially, our number is between 10,000 and 100,000. Let's count each tick mark to determine where to place 8.5 times 10 to the 4 power. The first tick mark is 1 times 10 to the 4 power. *(point to each tick mark as you count)* The next tick mark would be 2 times 10 to the 4 power, then 3 times 10 to the 4 power, then 4 times 10 to the 4 power, then 5 times 10 to the 4 power, then 6 times 10 to the 4 power, then 7 times 10 to the 4 power, then 8 times 10 to the 4 power, then 9 times 10 to the 4 power, and then our last tick mark is 10 times 10 to the 4 power.



The leading factor of 8.5 means that our number will between 8 and 9 times 10 to the 4 power. Since it's 8.5, I'll put a point directly between those two tick marks. *(mark a point as shown)* We were just able to use a number line to mark the location of a number in scientific notation between two powers of 10.

To recap a major takeaway from today, what criteria mean a number is written in scientific notation? Possible Student Answers, Key Points:

- It must be written as the product of two factors.
- One factor must be greater than or equal to 1, but less than 10. The other factor must be an integer power of 10.

Let's Try it (Slides 6 - 7): We'll practice some more together, and then you'll get a chance to show what you know about scientific notation independently. Scientific notation is helpful because it can quickly show us the place value of a large or small number. When we consider whether a number is in scientific notation or not, we'll want to identify a leading factor that is 1 or more, but less than 10. We'll also want to make sure the second factor is an integer power of 10. We've practiced a lot already, so I know you're ready to try some more scientific notation work. Let's go for it!

WARM WELCOME

Today we will identify numbers written in scientific notation, and rewrite numbers written in different forms in scientific notation.

Let's Talk:

What's the same? What's different?

75 billion

75,000,000,000

$750 \cdot 10^{8}$

$75 \cdot 10^{9}$

$7.5 \cdot 10^{10}$

Let's Think:

Is each number in scientific notation? If not, write it in scientific notation.

a. $3.1 \cdot 10^{8}$

b. 0.00945

c. $9 \cdot 10^{-7}$

d. $62 \cdot 10^{4}$

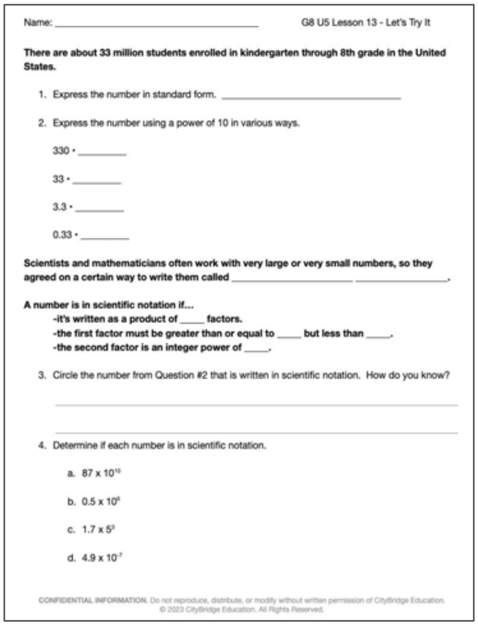
Let's Think:

Which two powers of 10 is the number between? Plot the number on the number line.

8.5×10^4

Let's Try It:

Let's explore identifying numbers written in scientific notation, and rewriting numbers written in different forms in scientific notation together.



Name: ____________________ G8 U5 Lesson 13 - Let's Try It

There are about 33 million students enrolled in kindergarten through 8th grade in the United States.

1. Express the number in standard form. ____________________
2. Express the number using a power of 10 in various ways.

330 • ________

33 • ________

3.3 • ________

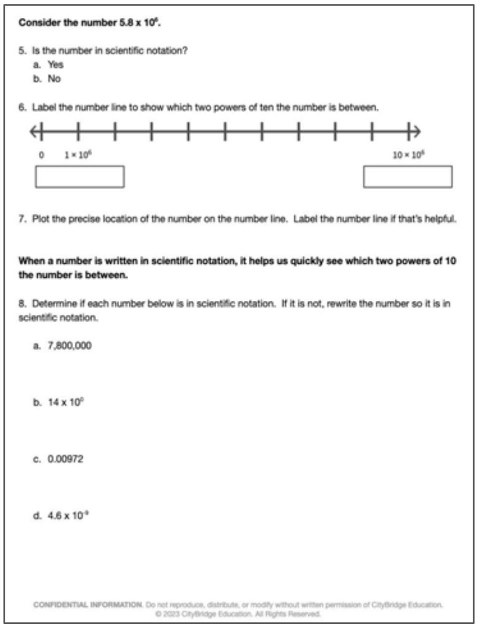
0.33 • ________

Scientists and mathematicians often work with very large or very small numbers, so they agreed on a certain way to write them called ____________ ____________.

A number is in scientific notation if...
-it's written as a product of _____ factors.
-the first factor must be greater than or equal to _____ but less than _____.
-the second factor is an integer power of _____.

3. Circle the number from Question #2 that is written in scientific notation. How do you know?

4. Determine if each number is in scientific notation.
   - a. 87×10^{10}
   - b. 0.5×10^{6}
   - c. 1.7×5^{3}
   - d. 4.9×10^{-7}



Consider the number 5.8×10^{6}.

5. Is the number in scientific notation?
   - a. Yes
   - b. No
6. Label the number line to show which two powers of ten the number is between.

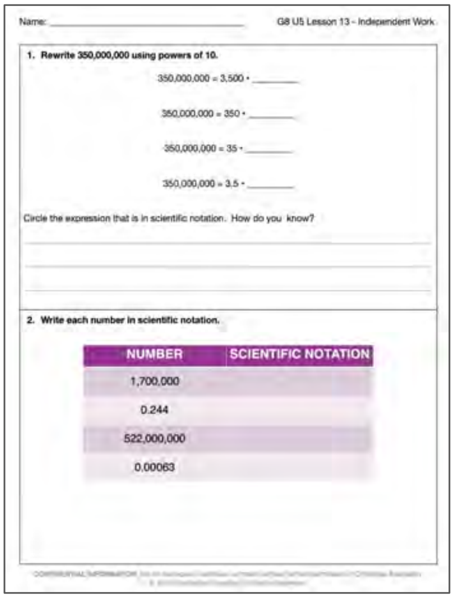
7. Plot the precise location of the number on the number line. Label the number line if that's helpful.

When a number is written in scientific notation, it helps us quickly see which two powers of 10 the number is between.

8. Determine if each number below is in scientific notation. If it is not, rewrite the number so it is in scientific notation.
   - a. 7,800,000
   - b. 14×10^{9}
   - c. 0.00972
   - d. 4.6×10^{-9}

On your Own:

Now it's time to identify numbers written in scientific notation, and rewrite numbers written in different forms in scientific notation on your own.



Name: ______________________ G8 U5 Lesson 13 - Independent Work

1. Rewrite 350,000,000 using powers of 10.

350,000,000 = 3,500 • ________

350,000,000 = 350 • ________

350,000,000 = 35 • ________

350,000,000 = 3.5 • ________

Circle the expression that is in scientific notation. How do you know?

2. Write each number in scientific notation.

NUMBER	SCIENTIFIC NOTATION
1,700,000	
0.244	
522,000,000	
0.00063	

3. Write each number in scientific notation.

NUMBER	SCIENTIFIC NOTATION
25×10^5	
0.44×10^3	
158×10^{-1}	

4. Sort the numbers below.

55×10^7 1.47×10^{-11} 8.83×10^3 27,000,000 0.0014

SCIENTIFIC NOTATION	NOT SCIENTIFIC NOTATION

Rewrite each value that was not written in scientific notation so that it is in scientific notation.

Name: ____ G8 U5 Lesson 13 - Let's Try It

There are about 33 million students enrolled in kindergarten through 8th grade in the United States.

1. Express the number in standard form. ___________________________________

2. Express the number using a power of 10 in various ways.

   330 • _________

   33 • _________

   3.3 • _________

   0.33 • _________

Scientists and mathematicians often work with very large or very small numbers, so they agreed on a certain way to write them called _______________________ __________________.

A number is in scientific notation if…

-it's written as a product of _____ factors.

-the first factor must be greater than or equal to _____ but less than _____.

-the second factor is an integer power of _____.

3. Circle the number from Question #2 that is written in scientific notation. How do you know?

   ____

   ____

4. Determine if each number is in scientific notation.

   a. 87×10^{10}

   b. 0.5×10^{6}

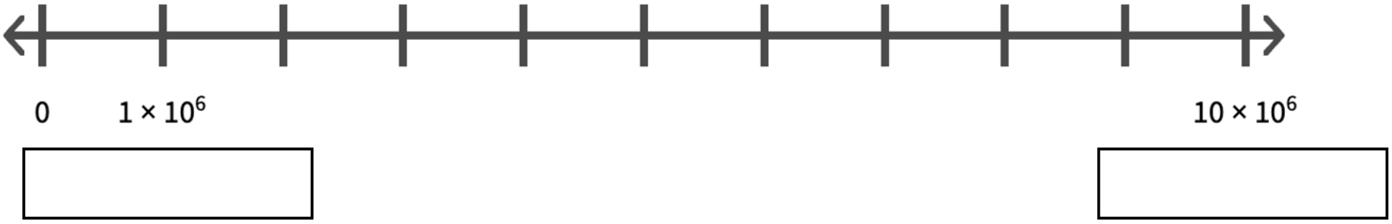
   c. 1.7×5^{3}

   d. 4.9×10^{-7}

Consider the number 5.8 x 10^6.

5. Is the number in scientific notation?
   a. Yes
   b. No

6. Label the number line to show which two powers of ten the number is between.



7. Plot the precise location of the number on the number line. Label the number line if that's helpful.

When a number is written in scientific notation, it helps us quickly see which two powers of 10 the number is between.

8. Determine if each number below is in scientific notation. If it is not, rewrite the number so it is in scientific notation.

   a. 7,800,000

   b. 14 x 10^0

   c. 0.00972

   d. 4.6 x 10^{-9}

Name: ______________________________________ G8 U5 Lesson 13 - Independent Work

1. Rewrite 350,000,000 using powers of 10.

350,000,000 = 3,500 • __________

350,000,000 = 350 • __________

350,000,000 = 35 • __________

350,000,000 = 3.5 • __________

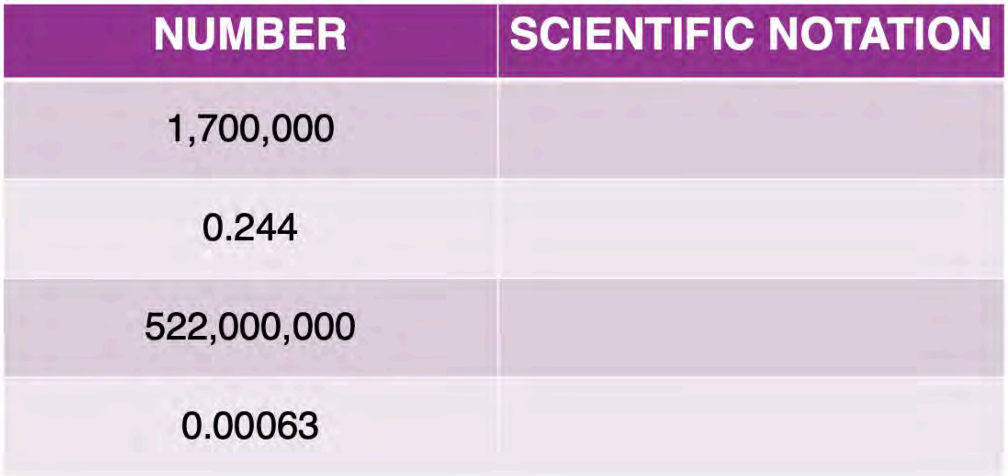
Circle the expression that is in scientific notation. How do you know?

____

____

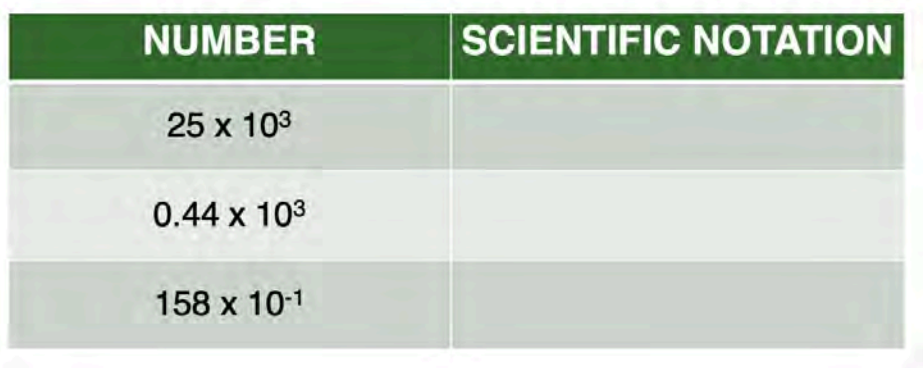
____

2. Write each number in scientific notation.



NUMBER	SCIENTIFIC NOTATION
1,700,000	
0.244	
522,000,000	
0.00063	

3. **Write each number in scientific notation.**



NUMBER	SCIENTIFIC NOTATION
25×10^3	
0.44×10^3	
158×10^{-1}	

4. **Sort the numbers below.**

55×10^7 | 1.47×10^{-11} | 8.83×10^3 | 27,000,000 | 0.0014

SCIENTIFIC NOTATION	NOT SCIENTIFIC NOTATION

Rewrite each value that was not written in scientific notation so that it is in scientific notation.

Name: KEY

There are about 33 million students enrolled in kindergarten through 8th grade in the United States.

1. Express the number in standard form. 33,000,000

2. Express the number using a power of 10 in various ways.

$330 \cdot 10^5$

$33 \cdot 10^6$

[✓ $3.3 \cdot 10^7$]

$0.33 \cdot 10^8$

Scientists and mathematicians often work with very large or very small numbers, so they agreed on a certain way to write them called scientific notation.

A number is in scientific notation if…

-it's written as a product of 2 **factors.**

-the first factor must be greater than or equal to 1 **but less than** 10**.**

-the second factor is an integer power of 10**.**

3. Circle the number from Question #2 that is written in scientific notation. How do you know?

3.3 is the only leading factor between 1 (inclusive) and 10.

4. Determine if each number is in scientific notation.

~~a.~~ 87×10^{10} NO

~~b.~~ 0.5×10^6 NO

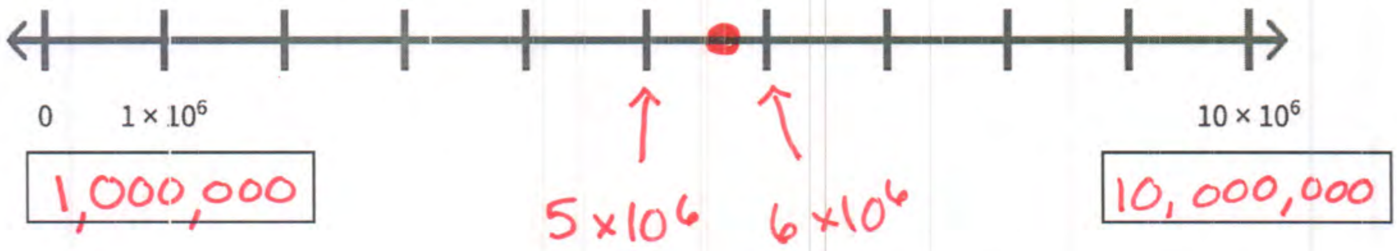
~~c.~~ 1.7×5^3 NO

[✓ d.] 4.9×10^{-7} YES!

Consider the number 5.8 x 10^6.

5. Is the number in scientific notation?
   - [✓ a. Yes]
   - b. No

6. Label the number line to show which two powers of ten the number is between.



7. Plot the precise location of the number on the number line. Label the number line if that's helpful.

When a number is written in scientific notation, it helps us quickly see which two powers of 10 the number is between.

8. Determine if each number below is in scientific notation. If it is not, rewrite the number so it is in scientific notation.

   a. 7,800,000
   NO
   7.8×10^6

   b. 14 x 10^0
   NO
   1.4×10^1

   c. 0.00972
   NO
   9.72×10^{-3}

   d. 4.6 x 10^{-9}
   ↖ in scientific notation

Name: KEY

1. Rewrite 350,000,000 using powers of 10.

350,000,000 = 3,500 • 10^{5}

350,000,000 = 350 • 10^{6}

350,000,000 = 35 • 10^{7}

[✓ 350,000,000 = 3.5 • 10^{8}]

Circle the expression that is in scientific notation. How do you know?

3.5 is greater than or equal to 1 and less than 10. Also, 10^8 is an integer power of 10.

2. Write each number in scientific notation.

NUMBER	SCIENTIFIC NOTATION
1,700,000	1.7×10^{6}
0.244	2.44×10^{-1}
522,000,000	5.22×10^{8}
0.00063	6.3×10^{-4}

3. Write each number in scientific notation.

NUMBER	SCIENTIFIC NOTATION
25×10^{3}	2.5×10^{4}
0.44×10^{3}	4.4×10^{2}
158×10^{-1}	1.58×10^{1}

4. Sort the numbers below.

55×10^{7} | 1.47×10^{-11} | 8.83×10^{3} | 27,000,000 | 0.0014

SCIENTIFIC NOTATION	NOT SCIENTIFIC NOTATION
1.47×10^{-11}	55×10^{7}
8.83×10^{3}	27,000,000
	0.0014

Rewrite each value that was not written in scientific notation so that it is in scientific notation.

$55 \times 10^{7} \downarrow \boxed{5.5 \times 10^{8}}$

$27,000,000 \downarrow \boxed{2.7 \times 10^{7}}$

$0.0014 \downarrow \boxed{1.4 \times 10^{-3}}$

G8 U5 Lesson 14
Multiply and divide numbers in scientific notation, and use scientific notation and estimation to compare quantities.

CITYTUTOR DC

G8 U5 Lesson 14 - Students will multiply and divide numbers in scientific notation, and use scientific notation and estimation to compare quantities.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): In our previous lesson, we explored scientific notation. Scientific notation is an agreed upon method for representing large or small numbers that many professionals use. What criteria must a number meet in order to be considered in scientific notation?
Possible Student Answers, Key Points:

- It must be written as the product of two factors.
- One factor must be greater than or equal to 1, but less than 10. The other factor must be an integer power of 10.

Today we will continue our work with scientific notation. Specifically, we will multiply and divide with numbers in scientific notation and see numbers in scientific notation used in comparison contexts.

Let's Talk (Slide 3): The table below shows the number of red, blue, and yellow marbles used to make an art project. After taking a quick glance at the table, why might it be challenging to compare the values? Possible Student Answers, Key Points:

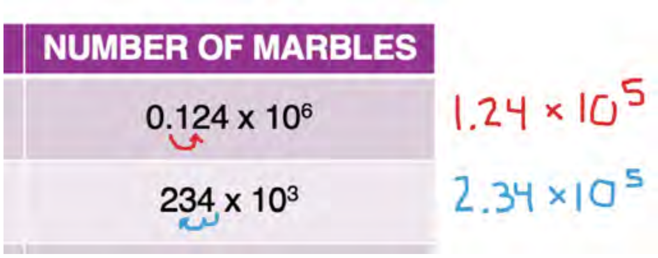
- They each have different exponents.
- Some leading factors are decimals and some are whole numbers.

What do you think we could do with the numbers to make them a bit easier to compare and work with?
Possible Student Answers, Key Points:

- We could write them all in standard form.
- We could write them all in scientific notation.
- We could get them all to have the same power of 10.

Getting each number in the same form would help us more easily compare and operate with these numbers. Let's keep that in mind as we answer some questions about the marbles in this art project.

Let's Think (Slide 4): The first problem we have wants us to compare the number of blue marbles to the number of red marbles. It wants to know *approximately* how many times more blue marbles there are than red marbles. To help us compare and calculate, let's write each in scientific notation.



NUMBER OF MARBLES	
0.124×10^6	1.24×10^5
234×10^3	2.34×10^5

I'll start with the number of red marbles. *(use arrows to show shifting)* If I shift the digits over one place left, I end up with 1.24 as a leading factor. Since I shifted the digits one place left, I'll adjust the exponent by decreasing it 1. 1.24 times 10 to the 5 power is now in scientific notation. *(rewrite number in scientific notation)*

What about the blue marbles? How can I write that number in scientific notation? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- We can shift the digits to the right two place values, so the leading factor is 2.34. Since we shifted the digits two places right, we can increase the exponent by 2.
- 234 times 10 to the 3 power can be written as 2.34 times 10 to the 5 power.

Our numbers are in scientific notation. They're in the same form. As written, the leading factors still are not really compatible or easy to work with. Since this problem allows us to estimate, I'll make them a little easier by thinking of the leading factor of the blue marbles as just 2 and the leading factor of the red marbles as just 1.

$$\frac{2 \times 10^5}{1 \times 10^5}$$

$$2 \times 1$$

②

(write a ratio in fraction form with the estimated values) To compare, I'll use this ratio written in fraction form using the estimated values we found. We know that from here, we can divide the leading factors and then divide the powers of 10. What would that look like mathematically? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- The leading factors are 2 and 1. 2 divided by 1 is 2.
- The powers of 10 would cancel out. The same numerator and denominator always results in a value of 1.

We end up with an approximate answer of 2. This means there are about 2 times as many blue marbles as red marbles. We were able to use scientific notation and estimation to help us find our approximate answer.

Let's Think (Slide 5): The next problem is similar, but now we're comparing the red marbles to the yellow marbles. Since we've already done a related example, I might ask you for a bit more support thinking through this one.

406×10^1 $\quad 4.06 \times 10^3$

To start comparing, let's think of the yellow marbles as a number in scientific notation. How can I write 406 times 10 to the 1 power in scientific notation? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- Shift the digits in 406 two place values right. We can also think of this as shifting the decimal two places left.
- Since we shifted 406 to make it 4.06, we'll add two to the exponent to make it 10 to the 3 power.

The number of yellow marbles written in scientific notation is 4.06 times 10 to the 3. We already know that the number of red marbles in scientific notation is 1.24 times 10 to the 5 power. Since we're estimating, I'll use 4 and 1.2 as the leading factors since they're fairly compatible.

$$\frac{1.2 \times 10^5}{4 \times 10^3}$$

$$0.3 \times 10^2$$

㉚

From here, we can set up a ratio to compare the red marbles to the yellow marbles. *(write as you narrate)* I'll write the approximate number of red marbles in scientific notation in the numerator and the approximate number of yellow marbles in scientific notation in the denominator. How can I divide these values? *(write as student shares)* Possible Student Answers, Key Points:

- If we divide the leading factors we can think about 1.2 divided by 4. I know 12 tenths divided by 4 is 3 tenths, or 0.3.
- We can divide the powers of 10 by subtracting the exponents. We'd end up with 10 to the 2 power.

When we divide the leading factors, we end up with 0.3. When we divide the powers of 10, we end up with 10 to the 2 power. 0.3 times 10 to the 2 power is equivalent to 30. What does that answer mean in the context of this problem? Possible Student Answers, Key Points:

- There are approximately 30 times more red marbles than yellow marbles used in the art project.

We just used estimation and scientific notation to determine that the amount of red marbles is about 30 times as much as the amount of yellow marbles. Nice work!

Let's Try it (Slides 6 - 7): It's time to collaborate on a few more problems before you have the opportunity to work independently and show what you've learned. When multiplying and dividing large or small numbers, we've seen it is helpful to write them all in scientific notation. Numbers in the same form are often easier to work with. Numbers in the same form are often easier to compare. Once we have numbers represented in scientific notation, we can efficiently use exponent rules to multiply or divide. Remember though, a number is only in scientific notation if one factor is greater than or equal to 1 and less than 10, and the other factor is an integer power of 10. Let's look at the next examples.

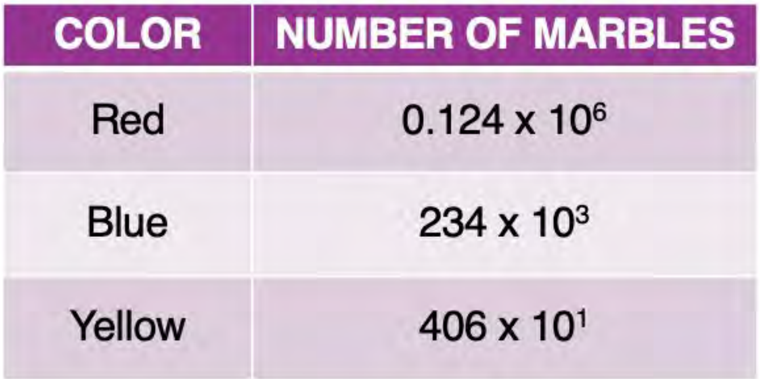
WARM WELCOME

Today we will multiply and divide numbers in scientific notation, and use scientific notation and estimation to compare quantities.

Let's Talk:

Red, blue, and yellow marbles were made to create an art piece.

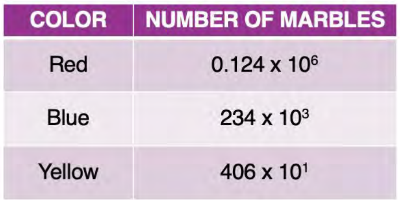
What makes the values difficult to compare?



COLOR	NUMBER OF MARBLES
Red	0.124×10^6
Blue	234×10^3
Yellow	406×10^1

Let's Think:

Approximately how many times more blue marbles are there than red marbles?



COLOR	NUMBER OF MARBLES
Red	0.124×10^6
Blue	234×10^3
Yellow	406×10^1

Let's Think:

Approximately how many times more red marbles are there than yellow marbles?

COLOR	NUMBER OF MARBLES
Red	0.124×10^6
Blue	234×10^3
Yellow	406×10^1

Let's Try It:

Let's explore multiplying and dividing numbers in scientific notation, and using scientific notation and estimation to compare quantities together.

Name: ______________________ G8 U5 Lesson 14 – Let's Try It

The number of animals in a country is shared in the table below.

1. What makes it difficult to compare the animal populations as listed?

2. Rewrite each number in scientific notation.

DEER:

SQUIRREL:

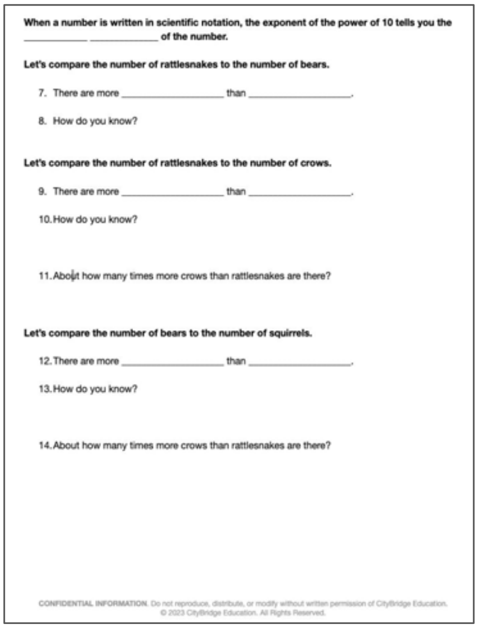
BEAR:

CROW:

RATTLESNAKE:

When the numbers are in scientific notation, it is easier to compare them. Let's compare the number of rattlesnakes to the number of squirrels.

3. What is the number of rattlesnakes in standard form?
4. What is the number of squirrels in standard form?
5. Which is greater? Sketch a place value chart, if that's helpful.
6. How can you use scientific notation to help compare the number of rattlesnakes to the number of squirrels?



When a number is written in scientific notation, the exponent of the power of 10 tells you the ____________ ____________ of the number.

Let's compare the number of rattlesnakes to the number of bears.

7. There are more __________________ than __________________.
8. How do you know?

Let's compare the number of rattlesnakes to the number of crows.

9. There are more __________________ than __________________.
10. How do you know?
11. About how many times more crows than rattlesnakes are there?

Let's compare the number of bears to the number of squirrels.

12. There are more __________________ than __________________.
13. How do you know?
14. About how many times more crows than rattlesnakes are there?

On your Own:

Now it’s time to multiply and divide numbers in scientific notation, and use scientific notation and estimation to compare quantities on your own.

Name: ______________________ G8 U5 Lesson 14 - Independent Work

1. **Sort the numbers below.**

2.03×10^4 | 0.00084 | 5×10^{-4} | 564.8×10^5

SCIENTIFIC NOTATION	NOT SCIENTIFIC NOTATION

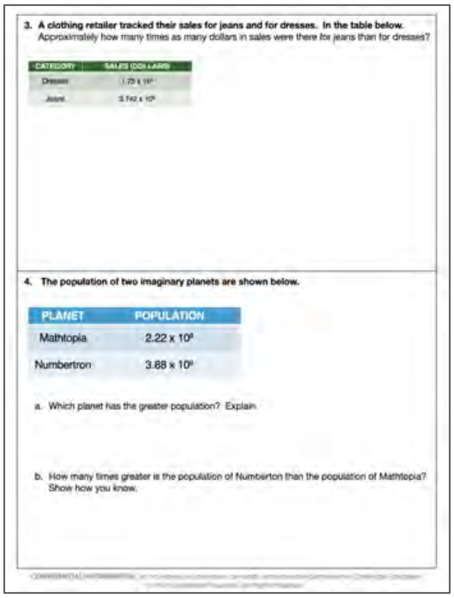
Rewrite each value that was not written in scientific notation so that it is in scientific notation.

2. **Look at the table below.**

a. Did Tasty Donuts or Scrumptious Donut Company sell more donuts? How do you know?

b. Did Amazing Donut Factory or Yum Yum Donuts sell more donuts? How do you know?

COMPANY	[illegible]
Donut Delight	[illegible]
Tasty Donuts	[illegible]
Amazing Donut Factory	[illegible]
Scrumptious Donut Company	[illegible]
Yum Yum Donuts	[illegible]



3. **A clothing retailer tracked their sales for jeans and for dresses. In the table below.** Approximately how many times as many dollars in sales were there for jeans than for dresses?

CATEGORY	SALES (DOLLARS)
Dresses	[illegible]
Jeans	[illegible]

4. **The population of two imaginary planets are shown below.**

PLANET	POPULATION
Mathtopia	2.22×10^8
Numbertron	3.88×10^9

a. Which planet has the greater population? Explain

b. How many times greater is the population of Numberton than the population of Mathtopia? Show how you know.

The number of animals in a country is shared in the table below.

ANIMAL	NUMBER IN COUNTRY
Deer	0.206×10^6
Squirrel	234×10^4
Bear	506×10^3
Crow	1,160,000
Rattlesnake	41,500

1. What makes it difficult to compare the animal populations as listed?

2. Rewrite each number in scientific notation.

DEER:

SQUIRREL:

BEAR:

CROW:

RATTLESNAKE:

When the numbers are in scientific notation, it is easier to compare them. Let’s compare the number of rattlesnakes to the number of squirrels.

3. What is the number of rattlesnakes in standard form?

4. What is the number of squirrels in standard form?

5. Which is greater? Sketch a place value chart, if that’s helpful.

6. How can you use scientific notation to help compare the number of rattlesnakes to the number of squirrels?

When a number is written in scientific notation, the exponent of the power of 10 tells you the ____________ _____________ of the number.

Let's compare the number of rattlesnakes to the number of bears.

7. There are more ____________________ than ____________________.
8. How do you know?

Let's compare the number of rattlesnakes to the number of crows.

9. There are more ____________________ than ____________________.
10. How do you know?

11. About how many times more crows than rattlesnakes are there?

Let's compare the number of bears to the number of deer.

12. There are more ____________________ than ____________________.
13. How do you know?

14. About how many times more bear than deer are there?

Name: ____

1. Sort the numbers below.

2.03×10^4 0.00084 5×10^{-3} 564.8×10^8

SCIENTIFIC NOTATION	NOT SCIENTIFIC NOTATION

Rewrite each value that was not written in scientific notation so that it is in scientific notation.

2. Look at the table below.

a. Did Tasty Donuts or Scrumptious Donut Company sell more donuts? How do you know?

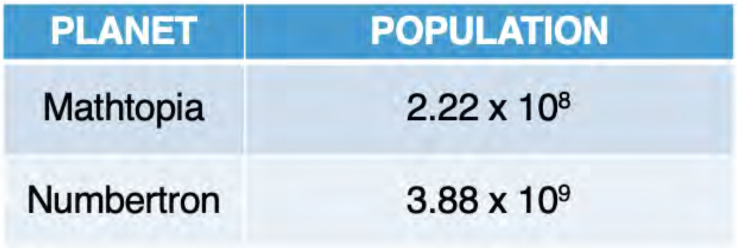
b. Did Amazing Donut Factory or Yum Yum Donuts sell more donuts? How do you know?

COMPANY	NUMBER OF DONUTS SOLD
Donut Delight	6.1×10^3
Tasty Donuts	8.3×10^4
Amazing Donut Factory	2.2×10^4
Scrumptious Donut Company	6.4×10^3
Yum Yum Donuts	5.9×10^4

3. **A clothing retailer tracked their sales for jeans and for dresses in the table below.** Approximately how many times as many dollars in sales were there for jeans than for dresses?

CATEGORY	SALES (DOLLARS)
Dresses	1.75 x 10^9
Jeans	3.742 x 10^8

4. **The population of two imaginary planets are shown below.**



PLANET	POPULATION
Mathtopia	2.22 x 10^8
Numbertron	3.88 x 10^9

a. Which planet has the greater population? Explain.

b. How many times greater is the population of Numberton than the population of Mathtopia? Show how you know.

Name: KEY

The number of animals in a country is shared in the table below.

ANIMAL	NUMBER IN COUNTRY
Deer	0.206×10^6
Squirrel	234×10^4
Bear	506×10^3
Crow	1,160,000
Rattlesnake	41,500

1. What makes it difficult to compare the animal populations as listed?

The numbers are in different forms.

2. Rewrite each number in scientific notation.

DEER: 2.06×10^5

SQUIRREL: 2.34×10^6

BEAR: 5.06×10^5

CROW: 1.16×10^6

RATTLESNAKE: 4.15×10^4

When the numbers are in scientific notation, it is easier to compare them. Let's compare the number of rattlesnakes to the number of squirrels.

3. What is the number of rattlesnakes in standard form? 41,500

4. What is the number of squirrels in standard form? 2,340,000

5. Which is greater? Sketch a place value chart, if that's helpful.

The number of squirrels is greater.

6. How can you use scientific notation to help compare the number of rattlesnakes to the number of squirrels?

2.34×10^6 4.15×10^4

↑ squirrels have a greater power of 10

When a number is written in scientific notation, the exponent of the power of 10 tells you the place value **of the number.**

Let's compare the number of rattlesnakes to the number of bears.

7. There are more bears than rattlesnakes.

8. How do you know?

$10^5 > 10^4$

Let's compare the number of rattlesnakes to the number of crows.

9. There are more crows than rattlesnakes.

10. How do you know?

$10^6 > 10^4$

11. About how many times more crows than rattlesnakes are there?

$\frac{1.2 \times 10^6}{4 \times 10^4}$ 0.3×10^2 30

Let's compare the number of bears to the number of deer **~~squirrels.~~**

12. There are more bears than deer.

13. How do you know?

5.06 > 2.06

14. About how many times more bear ~~crows~~ than deer ~~rattlesnakes~~ are there?

$\frac{5 \times 10^5}{2 \times 10^5}$

2.5×1 2.5

Name: KEY

1. Sort the numbers below.

2.03×10^4	0.00084	5×10^{-3}	564.8×10^8

SCIENTIFIC NOTATION	NOT SCIENTIFIC NOTATION
2.03×10^4	0.00084
5×10^{-3}	564.8×10^8

Rewrite each value that was not written in scientific notation so that it is in scientific notation.

$$0.00084 \downarrow \boxed{8.4 \times 10^{-4}}$$

$$564.8 \times 10^8 \downarrow \boxed{5.648 \times 10^{10}}$$

2. Look at the table below.

COMPANY	NUMBER OF DONUTS SOLD
Donut Delight	6.1×10^3
Tasty Donuts	8.3×10^4
Amazing Donut Factory	2.2×10^4
Scrumptious Donut Company	6.4×10^3
Yum Yum Donuts	5.9×10^4

a. Did Tasty Donuts or Scrumptious Donut Company sell more donuts? How do you know?

Tasty Donuts

$10^4 > 10^3$

b. Did Amazing Donut Factory or Yum Yum Donuts sell more donuts? How do you know?

Yum Yum

$5.9 > 2.2$

3. **A clothing retailer tracked their sales for jeans and for dresses. In the table below.** Approximately how many times as many dollars in sales were there for jeans than for dresses?

CATEGORY	SALES (DOLLARS)
Dresses	1.75×10^9
Jeans	3.742×10^8

$$\frac{3.742 \times 10^8}{1.75 \times 10^9}$$

$$\frac{4 \times 10^8}{2 \times 10^9}$$

$$2 \times 10^{-1}$$

$$\boxed{0.2}$$

4. **The population of two imaginary planets are shown below.**

PLANET	POPULATION
Mathtopia	2.22×10^8
Numbertron	3.88×10^9

a. Which planet has the greater population? Explain.

Numbertron has more people.

$10^9 > 10^8$

b. How many times greater is the population of Numberton than the population of Mathtopia? Show how you know.

$$\frac{4 \times 10^9}{2 \times 10^8} \rightarrow 2 \times 10^1 \rightarrow \boxed{20}$$

G8 U5 Lesson 15
Add and subtract numbers in scientific notation.

CITYTUTOR DC

G8 U5 Lesson 15 - Students will add and subtract numbers in scientific notation.

Warm Welcome (Slide 1): Tutor choice

Frame the Learning/Connect to Prior Learning (Slide 2): Today is our final lesson in our unit all about exponents and scientific notation. We've learned a lot. What important things stand out to you from all of our lessons so far? Possible Student Answers, Key Points:

- Writing exponential expressions in expanded form can often help us see and manipulate all the factors.
- When we multiply factors with the same base, we can add the exponents. When we divide factors with the same base, we can subtract the exponents. When we take a power to a power, we can multiply the exponents. A negative exponent is like repeated multiplication of the reciprocal of the base.
- Exponents and powers of 10 can help us write really big and really small numbers.
- A number is in scientific notation if the first factor is greater than or equal to 1, but less than 10, and the second factor is an integer power of 10.

We have really learned a lot. For our final lesson of this unit, we'll focus on scientific notation. Today, we'll add and subtract numbers in scientific notation.

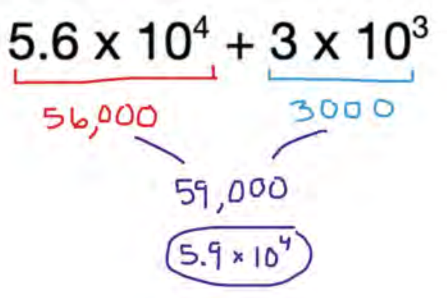
Let's Talk (Slide 3): Take a look at the two expressions here. They're both written in unit form. Which problem do you feel is more efficient to add, and why? Possible Student Answers, Key Points:

- I think the first one is more efficient to add, because it's easy to add like units.
- The first example adds thousands plus thousands. That's easy mental math for me. It's at least easier to do in my head than adding thousands and ten thousands.

The first example is easy to mentally compute. 67 thousands plus 4 more thousands is just 71 thousands.

When adding and subtracting, it's often easier to manipulate like units. This is true for fractions. It's true for decimals. It's true for whole numbers. When we have like units, it's easy to combine or take away quantities. As we work with adding and subtracting expressions in scientific notation, we'll see that this holds true If we have numbers with the same power of 10, it can make computing the sum or difference much easier.

Let's Think (Slide 4): Our first problem wants us to find the sum of the two numbers that are written in scientific notation. One arguably less efficient way to find the sum is just to rewrite the numbers in standard form. Let's start by doing that, and then I'll show you another way that you might find easier.



(write as you narrate) I can think of 5.6 times 10 to the 4 power as 56,000 in standard form. I know, because I can shift each digit four place values left. I can think of 3 times 10 to the 3 power as being 3,000 in standard form. I know, because I can shift each digit 3 place values left. If I add 56,000 and 3,000, I end up with 59,000.

The prompt requires me to write my answer in scientific notation. If I shift the digits in 59,000 to the right 4 place values, I end up with 5.9 times 10 to the 4 power.

This process wasn't overly challenging. We know how to do each part of the process from previous lessons. The downside is that I had to convert both numbers *out* of scientific notation, and then I had to convert the sum back *into* scientific notation. Let's explore a way we can do this without having to change the form of our addends nearly as much.

Instead of rewriting everything, I can make this problem easier by changing one of the addends so that the powers of 10 are consistent throughout the problem. Let's change 3 times 10 to the 3 power so it has a matching power of 10 to the first addend. How can I do that? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- We can shift 3 one place value right, and increase the exponent by 1.
- I know 3 times 10 to the 3 power is equivalent to 0.3 times 10 to the 4 power.

$$5.6 \times 10^4 + \underbrace{3 \times 10^3}_{0.3 \times 10^4}$$

$$5.9 \times 10^4$$

We now are combining addends with the same power of 10. Essentially, we're combining addends with the same unit. The unit is 10 to the 4 power or ten thousands. All we have to do now is add the leading factors. 5.6 ten thousands plus 0.3 ten thousands would be 5.9 ten thousands. We can add the leading factors, and the power of 10 remains the same. We end up with a sum of 5.9 times 10 to the 4 power. *(write answer)*

To add expressions in scientific notation, we can either rewrite them in standard form and then convert them back to scientific notation, or we can make our addends have a consistent power of 10 so we can add the leading factors easily. Either way works, and you might find you switch up your strategy depending on the numbers in a given problem. Let's look at one more example.

Let's Think (Slide 5): This problem is similar, but now we're being asked to subtract. Again, we can always write our numbers in standard form to add or subtract. Let's try that out, and then we'll try the strategy where we rewrite the powers of 10.

$$\underbrace{9.1 \times 10^4}_{91{,}000} - \underbrace{2.44 \times 10^3}_{2{,}440}$$

$$88560$$

$$\boxed{8.856 \times 10^4}$$

How can I write each number in this problem in standard form? *(write as student shares, supporting as needed)* Possible Student Answers, Key Points:

- 9.1 times 10 to the 4 power is equivalent to 91,000.
- 2.44 times 10 to the 3 power is 2,440.

When we subtract 91,000 minus 2,440, we get a difference of 88,560. One downside to this strategy is that our answer doesn't end up in scientific notation like was asked. If we shift each digit 4 place values right, we end up with an answer of 8.856 times 10 to the 4 power. *(write answer)*

$$9.1 \times 10^4 - \underbrace{2.44 \times 10^3}_{0.244 \times 10^4}$$

$$\boxed{8.856 \times 10^4}$$

Let's try the same problem, but now we'll adjust the powers of 10 rather than rewrite the numbers in standard form. I'll change 2.44 times 10 to the 3 power so it is written to the power of 4. I can shift the digits one place value right, then rewrite it as 0.244 times 10 to the 4 power. *(rewrite subtrahend as stated)* Now we have the same power of 10, which is like having the same unit. If I subtract the leading factors, 9.1 minus 0.244 is 8.856, and the power of 10 remains constant. 9.1 ten thousands minus 0.244 ten thousands is 8.856 ten thousands. We can write that as 8.856 times 10 to the 4. *(write answer)*

Of the two strategies we've explored to add or subtract numbers in scientific notation, which do you prefer and why? Possible Student Answers, Key Points:

- I like changing the powers of 10 to be the same, because then all I have to do is focus primarily on the leading factors.

- I like changing the powers of 10 to be the same, because sometimes writing really big or really small numbers in standard form can be tedious.
- I like converting the numbers to standard form, because I feel more comfortable adding and subtracting in standard from.

As we practice more problems, you’re welcome to choose either strategy.

Let’s Try it (Slides 6 - 7): Let’s work on a few more problems involving addition and subtraction with quantities in scientific notation. As we saw from our previous examples, we’ll want to make sure our values use the same power of 10 if we are working with exponents. We can also rewrite numbers in standard form if that’s helpful, but it does leave room for error and can be a cumbersome process in certain problems. Let’s keep these previous examples in mind as we tackle a few more. As always, you’ll get a chance to show what you know independently once we’re finished.

WARM WELCOME

Today we will add and subtract in scientific notation.

Let's Talk:

Which is more efficient to add? Why?

67 thousands + 4 thousands

67 thousands + 4 ten thousands

Let's Think:

Determine the sum in scientific notation.

$$5.6 \times 10^4 + 3 \times 10^3$$

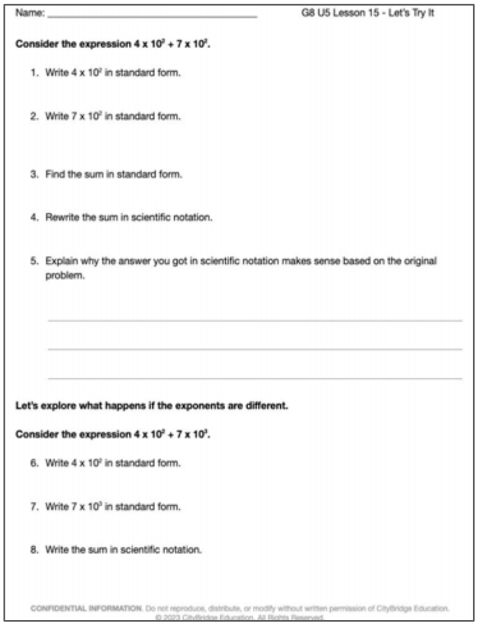
Let's Think:

Determine the difference in scientific notation.

$$9.1 \text{ x } 10^4 - 2.44 \text{ x } 10^3$$

Let's Try It:

Let's explore adding and subtracting in scientific notation together.



Name: ______________________ G8 U5 Lesson 15 - Let's Try It

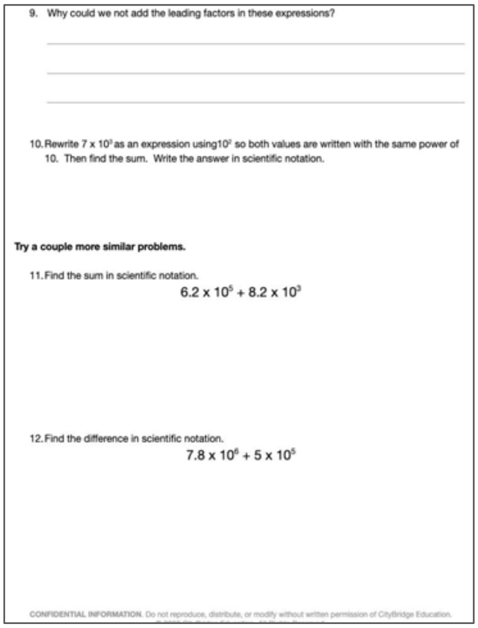
Consider the expression $4 \text{ x } 10^2 + 7 \text{ x } 10^2$.

1. Write $4 \text{ x } 10^2$ in standard form.
2. Write $7 \text{ x } 10^2$ in standard form.
3. Find the sum in standard form.
4. Rewrite the sum in scientific notation.
5. Explain why the answer you got in scientific notation makes sense based on the original problem.

Let's explore what happens if the exponents are different.

Consider the expression $4 \text{ x } 10^2 + 7 \text{ x } 10^3$.

6. Write $4 \text{ x } 10^2$ in standard form.
7. Write $7 \text{ x } 10^3$ in standard form.
8. Write the sum in scientific notation.



9. Why could we not add the leading factors in these expressions?

10. Rewrite $7 \text{ x } 10^3$ as an expression using10^2 so both values are written with the same power of 10. Then find the sum. Write the answer in scientific notation.

Try a couple more similar problems.

11. Find the sum in scientific notation.

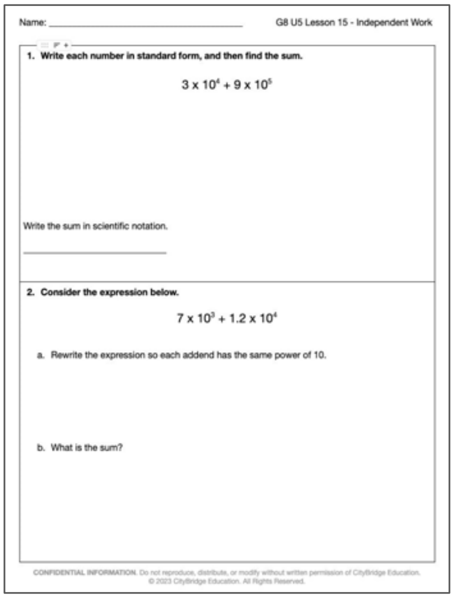
$$6.2 \text{ x } 10^5 + 8.2 \text{ x } 10^3$$

12. Find the difference in scientific notation.

$$7.8 \text{ x } 10^6 + 5 \text{ x } 10^5$$

On your Own:

Now it’s time to add and subtract in scientific notation on your own.



Name: ______________________ G8 U5 Lesson 15 - Independent Work

1. Write each number in standard form, and then find the sum.

$3 \times 10^4 + 9 \times 10^5$

Write the sum in scientific notation.

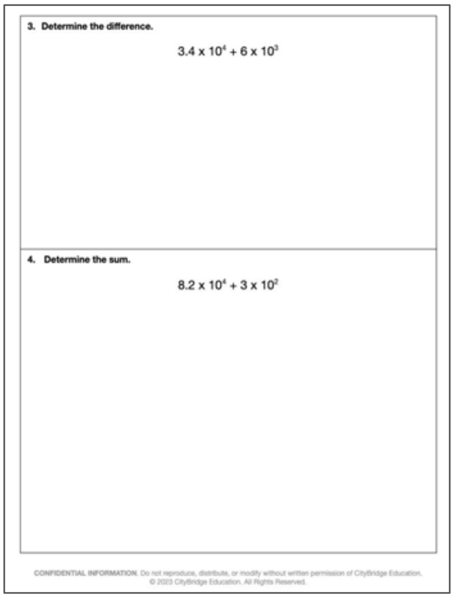
____

2. Consider the expression below.

$7 \times 10^3 + 1.2 \times 10^4$

a. Rewrite the expression so each addend has the same power of 10.

b. What is the sum?



3. Determine the difference.

$3.4 \times 10^4 + 6 \times 10^3$

4. Determine the sum.

$8.2 \times 10^4 + 3 \times 10^2$

Name: ____ G8 U5 Lesson 15 - Let’s Try It

Consider the expression 4 x 10^2 + 7 x 10^2.

1. Write 4 x 10^2 in standard form.

2. Write 7 x 10^2 in standard form.

3. Find the sum in standard form.

4. Rewrite the sum in scientific notation.

5. Explain why the answer you got in scientific notation makes sense based on the original problem.

____

____

____

Let’s explore what happens if the exponents are different.

Consider the expression 4 x 10^2 + 7 x 10^3.

6. Write 4 x 10^2 in standard form.

7. Write 7 x 10^3 in standard form.

8. Write the sum in scientific notation.

9. Why could we not add the leading factors in these expressions?

10. Rewrite 7×10^3 as an expression using 10^2 so both values are written with the same power of 10. Then find the sum. Write the answer in scientific notation.

Try a couple more similar problems.

11. Find the sum in scientific notation.

$$6.2 \times 10^5 + 8.2 \times 10^3$$

12. Find the difference in scientific notation.

$$7.8 \times 10^6 + 5 \times 10^5$$

Name: ____ G8 U5 Lesson 15 - Independent Work

1. **Write each number in standard form, and then find the sum.**

$$3 \text{ x } 10^4 + 9 \text{ x } 10^5$$

Write the sum in scientific notation.

____

2. **Consider the expression below.**

$$7 \text{ x } 10^3 + 1.2 \text{ x } 10^4$$

   a. Rewrite the expression so each addend has the same power of 10.

   b. What is the sum?

3. Determine the difference.

$$3.4 \text{ x } 10^4 - 6 \text{ x } 10^3$$

4. Determine the sum.

$$8.2 \text{ x } 10^4 + 3 \text{ x } 10^2$$

Name: KEY

G8 U5 Lesson 15 - Let's Try It

Consider the expression $4 \times 10^2 + 7 \times 10^2$.

1. Write 4×10^2 in standard form.

   400

2. Write 7×10^2 in standard form.

   700

3. Find the sum in standard form.

   $400 + 700 = 1{,}100$

4. Rewrite the sum in scientific notation.

   1.1×10^3

5. Explain why the answer you got in scientific notation makes sense based on the original problem.

   If we added the original leading factors, we'd have 11×10^2 which is equivalent to 1.1×10^3.

Let's explore what happens if the exponents are different.

Consider the expression $4 \times 10^2 + 7 \times 10^3$.

6. Write 4×10^2 in standard form.

   400

7. Write 7×10^3 in standard form.

   7000

8. Write the sum in scientific notation.

   $7{,}400 \rightarrow 7.4 \times 10^3$

9. Why could we not add the leading factors in these expressions?

They didn't have the same power of 10. It would be like adding values of different units.

10. Rewrite 7×10^3 as an expression using 10^2 so both values are written with the same power of 10. Then find the sum. Write the answer in scientific notation.

$$(70 \times 10^2) + (4 \times 10^2)$$

$$74 \times 10^2 = \boxed{7.4 \times 10^3}$$

Try a couple more similar problems.

11. Find the sum in scientific notation.

$$6.2 \times 10^5 + 8.2 \times 10^3$$

$$620 \times 10^3 \qquad 8.2 \times 10^3$$

$$628.2 \times 10^3$$

$$\boxed{6.282 \times 10^5}$$

12. Find the difference in scientific notation.

$$7.8 \times 10^6 + 5 \times 10^5$$

$$(7.8 \times 10^6) + (0.5 \times 10^6)$$

$$\boxed{8.3 \times 10^6}$$

Name: KEY

G8 U5 Lesson 15 - Independent Work

1. Write each number in standard form, and then find the sum.

$$3 \times 10^4 + 9 \times 10^5$$

30,000 + 900,000

930,000

Write the sum in scientific notation.

$\boxed{9.3 \times 10^5}$

2. Consider the expression below.

$$7 \times 10^3 + 1.2 \times 10^4$$

a. Rewrite the expression so each addend has the same power of 10.

$0.7 \times 10^4 + 1.2 \times 10^4$

b. What is the sum?

$\boxed{1.9 \times 10^4}$

3. Determine the difference.

$$3.4 \times 10^4 - 6 \times 10^3$$

$$3.4 \times 10^4 - 0.6 \times 10^4$$

$$\boxed{2.8 \times 10^4}$$

4. Determine the sum.

$$8.2 \times 10^4 + 3 \times 10^2$$

$$8,2 \times 10^4 + 0.03 \times 10^4$$

$$\boxed{8,23 \times 10^4}$$