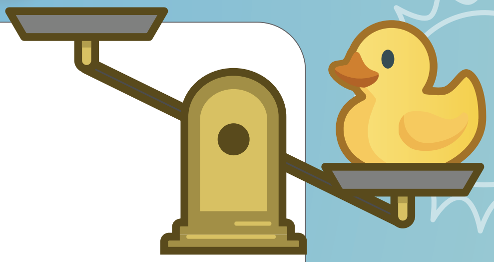
**Caregiver Support | Grade 8 Unit 7**



Unit 7

# Exponents and Scientific Notation

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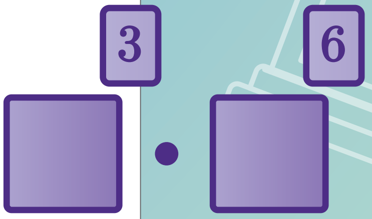
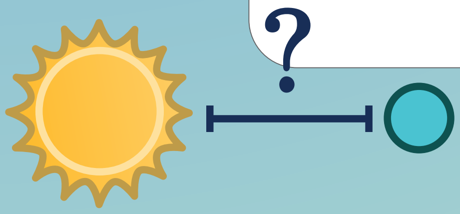
Numbers and operations with numbers can be represented in many different ways. How can you represent very large or very small numbers? How can you work with these numbers? In this unit, you will see how exponents, properties of exponents, and powers of 10 will be used to solve problems involving scales,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



## 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, $3^5 = \underbrace{3 \cdot 3 \cdot 3 \cdot 3 \cdot 3}_{\text{5 times}}$. 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<br>Not Equivalent |
| **Pair B** | $7^3 \cdot 2^3$ | $(7 \cdot 2)^3$ | Equivalent<br>Not Equivalent |
| **Pair C** | $16^3 + 16^2 + 16$ | $16^6$ | Equivalent<br>Not Equivalent |
| **Pair D** | $15^6$ | $(5 \cdot 3 \cdot 3 \cdot 5)^4$ | Equivalent<br>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 gets 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 an exponent of $0$ is equal to $1$.

Examples:

- $\left(\frac{1}{5}\right)^0 = 1$
- $(-3)^0 = 1$

Powers with negative exponents are equal to $1$ divided by the power with a positive exponent.

Examples:

- $5^{-2} = \left(\frac{1}{5}\right)^2 = \frac{1}{5} \cdot \frac{1}{5} = \frac{1}{25}$
- $10^{-3} = \frac{1}{10^3} \cdot \frac{1}{10 \cdot 10 \cdot 10} = \frac{1}{1000}$

## 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 | $a^n \bullet a^m = a^{n+m}$ | $6^2 \bullet 6^7 = 6^{2+7} = 6^9$ |
| 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 | $(a^n)^m = a^{n \bullet m}$ | $(1.7^5)^3 = 1.7^{(5 \bullet 3)} = 1.7^{15}$ |
| 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 | $a^n \bullet b^n = (ab)^n$<br>$\frac{a^n}{b^n} = \left(\frac{a}{b}\right)^n$ | $2^3 \bullet 5^3 = 10^3$<br>$\frac{2^3}{5^3} = \left(\frac{2}{5}\right)^3$ |
| 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 |
|---|---|---|
| $x^m \bullet x^n = x^{m+n}$ | $8^5 \bullet 8^7 = 8^{12}$ | Because the bases are the same, the expression can be expanded to 8 being multiplied by itself 12 times. |
| $(x^m)^n = (x^n)^m = x^{m \bullet n}$ | $(11^2)^3 = (11^3)^2 = 11^6$ | |
| $x^m \bullet y^m = (xy)^m$ | | |
| $\frac{x^m}{x^n} = x^{m-n}$ | | |
| $x^{-m} = \frac{1}{x^m}$ | | |
| $x^0 = 1$ | | |

# 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 $0$s.

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:

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

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:

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

## Try This

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

| | Expression 1 | Expression 2 |
|---|---|---|
| **Cell phone**<br>**0.13 kg** | | |
| **Tablet**<br>**0.68 kg** | | |
| **Grain of Rice**<br>**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: $1.5 \bullet 10^{-3}$ kilograms
- Egyptian pyramid weight: $5.216 \bullet 10^{9}$ kilograms

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

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

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

Divide the larger number by the smaller number.

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

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

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

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

$2.5 \bullet 10^{12}$ 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 $3 \bullet 10^{-6}$ kilograms each. Humans weigh about $6.2 \bullet 10^{1}$ kilograms each. Approximately how many ants weigh the same as one human?

**b** There are about $4.5 \bullet 10^{7}$ 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 | $7.5 \bullet 10^9$ | $6 \bullet 10^1$ | |
| Ants | $5 \bullet 10^{16}$ | $3 \bullet 10^{-6}$ | |

**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.

# Try This | Answer Key

## 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 |
|---|---|---|
| $6^5 \cdot 6^3$ | $(6 \cdot 6 \cdot 6 \cdot 6 \cdot 6)(6 \cdot 6 \cdot 6)$ | $6^8$ |
| $(8^4)^2$ | $(8 \cdot 8 \cdot 8 \cdot 8)(8 \cdot 8 \cdot 8 \cdot 8)$ | $8^8$ |
| $(2 \cdot 3)^5$ | $(2 \cdot 3)(2 \cdot 3)(2 \cdot 3)(2 \cdot 3)(2 \cdot 3)$<br>or<br>$6 \cdot 6 \cdot 6 \cdot 6 \cdot 6$ | $6^5$ |

## Lesson 3

| | | | |
|---|---|---|---|
| **Pair A** | $(12^2)^3$<br>$12^{2 \cdot 3} = 12^6$ | $12^4 \cdot 12^2$<br>$12^{4+2} = 12^6$ | [✓ Equivalent]<br>Not Equivalent |
| **Pair B** | $7^3 \cdot 2^3$<br>$7 \cdot 7 \cdot 7 \cdot 2 \cdot 2 \cdot 2 = 14^3$ | $(7 \cdot 2)^3$<br>$(14)^3 = 14^3$ | [✓ Equivalent]<br>Not Equivalent |
| **Pair C** | $16^3 + 16^2 + 16$<br>Cannot be simplified further | $16^6$<br>Cannot be simplified further | Equivalent<br>[✓ Not Equivalent] |
| **Pair D** | $15^6$<br>Cannot be simplified further | $(5 \cdot 3 \cdot 3 \cdot 5)^4$<br>$(15 \cdot 15)^4 = (15^2)^4 = 15^8$ | Equivalent<br>[✓ 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.*<br>$6^3 \cdot 5^3 = 30^3$ | *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.*<br>$\frac{3^8}{3^6} = 3^2$ | *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.*<br>$4^{-3} = \frac{1}{4^3}$ | *Responses vary.* If positive exponents represent repeated multiplication, negative exponents represent repeated division. |
| $x^0 = 1$ | *Responses vary.*<br>$188^0 = 1$ | *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<br>0.13 kg | $13 \cdot 10^{-2}$ | $1.3 \cdot 10^{-1}$ |
| Tablet<br>0.68 kg | $68 \cdot 10^{-2}$ | $6.8 \cdot 10^{-1}$ |
| Grain of Rice<br>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 |
|---|---|---|
| $31 \bullet 10^4$ | $(3.1 \bullet 10^1) \bullet 10^4$ | $3.1 \bullet 10^5$ |
| $(4 \bullet 10^2) \bullet (6 \bullet 10^4)$ | $(4 \bullet 6)(10^2 \bullet 10^4) = 24 \bullet 10^6$ | $2.4 \bullet 10^7$ |
| $\frac{8 \bullet 10^6}{2 \bullet 10^3}$ | $\frac{8}{2} \bullet \frac{10^6}{10^3} = 4 \bullet \frac{10^6}{10^3}$ | $4 \bullet 10^3$ |

## Lesson 11

- **a** Approximately 20 million ants weigh the same as one human. $\frac{6.2 \bullet 10^1}{3 \bullet 10^{-6}} \approx 2 \bullet 10^7$
- **b** The average Californian uses approximately 180 gallons of water a day.
  $\frac{8 \bullet 10^9}{4.5 \bullet 10^7} \approx 1.8 \bullet 10^2$

## Lesson 12

**a**

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

$$\begin{aligned} 6.875 \bullet 10^3 + 4.95 \bullet 10^4 &= 6.875 \bullet 10^3 + 49.5 \bullet 10^3 \\ &= 56.375 \bullet 10^3 \end{aligned}$$

- Rewriting the expression as a multiple of $10^4$:

$$\begin{aligned} 6.875 \bullet 10^3 + 4.95 \bullet 10^4 &= 0.6875 \bullet 10^4 + 4.95 \bullet 10^4 \\ &= 5.6375 \bullet 10^4 \end{aligned}$$

## 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.

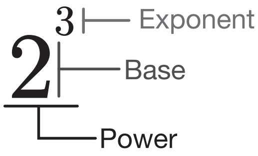
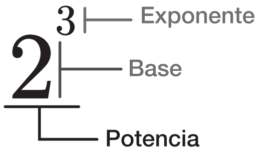
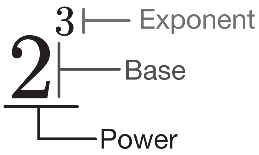
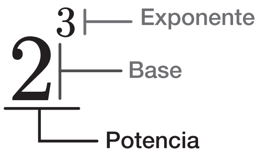
Total human mass: $(7.5 \cdot 10^9)(6.2 \cdot 10^1) \approx 46.5 \cdot 10^{10}$ kg

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

# Grade 8 Unit 7 Glossary/8.º grado Unidad 7 Glosario

| English | | Español |
|---|---|---|
| | **B** | |
| **base (of a power)** The number that is raised to an exponent. When determining the value of a power, the exponent tells you how many times the base should be multiplied.<br><br> <br>In this example, 2 is the base. | | **base (de una potencia)** El número elevado a un exponente. Al determinar el valor de una potencia, el exponente indica cuántas veces debe multiplicarse la base.<br><br> <br>En este ejemplo, 2 es la base. |
| | **E** | |
| **exponent** A number used to describe repeated multiplication.<br><br> <br>In this example, 3 is the exponent, which means $2^3 = 2 \cdot 2 \cdot 2$. | | **exponente** Un número que se usa para describir multiplicaciones repetidas.<br><br> <br>En este ejemplo, 3 es el exponente, lo cual significa que $2^3 = 2 \cdot 2 \cdot 2$. |
| | **P** | |
| **power of ten** A number written in the form $10^n$, where $n$ represents the number of times 10 is multiplied.<br>For example, 10000 written as a power of ten is $10^4$ because $10000 = 10 \cdot 10 \cdot 10 \cdot 10$. | | **potencia de diez** Un número escrito de la forma $10^n$, donde $n$ representa el número de veces que se multiplica el 10.<br>Por ejemplo, 10000 escrito como una potencia de diez es $10^4$ porque $10000 = 10 \cdot 10 \cdot 10 \cdot 10$. |
| | **S** | |
| **scientific notation** A way to write very large or very small numbers. In scientific notation, a number between 1 and 10 is multiplied by a power of 10.<br>For example, the number 425,000,000 in scientific notation is $4.25 \cdot 10^8$. The number 0.0000000783 in scientific notation is $7.83 \cdot 10^{-8}$. | | **notación científica** Una forma de escribir números muy grandes o muy pequeños. Cuando un número entre 1 y 10 está multiplicado por una potencia de 10, significa que está escrito en notación científica.<br>Por ejemplo, el número 425,000,000 en notación científica es $4.25 \cdot 10^8$. El número 0.0000000783 en notación científica es $7.83 \cdot 10^{-8}$. |