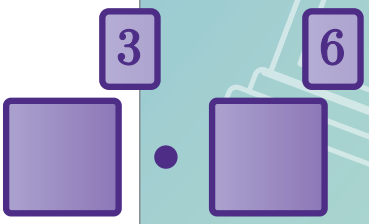


Unit 7

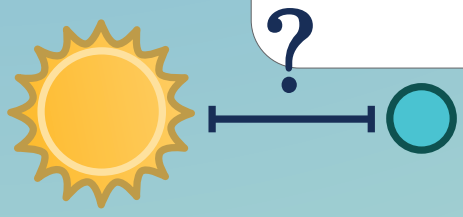
Exponents and Scientific Notation

Numbers and operations with numbers can be represented in many different ways. How can you represent very large or very small numbers? How can you work with these numbers? In this unit, you will see how exponents, properties of exponents, and powers of 10 will be used to solve problems involving scales, city lights, and net worth.



Essential Questions

- How can you use the properties of exponents to make connections between expressions?
- What is scientific notation and how can it be used to represent small and large numbers?



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Summary | Lesson 1

Expressions with *exponents* are useful for representing repeated multiplication. In the expression 3^5, 5 is the exponent. When the exponent is a positive integer, it says how many times the number or expression is multiplied.

For example, $3^5 = \underbrace{3 \cdot 3 \cdot 3 \cdot 3 \cdot 3}_{5 \text{ times}}$. Imagine writing 3^{100} using multiplication!

Here are a few more examples:

- $7 \cdot 7 \cdot 7 \cdot 7 \cdot 7 = 7^5$
- $5 \cdot 8 \cdot 5 \cdot 8 \cdot 5 \cdot 8 \cdot 5 = 5^4 \cdot 8^3$
- $10 \cdot 10 \cdot 10 + 10 \cdot 10 = 10^3 + 10^2$

Try This

You have some rice, and each day the number of grains of rice doubles. On day one, you have 2 grains of rice. On day two, you have 4 grains of rice.

a A classmate wrote the expression $2 + 2 + 2$ to represent the amount of rice on day three. Do you agree with your classmates' expression? Explain your thinking.

b Write an expression and find the amount of rice you will have after seven days.

Summary | Lesson 2

Expanding is one strategy for determining if expressions with exponents are equivalent.

Here are two **powers of ten** that are equivalent to 10^8. Each expression can be expanded to "$10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$."

- $10^5 \cdot 10^3 = (10 \cdot 10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10) = 10^8$
- $(10^2)^4 = (10 \cdot 10) \cdot (10 \cdot 10) \cdot (10 \cdot 10) \cdot (10 \cdot 10) = 10^8$

Try This

Expand the expression in each row and write the single power equivalent.

Expression	Expanded Expression	Single Power
$6^5 \cdot 6^3$		
$(8^4)^2$		
$(2 \cdot 3)^5$		

Summary | Lesson 3

Rewriting powers can help you make sense of different bases with the same exponent. Here is one example.

If you expand $4^6 \cdot 3^6$, it is equal to $(4 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot 4)\ (3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3)$. You can rearrange the factors to get $(4 \cdot 3)\ (4 \cdot 3)\ (4 \cdot 3)\ (4 \cdot 3)\ (4 \cdot 3)\ (4 \cdot 3)$, which is equal to 12^6. This means that $4^6 \cdot 3^6$ is equivalent to 12^6.

You may not need to expand an expression completely to determine whether it is equivalent to another expression. For example, $(12^4)^2$ is not equivalent to 12^6 because it is $(12^4) \cdot (12^4) = 12^8$.

Try This

Decide if each pair is equivalent. Expand the expressions if that helps your thinking.

Pair A	$(12^2)^3$	$12^4 \cdot 12^2$	Equivalent Not Equivalent
Pair B	$7^3 \cdot 2^3$	$(7 \cdot 2)^3$	Equivalent Not Equivalent
Pair C	$16^3 + 16^2 + 16$	16^6	Equivalent Not Equivalent
Pair D	15^6	$(5 \cdot 3 \cdot 3 \cdot 5)^4$	Equivalent Not Equivalent

Summary | Lesson 4

You can rewrite expressions as a single power like 7^3 to help you make sense of more complex expressions, especially ones that involve division. Expanding is one strategy for rewriting expressions with exponents as single powers.

Here are two examples.

$$\begin{aligned}\frac{(3^3)^2}{3^4} &= \frac{(3 \cdot 3 \cdot 3) \cdot (3 \cdot 3 \cdot 3)}{3 \cdot 3 \cdot 3 \cdot 3} \\ &= \frac{3}{3} \cdot \frac{3}{3} \cdot \frac{3}{3} \cdot \frac{3}{3} \cdot 3 \cdot 3 \\ &= 1 \cdot 1 \cdot 1 \cdot 1 \cdot 3 \cdot 3 \\ &= 3^2\end{aligned}$$

$$\begin{aligned}\frac{9^2 \cdot 3^5}{3^3} &= \frac{(9 \cdot 9) \cdot (3 \cdot 3 \cdot 3 \cdot 3 \cdot 3)}{3 \cdot 3 \cdot 3} \\ &= \frac{(3 \cdot 3 \cdot 3 \cdot 3) \cdot (3 \cdot 3 \cdot 3 \cdot 3 \cdot 3)}{3 \cdot 3 \cdot 3} \\ &= \frac{3}{3} \cdot \frac{3}{3} \cdot \frac{3}{3} \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \\ &= 1 \cdot 1 \cdot 1 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \\ &= 3^6\end{aligned}$$

Knowing that $\frac{(3^3)^2}{3^4} = 3^2$ and $\frac{9^2 \cdot 3^5}{3^3} = 3^6$ can help you compare the two: $\frac{9^2 \cdot 3^5}{3^3}$ is greater than $\frac{(3^3)^2}{3^4}$ because 3^6 is greater than 3^2.

Try This

a Rewrite each expression as a single power. Expand the expressions if that helps with your thinking.

Expression	Single Power Expression
$\frac{3^5 \cdot 3^2}{3^4}$	
$\frac{(3^3)^2}{3^4}$	
$\frac{9^2 \cdot 3^5}{3^3}$	

b Order the expressions from least to greatest.

Summary | Lesson 5

Positive, negative, and zero exponents are all related.

For example, this table shows that each time the exponent decreases by 1, the value is divided by 4. Based on this pattern, we can determine that $4^0 = 1$. Similarly, if we divide both sides of $4^0 = 1$ by 4, we get $4^{-1} = \frac{1}{4}$.

Exponent Form	Expanded Form	Value
4^2	$4 \cdot 4$	16
4^1	4	4
4^0	1	1
4^{-1}	$\frac{1}{4}$	$\frac{1}{4}$
4^{-2}	$\frac{1}{4} \cdot \frac{1}{4}$	$\frac{1}{16}$

We can use these patterns, to make generalizations about powers with zero and negative exponents.

- Any power with a 0 exponent is equal to 1.
  For example, $\left(\frac{1}{5}\right)^0 = 1$ and $(-3)^0 = 1$.
- Powers with negative exponents are equal to 1 divided by the power with a positive exponent. For example, $5^{-2} = \left(\frac{1}{5}\right)^2 = \frac{1}{5} \cdot \frac{1}{5} = \frac{1}{25}$.

Try This

Use your knowledge of negative and zero exponents to complete the problems.

a Write $\frac{2^4}{(2^2)^2}$ as a single power expression.

b Describe the relationship between 10^5 and 10^{-5}.

Summary | Lesson 6

There are several rules about powers that can be helpful when rewriting or comparing expressions with exponents.

Types of Powers	Rule With Variables	Example
Multiplying Powers With the Same Base	$a^n \cdot a^m = a^{n+m}$	$6^2 \cdot 6^7 = 6^{2+7} = 6^9$
Dividing Powers With the Same Base	$\frac{a^n}{a^m} = a^{n-m}$	$\frac{3^{11}}{3^4} = 3^{11-4} = 3^7$
Powers of Powers	$(a^n)^m = a^{n \cdot m}$	$(1.7^5)^3 = 1.7^{(5 \cdot 3)} = 1.7^{15}$
Negative Exponents	$a^{-n} = \frac{1}{a^n} = \left(\frac{1}{a}\right)^n$	$14^{-2} = \frac{1}{14^2} = \left(\frac{1}{14}\right)^2$
Powers With Different Bases	$a^n \cdot b^n = (ab)^n$ $\frac{a^n}{b^n} = \left(\frac{a}{b}\right)^n$	$2^3 \cdot 5^3 = 10^3$ $\frac{2^3}{5^3} = \left(\frac{2}{5}\right)^3$
Zero Exponents	$a^0 = 1$	$\left(\frac{5}{9}\right)^0 = 1$

Note: The variables a and b are not equal to 0, and n and m are integers.

Try This

Complete the table and explain the rule. Use a separate sheet of paper if it helps with your thinking.

Rule With Variables	Example	Explanation of Rule
$x^m \cdot x^n = x^{m+n}$	$8^5 \cdot 8^7 = 8^{12}$	Because the bases are the same, the expression can be expanded to 8 being multiplied by itself 12 times.
$(x^m)^n = (x^n)^m = x^{m \cdot n}$	$(11^2)^3 = (11^3)^2 = 11^6$	
$x^m \cdot y^m = (xy)^m$		
$\frac{x^m}{x^n} = x^{m-n}$		
$x^{-m} = \frac{1}{x^m}$		
$x^0 = 1$		

Summary | Lesson 7

You can write large numbers as a combination of powers of 10 to make them less awkward to work with and to prevent having to count 0s.

The number $90{,}700{,}000$ can be written many different ways using powers of 10.

For example:

- $90700000 = 9 \cdot 10^7 + 7 \cdot 10^5$
- $90700000 = 90 \cdot 10^6 + 7 \cdot 10^5$
- $90700000 = 9.07 \cdot 10^7$

Try This

a A bus weighs $7{,}816$ kilograms. Rewrite the weight as an expression using a power of ten.

b A ship weighs $4{,}850{,}000$ kilograms. Adrian represented the ship's weight using the expression $485 \cdot 10^6$. Do you agree with Adrian's expression? Explain your thinking.

Summary | Lesson 8

Like large numbers, you can write small numbers using combinations of powers of 10. Numbers less than 1 will use negative powers of 10.

For example:

- $0.000000877 = 8 \cdot 10^{-7} + 7 \cdot 10^{-8} + 7 \cdot 10^{-9}$
- $0.00000000034 = 3 \cdot 10^{-10} + 4 \cdot 10^{-11}$
- $0.00000049 = 4 \cdot 10^{-7} + 9 \cdot 10^{-8}$

You can write large and small values as a number times a single power of 10 to help compare those values and get a sense of their scale.

For example:

- $42000000000 = 4.2 \cdot 10^{10}$
- $2500000000 = 25 \cdot 10^{8}$
- $0.00000000034 = 3.4 \cdot 10^{-10}$
- $0.00000049 = 49 \cdot 10^{-8}$

Try This

For each household item, write two different expressions that could represent its weight.

	Expression 1	Expression 2
Cell phone 0.13 kg		
Tablet 0.68 kg		
Grain of Rice 0.000021 kg		

Summary | Lesson 9

There are many ways to express a number using a power of 10. One specific way is called **scientific notation**, which can be helpful for comparing very large or very small numbers. When a number is written in scientific notation, the first part is a number greater than or equal to 1, but less than 10. The second part is an integer power of 10.

For example:

- 425,000,000 is $4.25 \cdot 10^8$ in scientific notation
- 0.0000000000783 is $7.83 \cdot 10^{-11}$ in scientific notation

Try This

Here are the top speeds of different vehicles in kilometers per hour (kph). Complete the table.

Vehicle	Speed (kph)	Speed (kph) in Scientific Notation
Sports car	415	$4.15 \cdot 10^2$
Apollo command and service module (mother ship of the Apollo spacecraft)	39,900	
Jet boat	510	
Autonomous drone	21,000	

Summary | Lesson 10

Multiplying numbers written in scientific notation is an extension of multiplying decimals.

To multiply two numbers written in scientific notation:

- Multiply the first parts of each number.
- Multiply the powers of 10 using exponent properties.

For example: $(2 \cdot 10^3) \cdot (4 \cdot 10^6) = (2 \cdot 4) \cdot 10^{(3+6)} = 8 \cdot 10^9$.

To divide two numbers written in scientific notation, it can be helpful to rewrite the expression as a fraction.

- Divide the first part in the numerator by the first part in the denominator.
- Divide the powers of 10 using exponent properties.

For example: $\frac{8 \cdot 10^7}{4 \cdot 10^2} = \frac{8}{4} \cdot 10^{(7-2)} = 2 \cdot 10^5$.

Try This

For each expression, create an equivalent expression and find the value of the expression in scientific notation.

Expression	Equivalent Expression	Scientific Notation
$31 \cdot 10^4$		
$(4 \cdot 10^2) \cdot (6 \cdot 10^4)$		
$\frac{8 \cdot 10^6}{2 \cdot 10^3}$		

Summary | Lesson 11

You can use scientific notation when comparing quantities.

Here is one example. How many jelly beans weigh as much as one Egyptian pyramid?

- Jelly bean weight: $1.5 \cdot 10^{-3}$ kilograms
- Egyptian pyramid weight: $5.216 \cdot 10^{9}$ kilograms

It can be helpful to round the first parts of both numbers before calculating.

- $1.5 \cdot 10^{-3}$ is about $2 \cdot 10^{-3}$.
- $5.216 \cdot 10^{9}$ is about $5 \cdot 10^{9}$.

There are many strategies you can use when comparing quantities in scientific notation. Here are two:

Divide the larger number by the smaller number.

$$\frac{5 \cdot 10^{9}}{2 \cdot 10^{-3}} = 2.5 \cdot 10^{12}$$

$2.5 \cdot 10^{12}$ jelly beans weigh about the same as the pyramid.

Multiply the smaller number by the number needed to equal the larger number.

$$2 \cdot 10^{-3} \cdot ? = 5 \cdot 10^{9}$$

$2.5 \cdot 10^{12}$ jelly beans weigh about the same as the pyramid.

Try This

Compare the relative sizes of the items in each situation.

a Ants weigh about $3 \cdot 10^{-6}$ kilograms each. Humans weigh about $6.2 \cdot 10^{1}$ kilograms each. Approximately how many ants weigh the same as one human?

b There are about $4.5 \cdot 10^{7}$ residents in California. Californians altogether use around 8 billion gallons of water per day. How many gallons of water does the average Californian use per day?

Summary | Lesson 12

You can use scientific notation and exponent rules to solve real-world problems that include very large or very small numbers. For example, you can use the rules to calculate how many dollars worth of food are wasted in the United States each year or the total amount of student debt in the United States.

When solving a real-world problem, it is important to look at the information you know, determine what information is needed to solve the problem, and think about appropriate units of measurement. You can also use rounding to make some quantities simpler to work with.

Try This

The table shows the population of humans and ants and the approximate individual mass of each species.

Species	Population	Mass of Individual (kg)	Total Mass of Species (kg)
Humans	$7.5 \cdot 10^{9}$	$6 \cdot 10^{1}$	
Ants	$5 \cdot 10^{16}$	$3 \cdot 10^{-6}$	

a Calculate the total mass of each species.

b Which species has a greater total mass?

c How many times more massive is the species with the greater total mass?

Summary | Lesson 13

Scientific notation can be useful for adding or subtracting very large or very small numbers. It is important to pay attention to place value when adding and subtracting numbers written in scientific notation.

For example: Let's add $3.4 \cdot 10^5 + 2.1 \cdot 10^6$.

It may appear that you can add the first parts: 3.4 and 2.1. However, these numbers *do not* have the same place value because they are multiplied by different powers of 10.

If you rewrite one number so that both numbers have the same power of 10, then you can add their first parts. In this case, let's rewrite $2.1 \cdot 10^6$ as $21 \cdot 10^5$.

$$\begin{aligned} 3.4 \cdot 10^5 + 2.1 \cdot 10^6 &= 3.4 \cdot 10^5 + 21 \cdot 10^5 \\ &= 24.4 \cdot 10^5 \\ &= 2.44 \cdot 10^6 \end{aligned}$$

Now that the power of 10 is the same, you can add 3.4 and 21. The sum is $24.4 \cdot 10^5$, or $2.44 \cdot 10^6$ when rewritten in scientific notation.

Try This

Rewrite the expression $6.875 \cdot 10^3 + 4.95 \cdot 10^4$ and find the value of the expression.

Summary | Lesson 14

Scientific notation is a useful tool for adding, subtracting, multiplying, dividing, and comparing very small or very large numbers.

- You can rewrite the number $39{,}000{,}000{,}000{,}000$ as $3.9 \cdot 10^{13}$ and still convey just how large the number is.
- To add or subtract numbers written in scientific notation, it is useful to rewrite the numbers so they have the same power of 10.
- To multiply or divide numbers written in scientific notation, it is useful to multiply or divide the numbers that come before the powers of 10. Then you can use exponent rules to multiply or divide the powers of 10.
- If the product or quotient is not written in scientific notation, you can always rewrite it to be in that form.
- Sometimes it can be helpful to round numbers written in scientific notation when exact values are less important.

Some situations that involve very large or very small numbers include salaries of wealthy people, talking about large groups like the total number of workers at a company, or the sizes of microscopic objects like cells and bacteria.

Try This

The table shows the population of different species and the approximate individual mass of each species.

Species	Population	Mass of Individual (kg)
Humans	$7.5 \cdot 10^9$	$6.2 \cdot 10^1$
Sheep	$1.75 \cdot 10^9$	$6 \cdot 10^1$
Chickens	$2.4 \cdot 10^{10}$	$2 \cdot 10^0$

Is the total mass of humans greater than the total mass of chicken and sheep combined? Explain your thinking.

Lesson 1

a No. *Explanations vary*. Doubling means multiplying by 2. The expression $2 \cdot 2 \cdot 2$ or 2^3 would represent the amount of rice after three days.

b $2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$ or 2^7. The amount of rice would be 128 grains.

Lesson 2

Expression	Expansion	Single Power
$6^5 \cdot 6^3$	$(6 \cdot 6 \cdot 6 \cdot 6 \cdot 6)(6 \cdot 6 \cdot 6)$	6^8
$(8^4)^2$	$(8 \cdot 8 \cdot 8 \cdot 8)(8 \cdot 8 \cdot 8 \cdot 8)$	8^8
$(2 \cdot 3)^5$	$(2 \cdot 3)(2 \cdot 3)(2 \cdot 3)(2 \cdot 3)(2 \cdot 3)$ or $6 \cdot 6 \cdot 6 \cdot 6 \cdot 6$	6^5

Lesson 3

Pair A	$(12^2)^3$ $12^{2 \cdot 3} = 12^6$	$12^4 \cdot 12^2$ $12^{4+2} = 12^6$	(Equivalent) Not Equivalent
Pair B	$7^3 \cdot 2^3$ $7 \cdot 7 \cdot 7 \cdot 2 \cdot 2 \cdot 2 = 14^3$	$(7 \cdot 2)^3$ $(14)^3 = 14^3$	(Equivalent) Not Equivalent
Pair C	$16^3 + 16^2 + 16$ Cannot be simplified further	16^6 Cannot be simplified further	Equivalent (Not Equivalent)
Pair D	15^6 Cannot be simplified further	$(5 \cdot 3 \cdot 3 \cdot 5)^4$ $(15 \cdot 15)^4 = (15^2)^4 = 15^8$	Equivalent (Not Equivalent)

Lesson 4

a

Expression	Single Power Expression
$\frac{3^5 \cdot 3^2}{3^4} = \frac{(3 \cdot 3 \cdot 3 \cdot 3 \cdot 3)(3 \cdot 3)}{3 \cdot 3 \cdot 3 \cdot 3}$	3^3
$\frac{(3^3)^2}{3^4} = \frac{(3 \cdot 3 \cdot 3)(3 \cdot 3 \cdot 3)}{3 \cdot 3 \cdot 3 \cdot 3}$	3^2
$\frac{9^2 \cdot 3^5}{3^3} = \frac{(3 \cdot 3)(3 \cdot 3)(3 \cdot 3 \cdot 3 \cdot 3 \cdot 3)}{3 \cdot 3 \cdot 3}$	3^6

b From least to greatest: $\frac{(3^3)^2}{3^4}, \frac{3^5 \cdot 3^2}{3^4}, \frac{9^2 \cdot 3^5}{3^3}$

Lesson 5

a 2^0

b *Responses vary.* The two numbers are reciprocals. 10^5 is 1 multiplied by 10 five times, while 10^{-5} is 1 divided by 10 five times.

Lesson 6

Responses vary.

Rule With Variables	Example	Explanation of Rule
$x^m \cdot x^n = x^{m+n}$	$8^5 \cdot 8^7 = 8^{12}$	Because the bases are the same, the expression can be expanded to 8 being multiplied by itself 12 times.
$(x^m)^n = (x^n)^m = x^{m \cdot n}$	$(11^2)^3 = (11^3)^2 = 11^6$	*Responses vary.* Each 11 multiplied by itself three times raised to the second power can be expanded to be 11 multiplied by itself six times.
$x^m \cdot y^m = (xy)^m$	*Responses vary.* $6^3 \cdot 5^3 = 30^3$	*Responses vary.* 6 multiplied by 5 can be rearranged and rewritten as 30. In total, that would mean 30 is being multiplied by itself three times.
$\frac{x^m}{x^n} = x^{m-n}$	*Responses vary.* $\frac{3^8}{3^6} = 3^2$	*Responses vary.* The numerator can be expanded to be 3 multiplied by itself eight times. The denominator can be expanded to be 3 multiplied by itself six times. Six factors of 3 in the numerator and the denominator can be divided to equal 1, leaving only 3 times itself twice in the numerator.
$x^{-m} = \frac{1}{x^m}$	*Responses vary.* $4^{-3} = \frac{1}{4^3}$	*Responses vary.* If positive exponents represent repeated multiplication, negative exponents represent repeated division.
$x^0 = 1$	*Responses vary.* $188^0 = 1$	*Responses vary.* In understanding the rule of dividing powers with the same base, I know that $\frac{188^3}{188^3} = 188^0$. I also know that when simplifying a fraction with the same numerator and denominator, the result is 1. So $188^0 = 1$.

Lesson 7

a. $7.816 \cdot 10^3$ (or equivalent)

b. No. *Explanations vary.* Adrian's expression is equal to 485,000,000. 4,850,000 could be written as $4.85 \cdot 10^6$ or $485 \cdot 10^4$.

Lesson 8

	Expression 1	Expression 2
Cell phone 0.13 kg	$13 \cdot 10^{-2}$	$1.3 \cdot 10^{-1}$
Tablet 0.68 kg	$68 \cdot 10^{-2}$	$6.8 \cdot 10^{-1}$
Grain of Rice 0.000021 kg	$21 \cdot 10^{-6}$	$2.1 \cdot 10^{-5}$

Lesson 9

Vehicle	Speed (kph)	Speed (kph) in Scientific Notation
Sports car	415	$4.15 \cdot 10^2$
Apollo command and service module (mother ship of the Apollo spacecraft)	39,900	$3.99 \cdot 10^4$
Jet boat	510	$5.1 \cdot 10^2$
Autonomous drone	21,000	$2.1 \cdot 10^4$

Lesson 10

Expression	Equivalent Expression	Value in Scientific Notation
$31 \cdot 10^4$	$(3.1 \cdot 10^1) \cdot 10^4$	$3.1 \cdot 10^5$
$(4 \cdot 10^2) \cdot (6 \cdot 10^4)$	$(4 \cdot 6)(10^2 \cdot 10^4) = 24 \cdot 10^6$	$2.4 \cdot 10^7$
$\frac{8 \cdot 10^6}{2 \cdot 10^3}$	$\frac{8}{2} \cdot \frac{10^6}{10^3} = 4 \cdot \frac{10^6}{10^3}$	$4 \cdot 10^3$

Lesson 11

a Approximately 20 million ants weigh the same as one human. $\frac{6.2 \cdot 10^1}{3 \cdot 10^{-6}} \approx 2 \cdot 10^7$

b The average Californian uses approximately 180 gallons of water a day.
$\frac{8 \cdot 10^9}{4.5 \cdot 10^7} \approx 1.8 \cdot 10^2$

Lesson 12

a

Species	Population	Mass of Individual (kg)	Total Mass of Species (kg)
Humans	$7.5 \cdot 10^9$	$6 \cdot 10^1$	$45 \cdot 10^{10}$ (or equivalent)
Ants	$5 \cdot 10^{16}$	$3 \cdot 10^{-6}$	$15 \cdot 10^{10}$ (or equivalent)

b Humans have a greater total mass than ants.

c Human total mass is 3 times as much as the total mass of ants.

Lesson 13

Responses vary.

- Rewriting the expression as a multiple of 10^3:
$$6.875 \cdot 10^3 + 4.95 \cdot 10^4 = 6.875 \cdot 10^3 + 49.5 \cdot 10^3$$
$$= 56.375 \cdot 10^3$$
- Rewriting the expression as a multiple of 10^4:
$$6.875 \cdot 10^3 + 4.95 \cdot 10^4 = 0.6875 \cdot 10^4 + 4.95 \cdot 10^4$$
$$= 5.6375 \cdot 10^4$$

Lesson 14

The total mass of humans is greater than the total mass of both chicken and sheep combined. *Explanations vary*. You can find the total mass of all three species by multiplying the population of each by its individual mass. Human total mass is approximately $46.5 \cdot 10^{10}$ kg. Sheep total mass is approximately $10.5 \cdot 10^{10}$ kg, and chicken total mass is approximately $4.8 \cdot 10^{10}$ kg. Because the total mass for chicken and sheep were already written with a factor of 10^{10}, the total masses of chicken and sheep can be added easily and is approximately $15.3 \cdot 10^{10}$, which is still less than the approximate total human mass.

Total human mass: $(7.5 \cdot 10^{9})(6.2 \cdot 10^{1}) \approx 46.5 \cdot 10^{10}$ kg

Total sheep mass: $(1.75 \cdot 10^{9})(6 \cdot 10^{1}) \approx 10.5 \cdot 10^{10}$ kg

Total chicken mass: $(2.4 \cdot 10^{10})(2 \cdot 10^{0}) \approx 4.8 \cdot 10^{10}$ kg

Combined sheep and chicken mass: $4.8 \cdot 10^{10} + 10.5 \cdot 10^{10} \approx 15.3 \cdot 10^{10}$ kg