Name:

Skill Sheet 2.2 Converting Units

All measurements have two parts, an amount shown as a number and a unit shown as a word. For example, your height might be 64 (the amount) inches (the unit). This measurement is equivalent to 5 feet 4 inches. Why might you use feet and inches to describe your height versus inches only? The type of unit you use depends on how large or how small a measurement is. For example, the distance to your school might be 158,400 inches or 2.5 miles. Do you see why you might use miles to describe this distance? You will practice converting between units in this skill sheet.

1. Canceling units or ‘crossing out’

Canceling units is the key to converting units. Here are the four concepts involved. Take it a step at a time to see what is happening.

1. One factor multiplied by a fraction is equal to a single fraction:

$$23\ \text{cm} \times \frac{1\ \text{m}}{100\ \text{cm}} = \frac{23\ \text{cm} \times 1\ \text{m}}{100\ \text{cm}}$$

2. Units are just like algebraic variables. Think of them as multiplied by their amounts:

$$\frac{23\ \text{cm} \times 1\ \text{m}}{100\ \text{cm}} = \frac{23\ \times \text{cm} \times 1 \times \text{m}}{100 \times \text{cm}}$$

3. Anything divided by itself is equal to 1:

$$\frac{1}{1} = 1 \qquad \frac{23}{23} = 1 \qquad \frac{\text{cm}}{\text{cm}} = 1$$

4. One times anything is equal to that thing, so multiplying by 1 does not change the value:

$$1 \times 3 = 3 \qquad 1 \times \text{cup} = \text{cup} \qquad 1 \times \text{gram} = \text{gram}$$

See how each of these concepts works together. The first two concepts are applied to three separate fractions:

$$100\ \text{km} \times \frac{1{,}000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{mile}}{1{,}609\ \text{m}} = \frac{100 \times \text{km} \times 1{,}000 \times \text{m} \times 1 \times \text{mile}}{1 \times \text{km} \times 1{,}609 \times \text{m}}$$

Scanning this combined fraction above, we see two cases of like terms in the numerator and the denominator. Kilometers (km) and meters (m) appear in the numerator and the denominator. The third concept above says that anything divided by itself is equal to 1. Therefore, we can cancel out these terms.

$$100\ \text{km} \times \frac{1{,}000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{mile}}{1{,}609\ \text{m}} = \frac{100 \times \overset{1}{\cancel{\text{km}}} \times 1{,}000 \times \overset{1}{\cancel{\text{m}}} \times 1 \times \text{mile}}{1 \times \cancel{\text{km}} \times 1{,}609 \times \cancel{\text{m}}}$$

The fourth concept says that the two 1’s that resulted from canceling will not change the final value. Note that the single remaining unit (miles) is carried over as the unit in the result. To provide a final check, determine whether the resulting unit—in this case, miles—makes sense. Does it make sense to say that 100 kilometers is equal to 62.1 miles?

$$\frac{100 \times 1 \times 1{,}000 \times 1 \times 1 \times \text{mile}}{1 \times 1 \times 1{,}609 \times 1} = 62.1\ \text{miles}$$

2. Choosing conversion factors

The first step of converting units is to select a conversion factor that matches the units of the problem. Sometimes you need more than one conversion factor to solve the problem. For each problem below, circle one or more conversion factors that you would use to solve each problem. You do not need to solve these problems.

Problem	Conversion Factors
Example: 3, 043 meters equals how many kilometers?	$\frac{10\text{ mm}}{1\text{ cm}}$ $\frac{10\text{ cm}}{1\text{ m}}$ [✓ $\frac{1\text{ km}}{1,000\text{ m}}$]
The problem involves meters and kilometers. The circled conversion factor shows the relationship between meters and kilometers (1 km = 1,000 m) so this is the conversion factor to use.	
1. 183 cm equals how many meters?	$\frac{10\text{ mm}}{1\text{ cm}}$ $\frac{1\text{ m}}{100\text{ cm}}$ $\frac{1,000\text{ m}}{1\text{ km}}$
1. 53 mm equals how many centimeters?	$\frac{10\text{ mm}}{1\text{ cm}}$ $\frac{10\text{ cm}}{1\text{ m}}$ $\frac{1,000\text{ m}}{1\text{ km}}$
1. 73,680 cm equals how many kilometers?	$\frac{10\text{ mm}}{1\text{ cm}}$ $\frac{1\text{ m}}{100\text{ cm}}$ $\frac{1\text{ km}}{1,000\text{ m}}$

3. Applying the conversion factor correctly

Conversion problems are solved with one or more conversion factors. In the conversion process, the starting unit is canceled, leaving only the ending unit in the answer. To do this, the unit to be canceled must appear in the denominator of the conversion factor. Sometimes this requires you to invert the conversion factor. Solve each problem with the conversion factor as is or inverted.

Problem	Conversion factors
Example: 1.5 miles is equal to how many kilometers?. $1.5\,\cancel{\text{miles}} \times \frac{1\text{ kilometer}}{0.624\,\cancel{\text{miles}}} = 2.4\text{ kilometers}$	$\cancel{\frac{0.624\text{ miles}}{1\text{ kilometer}}}$ $\frac{1\text{ kilometer}}{0.624\text{ miles}}$ In this problem, the conversion factor needs to be inverted.
1. 4.3 centimeters is equal to how many millimeters?	$\frac{10\text{ millimeters}}{1\text{ centimeter}}$
1. 8,700 milligrams is equal to how many grams?	$\frac{10\text{ milligrams}}{1\text{ gram}}$
1. 4.3 Astronomical Units is equal to how many kilometers?	$\frac{149,597,870.7\text{ kilometers}}{1\text{ Astronomical Unit}}$

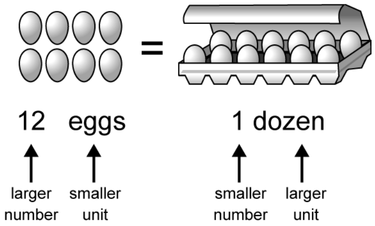
4. Practice problems

Solve the following problems using the conversion factors found on the back cover of your text, *Foundations of Physics*. Additional conversion factors are included with each problem. Round final answers to the nearest tenth.

In problems with more than one conversion factor, work each conversion factor one at a time, working from left to right. Treat the result of the first conversion as though it were the beginning of a new problem and ensure that the new unit to be canceled is in the denominator of the next conversion factor.

Use the following rules to check your work:

- If the ending unit is larger than the starting unit, the ending amount must be smaller that the starting amount. Example: 12 eggs = 1 dozen
  Dozen is a larger unit than egg; 1 is smaller than 12.
- If the ending unit is smaller, the ending amount must be larger than the starting amount.
  Example: 1 meter = 100 centimeters
  Centimeter is smaller than meter; 100 is larger than 1.
- The final unit after conversion must answer the original question.



1. Fill in the following table:

Starting amount and unit	Ending amount and unit
3.0 inches	_____ meters
3.7 gallons	_____ liters
47.0 pounds	_____ kilograms
3.0 pints	_____ liters
230 grams	_____ kilograms
42 millimeters	_____ centimeters
1,000 milliliters	_____ liters
24.3 meters	_____ kilometers

Conversion factors: 0.4536 kilograms = 1 pound or $\frac{0.4536\text{ kg}}{1\text{ pound}}$; 8 pints = 1 gallon or $\frac{8\text{ pints}}{1\text{ gallon}}$

2. The volume of a European hot tub is 2,800 liters, but the building code for floor joist size to support the tub is in gallons. How many gallons should the builder use to calculate the weight of the filled tub?

3. A bullet fired from a .22-caliber rifle leaves the barrel at 1,200 feet per second. How fast is that in meters per second?

   Conversion factor: 0.3048 meters = 1 foot or $\frac{0.3048\text{ meters}}{1\text{ foot}}$

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4. One reason that SI units are not popular in the United States is that converting English units directly into SI units results in numbers with decimals. What would the weight be of a 2-pound can of coffee in grams?

   Conversion factor:

   453.6 grams = 1 pound or $\frac{453.6\text{ grams}}{1\text{ pound}}$

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5. The beverage industry in the United States has been eager to use SI units. One liter of a beverage has 1,000 milliliters. Calculate how many milliliters are in one quart. Why do you think it would be a good marketing move to sell beverages by the liter rather than by the quart?

   Conversion factor:

   4 quarts = 1 gallon or $\frac{4\text{ quarts}}{1\text{ gallon}}$

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6. A young French girl went to the market and bought 200 grams of cheese for her mother. About how many ounces of cheese did she buy?

   Conversion factors:

   453.6 grams = 1 pound or $\frac{453.6\text{ grams}}{1\text{ pound}}$

   16 ounces = 1 pound or $\frac{16\text{ ounces}}{1\text{ pound}}$

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7. **Challenge problem:** Here is a good multipart problem that gives you an eye-opening idea of the immense distances of space. It is also completely imaginary. Although we know sound cannot travel through a vacuum, imagine that sound can travel in space at the same speed it travels through air under standard conditions. Our sun has just erupted in an enormous solar flare. We will see it in about 8 $^1/_2$ minutes because of the speed of light. But how long after the flare would we hear it under these imaginary conditions? Round to the nearest whole number after each step.

   Conversion factors:

   Distance to sun = 93,000,000 miles

   Speed of sound under standard conditions = 343 meters per second.

   One kilometer = 0.62 miles

   One kilometer = 1,000 meters

   One hour = 3,600 seconds.

   One year = 8,766 hours.

   HINT: Convert the sun's distance to meters and calculate the number of seconds, then convert the number of seconds to years.
