Name: _____ Date: _____

Student Exploration: Unit Conversions

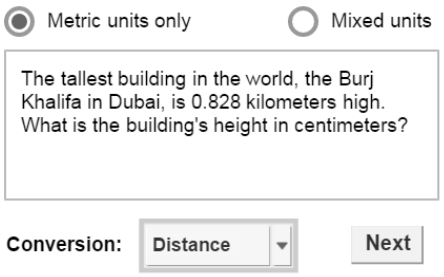
Vocabulary: base unit, cancel, conversion factor, dimensional analysis, metric system, prefix, scientific notation

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
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 60 inches tall. If there are 2.54 centimeters in an inch, who is taller? _____

2. Michael tells Sara he weighs 104 pounds. Sara says she is 44 kilograms. If there are 2.2 pounds in a kilogram, who is heavier? _____

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.



1. 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.)
   A. What unit is given in the question? _____
   B. What unit is asked for? _____

2. 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.
   A. According to this tile, how many meters are in a kilometer? _____
   B. Look at the tile next to it. How man centimeters are in a meter? _____

Activity A: **Dimensional analysis**	Get the Gizmo ready: • Check that the question is still about Burj Khalifa.	1000 micromet 1 millimeter

Goal: Use dimensional analysis to solve conversion problems.

1. 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.

   A. 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.

   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? _____

4. Analyze: Drag this tile to the green 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? _____

   _____

(Activity A continued on next page)

Activity A (continued from previous page)

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: Turn off **Show result**. 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?

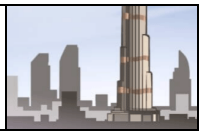
      Given unit: _____ Answer unit: _____ Solution: _____

   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 • _____ • _____ = _____

Activity B: Metric units	Get the Gizmo ready: • Check that **Metric units only** and **Distance** is still selected.	

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 determine the meaning of the following metric prefixes. The first row has been completed for you.

Prefix	Meaning
kilo-	Multiply base unit by 1,000
centi-	
milli-	
micro-	
nano-	

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?

   $$\frac{\text{\_\_\_\_\_ grams}}{\text{\_\_\_\_\_ kilograms}}$$

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

(Activity B continued on next page)

Activity B (continued from previous page)

4. On Your Own: Use the gram-to-kilograms conversion tile to answer the first question about the rock's mass. Turn on **Show result** to check your calculation. Then, click **Submit**. Continue until you've answered all of the **Mass** questions. The Gizmo will keep track of how many problems you solve.

5. On Your Own: Check that **Metric units only** is selected. Continue using the Gizmo to solve the **Time** and **Volume** problems. *Note: While common time units (minutes, hours, days) are acceptable to use in the metric system, they are not a part of the metric system.*

6. 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?

   _____

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

   _____

   _____

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

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

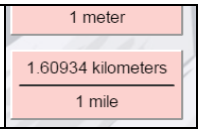
   B. Drag the kilometer-to-meters tile to the green bar. If these aren't the units you want, click **Flip tile**. What unit is given now? _____

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

8. Practice: Turn off **Show result**. Click **Next**, and use what you've learned to solve another speed conversion problem. After you have completed all the speed problems, try solving the density problems. The Gizmo will keep track of how many problems you solve.

   If you are stuck, try converting the unit in the numerator first. Then, convert the unit in the denominator.

9. Challenge: Select **Random** from the **Conversion** menu. You can solve as many problems as you like. Some problems will only require you to convert one unit. Others will require you to convert two units. Good luck!

Activity C: **Mixed units**	Get the Gizmo ready: • Select **Mixed units**. • Select **Distance** from the **Conversion** menu.	

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? _____

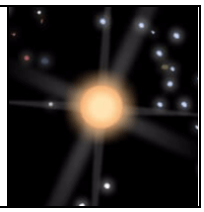
   _____

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

2. Practice: Work through the other mixed-unit distance, speed, mass, volume, and density problems. Then, you can try solving the random problems. The Gizmo will keep track of how many problems you solve. (Note: There are no mixed-unit problems for time because seconds, minutes, and hours are the primary units of time in all predominant measurement systems.)

3. 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

Extension: **Scientific notation**	Get the Gizmo ready: • 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.	

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 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	1 2 3 4 5 6 7 8.3 500 000	83 500 000.0	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
3,700,000	3.700 000	1 2 3 4 5 6 3.700 000	3.7×10^6

   Practice this with the two numbers below:

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

(Extension continued on next page)

Extension (continued from previous page)

3. Identify: Look at the last tile.

   A. 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}	1 2 3 4 5 6 000 007.9	0.000 007.9	0.0000079

Try converting these numbers into standard form:

$1.0 \cdot 10^{-10}$ = _____ $1.6 \cdot 10^{-7}$ = _____

You can perform this process in reverse to convert numbers in standard form into scientific notation, as shown below.

Standard form	Place new decimal point	Count digits	Scientific notation
0.000 05	0.000 05.0	1 2 3 4 5 0.000 05.0	5.0×10^{-5}

Practice this with the two numbers below:

0.00012 = _____ 0.00000000458 = _____

5. Practice: Click **Next** so that you see the question about helium atoms.

   A. What is the diameter of a helium atom in meters? _____

   B. Write this number in standard form: _____