

Name: _____

Date: _____

Student Exploration: Unit Conversions

Vocabulary: base unit, cancel, conversion factor, dimensional analysis, metric system, prefix, scientific notation

Gizmo Warm-up

As you could see from the questions above, there are different ways to measure the same quantity. Every measurement includes both a number and a unit. There are many, many different units you can use to measure the same attribute, such as height, weight, or volume. The *Unit Conversions* Gizmo shows you how you can convert from one unit to another in order to compare measurements.

Metric units only Mixed units

The tallest building in the world, the Burj Khalifa in Dubai, is 0.828 kilometers high. What is the building's height in centimeters?

Conversion: Distance Next

- To begin, check that this question is shown: *The tallest building in the world, the Burj Khalifa in Dubai, is 0.828 kilometers high. What is the building's height in centimeters?* (If this is not the question you see, click **Next** until it appears.)
 - What unit is asked for? _____
 - What unit is given in the question? _____
- Look for the **Unit Conversion Tile** that has the unit "meter" on top and "kilometer" on the bottom. This tile shows a **conversion factor**, or a ratio that compares two equivalent values.
 - According to this tile, how many meters are in a kilometer? _____
 - Look at the tile next to it. How many centimeters are in a meter? _____

Activity A:	<u>Get the Gizmo ready:</u>	1000 micromet
Dimensional analysis	<input type="checkbox"/> Check that the question is still about Burj Khalifa.	1 millimeter

Goal: Use dimensional analysis to solve conversion problems.

- Observe: In the question, you are asked to convert kilometers to centimeters. To do this, first you will convert kilometers to meters. Drag the 1000 meters/1 kilometer tile down.
 - What do you notice? _____

B. Because kilometers appear in the numerator of one term and in the denominator of another, they **cancel**, or disappear. The process of converting units by canceling is called **dimensional analysis**.

How many meters are in 0.828 kilometers? _____

C. A meter is a much shorter unit of measurement than a kilometer. Based on this fact, does your answer to B make sense? _____

2. Identify: Now find a tile that converts meters to centimeters. Drag it down next to the first tile.

A. What units cancel now? _____

B. What is the unit in the answer? _____

C. How many centimeters tall is the Burj Khalifa? _____

D. Click **Submit**. Is this answer correct? _____

3. Find: Click **Next**. What conversion tile can you use to solve this problem? Give the ratio.

4. Analyze: Drag this tile to the grey strip. Turn on **Show results**.

A. What units are given to the right of the equals sign? _____

B. Why didn't the units cancel in this case? _____

C. What do you think you could do to make them cancel? _____

5. Observe: Click **Flip tile**.

A. What unit is given now? _____

B. Click **Submit**. How many millimeters wide is a human egg cell? _____

6. Practice: Make sure **Metric units only** and **Distance** are selected. Click **Next**, and use what you've learned to solve another unit conversion problem. For each problem, list the units given, the units asked for, and the solution.

A. On a caterpillar's map, all distances are marked in millimeters. The caterpillar's map shows that the distance between two milkweed plants is 4,012 millimeters. What is this distance in kilometers?

Given unit: _____ Answer unit: _____ Solution: _____

B. The closest star to our Sun is Proxima Centauri, which is 4.242 light years away. What is the distance to Proxima Centauri in kilometers?


Given unit: _____ Answer unit: _____ Solution: _____

C. A helium atom has a diameter of approximately $9.8 \cdot 10^{-11}$ meters. What is the diameter of a helium atom in nanometers?

Given unit: _____ Answer unit: _____ Solution: _____

7. On your own: A blue whale has a length of 28,578 millimeters. What is the length of a blue whale in kilometers? Show your work below by writing the conversion factors you use to solve this question.

28,578 mm • _____ • _____ = _____ kilometers

<p>Activity B:</p> <p>Metric units</p>	<p><u>Get the Gizmo ready:</u></p> <p><input type="checkbox"/> Check that Metric units only and Distance is still selected.</p>	
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Introduction: During the Warm-up activity, you learned that 1,000 meters equals 1 kilometer. Both of these units are part of the **metric system**, a measurement system based on powers of 10. No matter what quantity you are working with, converting between metric units will involve multiplying by a power of 10.

Goal: Convert from one metric unit to another.

1. Infer: The metric system uses **prefixes** to tell you how much to multiply the **base unit** by. For example, in the metric system, the base unit for length is the meter. Examples of prefixes include *kilo-*, *centi-*, and *milli-*.

Knowing that 1,000 meters are in 1 kilometer, what do you think the prefix *kilo-* means?

2. **Analyze:** Use the **Unit Conversion Tiles** to help you fill out the rest of the table below. Other rows for prefixes not used in this Gizmo are shown for comparison

Common Prefixes used with SI Units			
Prefix	Symbol	Meaning	Order of Magnitude
<i>giga-</i>	G	1 000 000 000	10^9
<i>mega-</i>	M	1 000 000	10^6
<i>kilo-</i>	k		10^3
<i>hecto-</i>	h	100	10^2
<i>deka-</i>	da	10	10^1
	base unit	1	10^0
<i>deci-</i>	d	0.1	10^{-1}
<i>centi-</i>	c		10^{-2}
<i>milli-</i>	m		10^{-3}
<i>micro-</i>	μ		10^{-6}
<i>nano-</i>	n		10^{-9}

3. **Create:** Knowing the meaning of metric system prefixes can help you write your own conversion factors. In the metric system, the base unit for mass is the gram. What do you think the conversion factor for gram-to-kilograms would be?

_____ grams

_____ kilograms

Select **Mass** on the **Conversion** dropdown menu to check your answer.

Observe: Up until now, all the problems you have solved have involved converting only one unit. However, some conversion problems require you to convert two or more units. Select **Speed** from the menu. What two units do you need to convert to solve this problem?

4. **Think about it:** How do you think you can use conversion factors to solve this problem?

5. **Solve:** Turn on **Show result**. Drag the seconds-to-hour tile to the green bar.

A. How many meters per hour did Marcia run? _____

B. Drag the kilometer-to-meters tile to the green bar. If these aren't the units you want, click

Flip tile. What unit is given now? _____

C. Click **Submit**. How many kilometers per hour did Marcia run? _____

Activity C: Mixed units	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Select Mixed units. • Select Distance from the Conversion menu. 	<table border="1"> <tr><td>1 meter</td></tr> <tr><td>1.60934 kilometers</td></tr> <tr><td>1 mile</td></tr> </table>	1 meter	1.60934 kilometers	1 mile
1 meter					
1.60934 kilometers					
1 mile					

Introduction: Up until now, most of the conversions you have done have involved metric units. However, many countries—including the United States—use non-metric units of measurement. It can be a bit harder to convert between metric units and U.S. units because U.S. units are not based on powers of 10. However, the basic principles of dimensional analysis still apply.

Goal: Convert between metric and non-metric units.

1. Analyze: Now that you know how to convert between metric units, try your hand at solving the mixed units problems. First, check that this question is shown: *Mount Everest is 29,029 feet high. What is the height of Mount Everest in kilometers?*

A. What unit is given? _____ What unit is asked for? _____

B. Which tile(s) should you use to solve this problem? _____

C. What is the height of Mount Everest in kilometers? _____

2. Challenge: Select **Distance** again from the **Conversion** menu. Use the conversion factors on the tiles to calculate how many miles, yards, feet, and inches are in 1 meter. Next, use the **Mass** and **Volume** conversion tiles to determine how many pounds and ounces are in a gram and how many gallons are in a liter.

Quantity	Metric base unit	U.S. unit equivalent
Distance	1 meter =	_____ miles
		_____ yards
		_____ feet
		_____ inches

Mass	1 gram =	_____ pounds
		_____ ounces

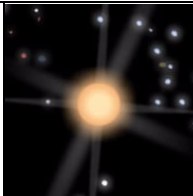
Volume	1 liter =	_____ gallons
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Comprehension Check

Sara lives in Toronto, Canada, while her cousin Michael lives in Detroit, Michigan. They like to compare how fast they are growing up.

1. Sara tells Michael she is 160 centimeters tall, while Michael says he is 64 inches tall. If there are 2.54 centimeters in an inch, who is taller? Show your work. _____

2. Michael tells Sara he weighs 104 pounds. Sara says she is 48 kilograms. If there are 2.2 pounds in a kilogram, who is heavier? _____

Extension: Scientific notation	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none">• Select Metric units only and Distance from the Conversion menu. Make sure Show result is off.• Click Next until you reach the question about Proxima Centauri.	
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Question: How can you convert numbers into and out of scientific notation?

1. Observe: Some of the problems in this Gizmo involve very small or very large quantities. Look at the bottom three **Unit Conversion Tiles**. What do you notice in the numerator?

The numbers in the numerators are written in **scientific notation**. In scientific notation, a number is converted to the product of a number between 1 and 10 and a power of 10. For example, 1,000,000 is written as $1.0 \cdot 10^6$. The “dot” is the same thing as the multiplication symbol “x”. The first part of this number is called the *coefficient*. The second part is called the *base*.

2. **Convert:** To convert a number written in scientific notation to a standard number, first look at the exponent on the base. If it is positive, move the decimal point on the coefficient to the right as many times as the exponent indicates, as shown below:

Look at exponent	Count digits	Move decimal point	Standard form
8.35×10^7	$\overset{1}{8} \overset{2}{.} \overset{3}{3} \overset{4}{5} \overset{5}{0} \overset{6}{0} \overset{7}{0}$ 8.3 500 000	83 500 000.	83,500,000

Practice converting the two numbers below into standard form:

$1.0 \cdot 10^9 =$ _____ $6.72 \cdot 10^{12} =$ _____

You can perform this process in reverse to convert numbers in standard form into scientific notation. The number of times you move the decimal point to the left will be equal to the exponent on your base.

Standard form	Place new decimal point	Count digits	Scientific notation
3,701,000	3.700 000	$\overset{1}{3} \overset{2}{.} \overset{3}{7} \overset{4}{0} \overset{5}{0} \overset{6}{0}$ 3.700 000	3.701×10^6

Practice this with the two numbers below:

$8,200,000 =$ _____ $50,880,000,000,000 =$ _____

3. **Identify:** Look at the last tile.

A. In scientific notation, how many kilometers are equal to 1 light year? _____

B. Write this number in standard form: _____

C. Drag this tile below to solve the problem. Turn on **Show result**. What is the distance to Proxima Centauri in kilometers? _____

D. Write this distance in standard form: _____

4. **Convert:** Not all numbers written in scientific notation are very large numbers. Scientific notation also can be used to write very small numbers. This is done by making the exponent on the base negative, indicating the decimal point should be moved to the left.

Look at exponent	Count digits	Move decimal point	Standard form
7.9×10^{-6}	$\overset{1}{0} \overset{2}{0} \overset{3}{0} \overset{4}{0} \overset{5}{0} \overset{6}{7}$ 000 007.9	0.000 007.9	0.0000079

