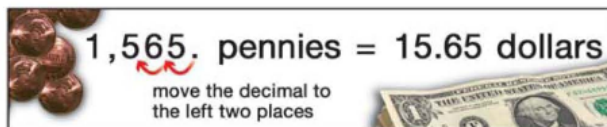


1.3 Converting Units

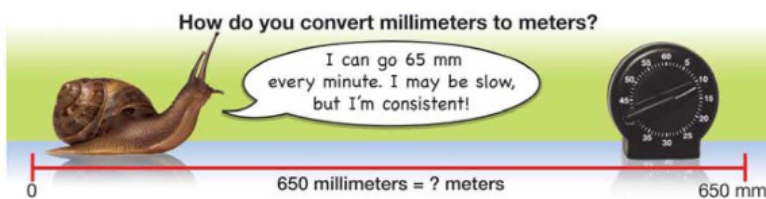
When describing the length of a ski, you could say that it is 150 centimeters or 1.5 meters. The ski length is the same—the only thing that is different is the measurement unit. Unit conversion is an important skill in measurement.

Why convert?

What does it mean to “convert”? Suppose you empty your coin bank and count out 1,565 pennies. How do you figure out how many dollars you have? You have to convert the 1,565 cents to a dollar amount. Since there are 100 pennies in a dollar, you divide 1,565 by 100. This is the same as moving the decimal point two places to the left. 1,565 pennies and 15.65 dollars represent the same amount of money.



Converting SI units Converting SI units is just as easy as converting pennies to dollars. Suppose a snail can travel about 65 millimeters in one minute. In ten minutes it can go ten times as far (65×10) or 650 mm. It's hard to visualize 650 mm. You know that a meter stick is relatively close in size to a yard stick, which you are familiar with. If you convert millimeters to meters, you might be able to better visualize how far the snail can travel in ten minutes.



CHALLENGE

SI Estimation Challenge

For each item below, only one measurement in the list is realistic. The other two measurements are wildly wrong. Can you choose the realistic measurement for each item?

- width of a postage stamp
1 m, 15 cm, or 20 mm
- thickness of a CD
0.1 m, 0.01 m, or 0.001 m
- height of a bus
152.4 mm, 20 m, or 250 cm
- length of an inchworm
25.4 mm, 25.4 cm, or 0.254 m
- length of a football field
91.44 m, 200 m, or 1 km

Chapter 1 MEASUREMENT



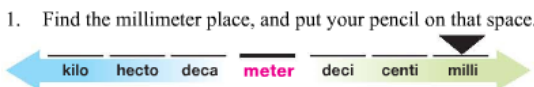
Solving Problems: Converting SI Units

When you convert from one SI unit to another, you multiply or divide by a series of tens. This conversion tool will help you move the decimal point.



Convert 650 millimeters to meters.

- 1. **Looking for:** You are asked for the distance in meters.
- 2. **Given:** You are given the distance in millimeters.
- 3. **Relationships:** There are 1,000 millimeters in 1 meter.
- 4. **Solution:**



- 1. Find the millimeter place, and put your pencil on that space.
- 2. Move your pencil to the meters place, and count how many spaces you move your pencil, including the last landing space.



- 3. Now move the decimal point in 650 to the left three places.

650. becomes .650
650 mm = 0.650 m

Your turn...

- a. Convert 142 kilometers to meters.
- b. Convert 754,000 centimeters to kilometers.

STUDY SKILLS

SI Conversion Tool

Copy this SI place value table on an index card so you can refer to it whenever you have to convert SI units. The table will tell you how many places to move the decimal point, and in what direction to move it.



SOLVE FIRST LOOK LATER

- a. 142,000 m
- b. 7.54 km

Converting between English and SI units

The problem of multiple units It would be easier if everyone always used the same unit, such as the meter, for length. Unfortunately, many different units of length are used depending on what's being measured and where the measurer lives. In the United States, inches, feet, and miles are used more commonly than centimeters, meters, and kilometers, but sometimes you will need to convert from English to SI units.

Comparing English and SI units Downhill skis come in many different lengths, measured in centimeters. If you stand a ski up next to you, the ski should come up as high as your chin. Suppose the distance from your toes to your chin is 4.5 feet. What length skis, in centimeters, should you buy? To answer the question, you need to convert from feet to centimeters. To do the conversion, you have to multiply 4.5 feet by a conversion factor. A **conversion factor** is a ratio that has the value of one. Study the problem solving steps on the next page to learn how to set up a conversion using conversion factors. This method of converting units is called **dimensional analysis**.



VOCABULARY

conversion factor - a ratio that has a value of one and is used when setting up a unit conversion problem.

dimensional analysis - a method of using conversion factors and unit canceling to solve a unit conversion problem.

SCIENCE FACT

English and SI Units

Suppose you are working on your bicycle and the wrench you select is one size too small. The illustration below shows that it is easier to choose the next bigger size if you use SI units.

Wrenches in Inches (English Units)	
	3/8"
	7/16"
Wrenches in Millimeters (SI Units)	
	11
	10

Which is the bigger wrench in each pair?

Chapter 1 MEASUREMENT



Solving Problems: Converting Units

Convert 4.5 feet to centimeters.

- 1. **Looking for:** You are asked for a length in centimeters.
- 2. **Given:** You are given the length in feet.
- 3. **Relationships:** There are 30.48 cm in 1 foot (you can look this up in a conversion table).
- 4. **Solution:**
 1. Write down the given measurement and a multiplication symbol.

$$4.5 \text{ feet} \times$$

2. Create a conversion factor by drawing a fraction bar and copying the given unit (feet) into the bottom of the fraction. Next, put the unit you are looking for in the numerator (cm). Put the number "1" next to the larger unit (foot) and for the smaller unit, write down how many of them equal one of the larger unit (30.48).

$$4.5 \text{ feet} \times \left(\frac{30.48 \text{ cm}}{1 \text{ foot}} \right)$$

3. Cancel like units in the problem setup. This is how you keep track of how well your dimensional analysis setup is working. Your goal is to cancel all units except the one you are solving for (cm).

$$4.5 \text{ feet} \times \left(\frac{30.48 \text{ cm}}{1 \text{ foot}} \right) = 137 \text{ cm}$$

4. Now you are ready to do the math! This problem setup tells you to multiply 4.5 by 30.48. The answer is 137 cm (rounded).

Your turn...

- a. Convert 175 yards to meters. (You might need more than one fraction!)
- b. Convert 2.50 inches to millimeters. (More than one fraction is needed!)

STUDY SKILLS

Handy Conversion Factors

Use these handy conversion factors anytime you need to set up a unit canceling problem like the one on this page.

Note: You can flip these fractions around as needed; the 1 (larger unit) isn't always in the denominator.



SOLVE FIRST LOOK LATER

- a. 160 m
- b. 63.5 mm

Working with measurements

Significant Digits All measurements involve a degree of uncertainty. The object in Figure 1.12 is definitely longer than 2.6 cm. But how much longer? Not everyone would agree on the third digit of the measurement. One person might read the measurement as 2.63 cm, and another might argue it is closer to 2.65 cm. In the real world it is *impossible* to make a measurement of the exact true value of anything (except when counting). Using the ruler pictured in Figure 1.12, the best answer for the length of the paper clip is 2.65 cm. To a scientist this number means “between 2.60 and 2.70 cm.” The last digit, 5, representing the smallest amount, is uncertain. **Significant digits** are the meaningful digits in a measured quantity. For the paper clip, the third digit is meaningful even though it is uncertain. The third digit tells someone the object is about halfway between 2.60 and 2.70 cm long. Therefore, we say there are three useful or significant digits in this length measurement. It is important to be honest when reporting a measurement, so readers know how much resolution it has. We do this by using significant digits to report the measurement.

Using significant digits in math problems What happens when you use measured quantities with *different numbers of significant digits* in a math problem? For example, a shoe is 38 cm long and you want to convert the length to inches.

$$38 \text{ cm} \times \left(\frac{1 \text{ inch}}{2.54 \text{ cm}} \right) = ?$$

To find the answer, divide 38 by 2.54 and you get 14.960629. This answer has an artificially large number of significant digits (eight!). An answer involving measured quantities should have no more significant digits than the starting measurement with the least number of significant digits. The correct answer to this conversion problem is rounded up to 15 inches, since 38 centimeters has two significant digits. Study the next page for more help with using significant digits in math problems.

VOCABULARY

significant digits - meaningful digits in a measured quantity.



Figure 1.12: Find the length of the object in centimeters. How many digits does your answer have?

Chapter

1

MEASUREMENT



Solving Problems: Significant Digits

What is the area of an 8.5-inch by 11.0-inch piece of paper?

- 1. Looking for:** You are asked for an area.
- 2. Given:** You are given the width, 8.5 inches, and the height, 11.0 inches.
- 3. Relationships:** Area = width \times length
- 4. Solution:** Area = 8.5 inch \times 11.0 inch

Area = 93.5 square inches (too many significant digits—see below)

93.5 has three significant digits. The width measurement had only two significant digits (8.5), and the length measurement had three significant digits (11.0). So how many significant digits should your answer have? The answer can have no more significant digits than the measurement with the least number. In this case, since the width measurement only had two significant digits, your answer can only have two. You must round 93.5 square inches to 94 square inches. The correct answer is 94 square inches.

Your turn...

- How many significant digits does each of these numbers have? 40 cm, 4 cm, 4.0 cm, 40. cm, 45 cm, 450 cm, 450. cm
- Convert 1.10 miles to kilometers and report your answer with the correct number of significant digits. Use the relationship 1 mi = 1.6 km.

STUDY SKILLS

Which digits are significant?

Digits that are **always significant**:

- Non-zero digits.
- Zeros between two significant digits.
- All *final zeros* to the *right* of a decimal point.

Digits that are **never significant**:

- Leading zeros to the right of a decimal point. (0.002 cm has only one significant digit.)
- Final zeros in a number that does not have a decimal point.

Note: A decimal point is used after a whole number ending in zero to indicate that a final zero IS significant. Thus, 50. cm has two significant digits, not one.

SOLVE FIRST LOOK LATER

- 40 cm: 1; 4 cm: 1; 4.0 cm: 2; 40. cm: 2; 45 cm: 2; 450 cm: 2; 450. cm: 3
- 1.8 km

Section 1.3 Review

1. What does it mean to “convert” from one unit to another? Give an example.
2. How many meters do you cover in a 10-kilometer (10-K) race?
3. An Olympic swimming pool is 50 meters long. You swam from one end to the other four times.
 - a. How many meters did you swim?
 - b. How many kilometers did you swim?
 - c. How many centimeters did you swim?
4. In the United States, a standard letter-sized piece of paper is 8.5 inches wide by 11.0 inches long. The international standard for a letter-sized piece of paper is different. The international standard is based on SI units: 21.0 cm wide by 29.7 cm long.
 - a. Convert 21.0 cm to inches. Show your dimensional analysis setup.
 - b. Convert 29.7 cm to inches. Show your dimensional analysis setup.
 - c. State the dimensions, in inches, of the international standard for a letter-sized piece of paper.
 - d. Which piece of paper is longer: a U.S. letter-sized piece of paper, or an international letter-sized piece of paper?
 - e. Suppose the United States adopted the international standard for letter-sized paper. Explain at least two things that might result from this change.
5. Which of these measurements has three significant digits? (There might be more than one correct answer choice.)
 - a. 29.3 cm
 - b. 290 cm
 - c. 0.029 cm
 - d. 290. cm
6. Convert 345 cm to inches. Show your dimensional analysis setup and report your answer with the correct number of significant digits. (1 in = 2.54 cm).

JOURNAL

Find Out!

What are the official measurements for an Olympic swimming pool? Create a table in your journal with the answers:

- length of pool
- width of pool
- number of lanes
- lane width
- water temperature
- depth

KEYWORDS

Do an Internet search using the key words “international paper size.” Write a report of your findings about the standards for paper sizes. Do all countries use the same size paper for letters? How was the international standard paper size defined? What are some interesting outcomes of having different standard paper sizes in different countries? What surprised you the most about what you learned from your research?

