SYSTEMS OF MEASUREMENT

In this unit, you will investigate the metric and customary systems of measurement. You will measure and convert units of length, mass, and capacity. You will examine conversions within and between the customary and metric systems of measurement. You will also learn how to use the scientific method of unit analysis to make conversions of rates. The unit closes with problems about formulas and scale drawings.

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Metric Units

Scientists, doctors, and people of many other countries use the metric system of measurement.

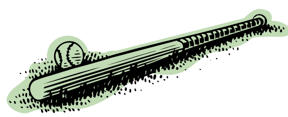
Length

Kilometer (km)

A kilometer is a distance that is about 7 blocks long.
Kilometers are used to measure long distances.

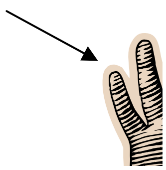
A kilometer equals 0.6 mile.

Meter (m)



A meter is about as long as a baseball bat.
A meter stick could be used to measure the length of a room.

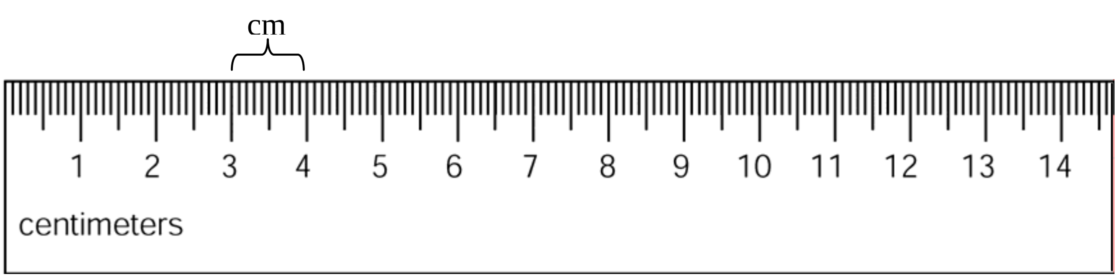
A meter equals 1.09 yards.



Centimeter (cm)

A centimeter is about the width of the “pinky” finger.
A centimeter is a little less than half an inch long.

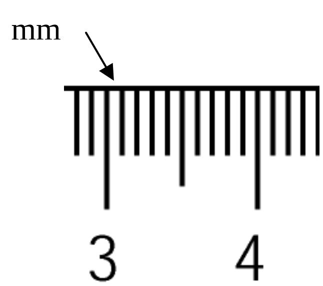
A centimeter equals 0.39 inches.



Millimeter (mm)

A millimeter is about as long as
the thickness of the wire in a paper clip.
The thickness of a dime is about 2 millimeters.

A millimeter equals 0.04 inches.

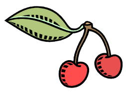


not actual size

Weight

A pair of shoes could weigh about a kilogram. 

A kilogram weighs 2.2 pounds.

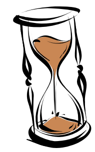


The weight of a cherry is close to a gram.

A gram weighs 0.04 ounces.

The weight of a grain of sand is close to a milligram.

A milligram weighs 0.000035 ounces.



Capacity

A liter is a little more than a quart of milk.

A liter equals 1.06 quarts.

The amount of medicine that is held in a dropper is about one milliliter.

A milliliter equals 0.03 ounces.

Metric System Prefixes

Metric prefixes have meaning.

Kilo **means 1000 times the base unit.**		***kilo*** **+ meter means 1000 meters.** **1 kilometer = 1000 meters** ***kilo*** **+ gram means 1000 grams.** **1 kilogram = 1000 grams**
Hecto **means 100 times the base unit.**		***hecto*** **+ meter means 100 meters.** **1 hectometer = 100 meters** ***hecto*** **+ liter means 100 liters.** **1 hectoliter = 100 liters**
Deca **+ meter means 10 meters.**		***deca*** **+ meter means 10 meters.** **1 decameter = 10 meters** ***deca*** **+ gram means 10 grams.** **1 decagram = 10 grams**
Deci **means** $\frac{1}{10}$ **th of the base.**		***deci*** **+ meter means** $\frac{1}{10}$ **of a meter.**
1 decimeter = $\frac{1}{10}$ **of a meter**	*or*	**1 meter = 10 decimeters**
Centi **means** $\frac{1}{100}$ **th of the base.**		***centi*** **+ meter means** $\frac{1}{100}$ **of a meter.**
1 centimeter = $\frac{1}{100}$ **of a meter**	*or*	**1 meter = 100 centimeters**
Milli **means** $\frac{1}{1000}$ **th of the base.**		***milli*** **+ meter means** $\frac{1}{1000}$ **of a meter.**
1 millimeter = $\frac{1}{1000}$ **of a meter**	*or*	**1 meter = 1000 millimeters**
		milli **+ gram means** $\frac{1}{1000}$ **of a gram.** **1 gram = 1000 milligrams**
		milli **+ liter means** $\frac{1}{1000}$ **of a liter.** **1 liter = 1000 milliliters**

Metric System Conversion Tables

Length	
kilometer (km)	1000 meters
hectometer (hm)	100 meters
dekameter (dkm)	10 meters
1 decimeter (dm)	$\frac{1}{10}$ m
1 centimeter (cm)	$\frac{1}{100}$ m
1 millimeter (mm)	$\frac{1}{1000}$ m

Weight	
kilogram (kg)	1000 grams
hectogram (hg)	100 grams
dekagram (dkg)	10 grams
1 decigram (dg)	$\frac{1}{10}$ g
1 centigram (cg)	$\frac{1}{100}$ g
1 milligram (mg)	$\frac{1}{1000}$ g

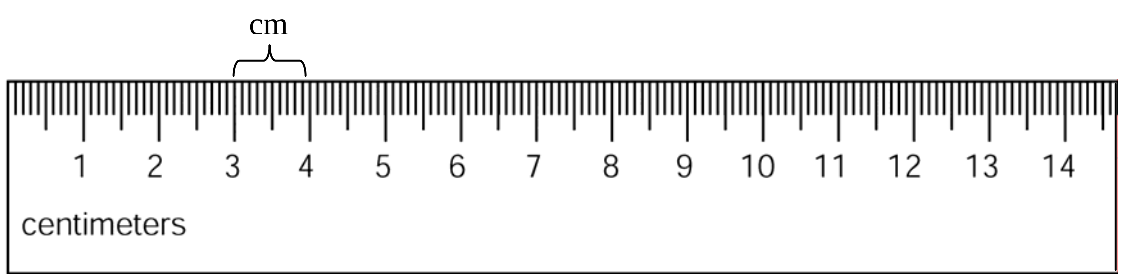
Capacity	
kiloliter (k*l*)	1000 liters
hectoliter (h*l*)	100 liters
dekaliter (dk*l*)	10 liters
1 deciliter (d*l*)	$\frac{1}{10}\,l$
1 centiliter (c*l*)	$\frac{1}{100}\,l$
1 milliliter (m*l*)	$\frac{1}{1000}\,l$

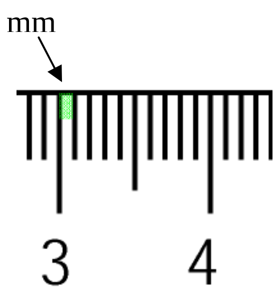
Measuring with Metric Units of Length

Look closely at the rulers below to view centimeters and millimeters.

Each centimeter is represented by the longest marks. A centimeter is the length from the mark of one number to the mark of the next number.

One centimeter (from 3 to 4) is enlarged to show the millimeter segments more clearly. Count the spaces between 3 and 4. There are 10 spaces. This means there are 10 millimeters in a centimeter.



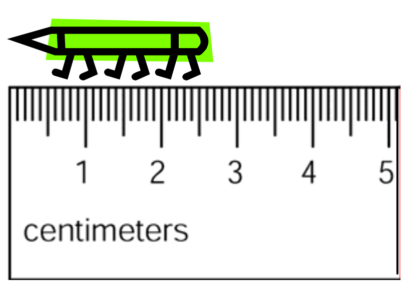


not actual size

1 cm = 10 mm

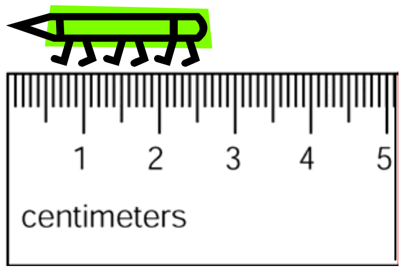
*Note: The marks that are longer than the millimeter marks, but shorter than the centimeter marks, are the halfway marks between one centimeter and the next centimeter. Thus the half-way marks denote 1/2 cm (1/2 of a centimeter) or 5 millimeters (1/2 of 10 millimeters).

Example 1: Using the ruler shown below, determine approximately how long the pencil is in **centimeters**.



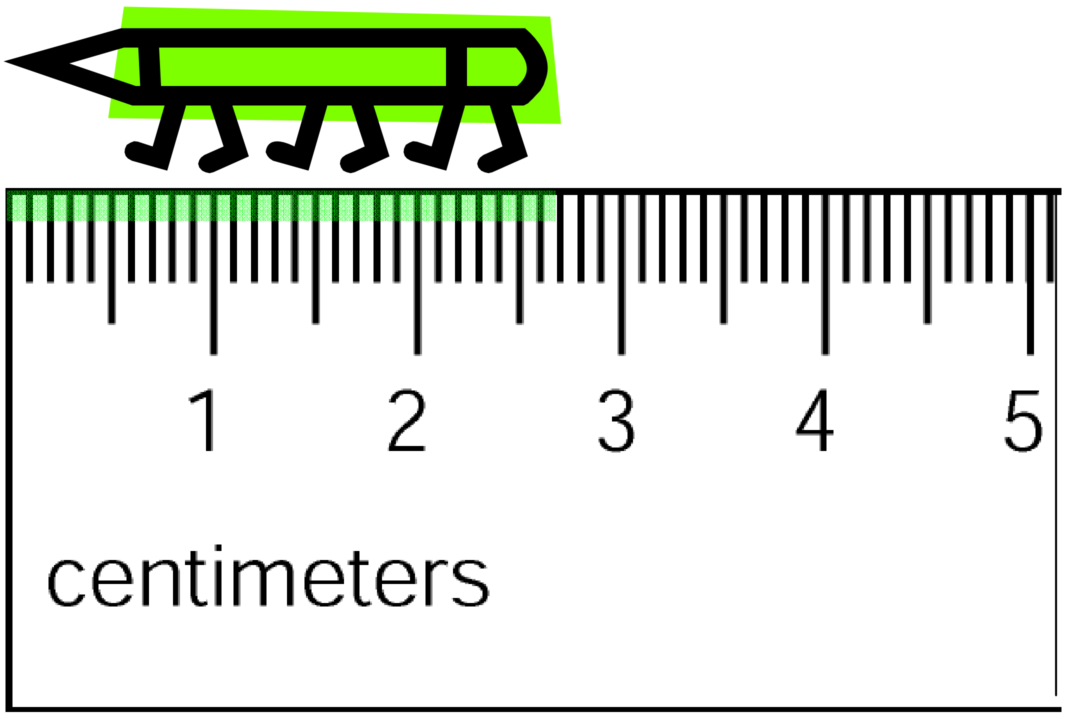
Since the pencil is a little over halfway between 2 and 3, the length of the pencil is closer to 3 cm than 2 cm. The pencil measures approximately **3 cm (centimeters)**.

Example 2: Using the same ruler shown below, determine approximately how long the pencil is in **millimeters**.



Since one centimeter equals 10 millimeters, count 10, 20 up to 2 centimeters, then count in ones. The pencil is approximately **27 mm (millimeters)** long.

Examine the “zoomed –in” view of the ruler for a closer look.

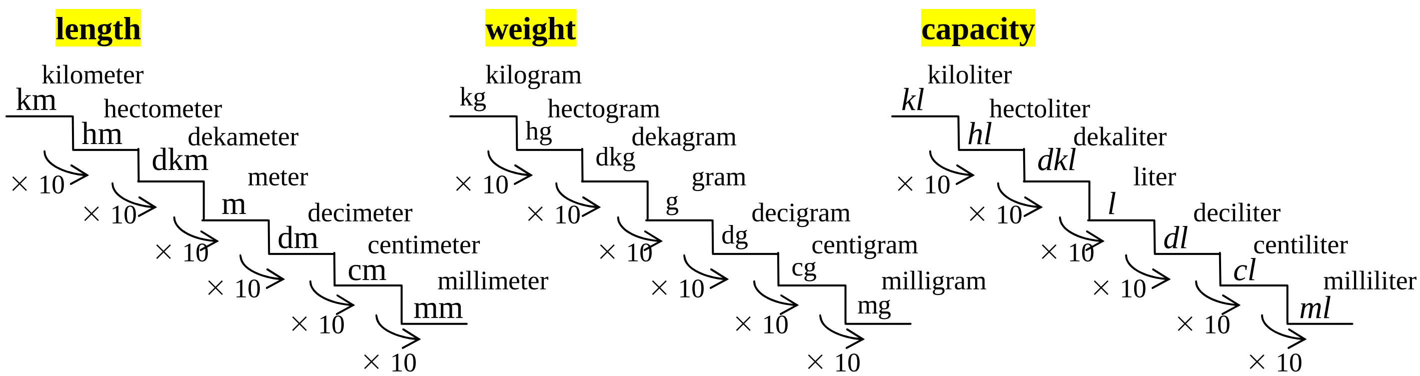


Converting Metric Units

Large Units to Small Units (MULTIPLY)

To express a **larger unit as a smaller unit**, **MULTIPLY** by the conversion factor.

The metric units are arranged on steps in order from the largest unit on the top step to the smallest unit on the bottom step. The conversion factor is beside the arrow. Start on the top step and **step down** to convert from a larger unit to a smaller unit.



Let's take a look at how to use the steps to convert units "within" the metric system. Place your pencil on the given unit, and then "step" down, counting each step down as you go along. Stop when you reach the unit to which you are converting. Each step down represents a "multiplication by 10".

Example 1: 7 km = ____________ m

Using the steps,

multiply 7 × 10 × 10 × 10 (three steps down)

or

multiply 7 × 1000.

7 km = 7000 m

Example 2: 4.8 g = ____________ cg

Using the steps,

multiply 4.8 × 10× 10 (two steps down)

or

multiply 4.8 × 100.

4.8 g = 480 cg

Example 3: 5 *dkl* = ____________ *l*

Using the steps, multiply 5 × 10.

5 *dkl* = 50 *l*

*Reminder: When you **multiply** by numbers that are powers of ten (10, 100, 1000, etc.), you can count the zeros and **move** the **decimal point** that many places to the **right**.

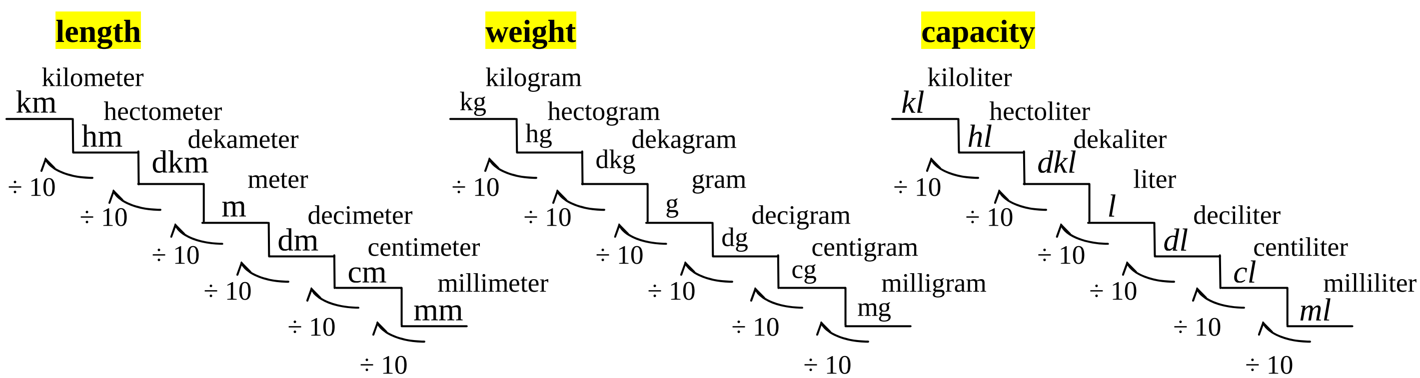
In Example 2 above, the shortcut for multiplying 4.8 by 100 is to move the decimal point two places to the right. Fill in with zeros as needed.

$$4.8 \times 100 = (4.\underline{8\_} \rightarrow 480.) = 480$$

Small Units to Large Units (DIVIDE)

To express a **smaller unit as a larger unit**, **DIVIDE** by the conversion factor.

The metric units are arranged on steps in order from the largest unit on the top step to the smallest unit on the bottom step. The conversion factor is beside the arrow. Start on the bottom step and **step up** to convert from a smaller unit to a larger unit.



Let’s take a look at how to use the steps to convert units “within” the metric system. Place your pencil on the given unit, and then “step” up, counting each step up as you go along. Stop when you reach the unit to which you are converting. Each step up represents a “division by 10”.

Example 1: 700 cm = __________ m

Using the steps,
compute 700 ÷ 10 ÷ 10.
(two steps up)
or
compute 700 ÷ 100.

700 cm = 7 m

Example 2: 80 mg = __________ cg

Using the steps, divide 80 by 10.

80 mg = 8 cg

Example 3: 6500 *ml* = __________ *l*

Using the steps,
compute 6500 ÷ 10 ÷ 10 ÷ 10.
(three steps up)
or
compute 6500 ÷ 1000.

6500 ml = 6.5 *l*

*Reminder: When you **divide** by numbers that are powers of ten (10, 100, 1000, etc.), you can count the zeros and **move** the **decimal point** that many places to the **left**.

In Example 3 above, the shortcut for dividing 4500 by 1000 is to move the decimal point three places to the left. Drop zeros that are no longer needed after the division occurs.

$$6500 \div 1000 = (6500. \to 6\underline{500}. \to 6.\underline{500} \to 6.5\cancel{0}\cancel{0}) = 6.5$$

Metric Units of Area

Use the table of metric units of area to find equivalent areas.

Unit	Abbreviation	Equivalence
square kilometer	sq km or km^2	1 sq km = 1,000,000 square meters
hectare	ha	1 ha = 10,000 square meters
square centimeter	sq cm or cm^2	1 sq cm = 0.0001 square meter

Example 1: Terry's ranch covers five hectares. She wants to calculate the area of her ranch in square meters.

- Terry's ranch is 5 hectares.
- Refer to the conversion table, 1 hectare = 10,000 square meters.
- Calculate the area in square meters.

$5 \text{ ha} = ? \text{ m}^2$

Write a proportion comparing units.

$$\frac{\text{ha}}{\text{m}^2} = \frac{\text{ha}}{\text{m}^2}$$

Substitute the conversion data from the chart (1 ha = 10,000 sq m) and the information given in the problem (5 ha) into the proportion. Let *n* represent the area of the farm in square meters.

$$\frac{1}{10,000} = \frac{5}{n}$$

Cross multiply.

$$n = 50,000$$

The area of the Terry's five-hectare ranch is 50,000 square meters.

Example 2: 2000 square centimeters = ___________ square meters

- Given: 2000 square centimeters.
- From the conversion table, 1 square centimeter = 0.0001 square meter.
- Set up a proportion and solve.

$$2000\ cm^2 = ?\ m^2$$

Write a proportion comparing units.

$$\frac{\mathrm{m}^2}{\mathrm{cm}^2} = \frac{\mathrm{m}^2}{\mathrm{cm}^2}$$

Substitute the conversion data from the chart (1 sq cm = 0.0001 sq m) and the information given in the problem (2000 sq cm) into the proportion. Let *n* represent the number of square meters.

$$\frac{0.0001}{1} = \frac{n}{2000}$$

Cross multiply.

$$(1)n = (0.0001)(2000) \qquad \text{-simplify}$$
$$n = 0.2$$

2000 sq cm = 0.2 sq m

Example 3: __________ hectare(s) = 12,000 square meters

- Given: 12,000 square meters.
- From the conversion table, 1 hectare = 10,000 square meters.
- Set up a proportion and solve.

$$?\ \mathrm{ha} = 12{,}000\ \mathrm{m}^2$$

Write a proportion comparing units.

$$\frac{\mathrm{ha}}{\mathrm{m}^2} = \frac{\mathrm{ha}}{\mathrm{m}^2}$$

Substitute the conversion data from the chart (1 ha = 10,000 sq m) and the information given in the problem (12,000 sq m) into the proportion. Let *n* represent the number of hectares.

$$\frac{1}{10,000} = \frac{n}{12,000}$$

Cross multiply.

$$10,000n = 12,000$$ -divide by 10,000

$$n = 1.2$$

12,000 sq m = 1.2 hectares

Metric Units of Volume

Unit	Abbreviation	Number of Cubic Meters
cubic meter	cu m or m^3	1 cubic meter = 1,000,000 cubic centimeters
cubic centimeter	cu cm or cm^3	1 cubic centimeter = 0.000001 cubic meter

Let's take a look at the meaning of the metric equivalences given in the table above.

First, let's examine the conversion: 1 cubic meter = 1,000,000 cubic centimeters.

$1 \text{ m} = 100 \text{ cm}$ Metric conversion of length from meter to centimeter.

$(1\,\text{m})^3 = (100\,\text{cm})^3$ Cube both sides of the equation.

$1\,\text{m}^3 = 1,000,000\,\text{cm}^3$ $100 \times 100 \times 100 = 1,000,000$

Next, let's examine the conversion: 1 cubic centimeter = 1 millionth of a cubic meter.

$1 \text{ cm} = \frac{1}{100} \text{ m}$ Metric conversion of length from centimeter to meter.

$(1\,\text{cm})^3 = (\frac{1}{100} \text{ m})^3$ Cube both sides of the equation.

$1\,\text{cm}^3 = \frac{1}{1,000,000}\,\text{m}^3$ $\frac{1}{100} \times \frac{1}{100} \times \frac{1}{100} = \frac{1}{1,000,000}$

$\therefore 1\,\text{cm}^3 = 0.000001 \text{ m}^3$ $\frac{1}{1,000,000} = 0.000001$

Example 1: 500 cubic meters = __________ cubic centimeters

- Given: 500 cubic meters.
- From the conversion table, 1 cubic meter = 1,000,000 cubic centimeters.
- Set up a proportion and solve.

$500 \text{ m}^3 = ? \text{ cm}^3$

Write a proportion comparing units.

$$\frac{\text{m}^3}{\text{cm}^3} = \frac{\text{m}^3}{\text{cm}^3}$$

Substitute the conversion data from the chart (1 cu m = 1,000,000 cu cm) and the information given in the problem (500 cu m) into the proportion. Let *n* represent the number of cubic centimeters.

$$\frac{1}{1,000,000} = \frac{500}{n}$$

Cross multiply.

$(1)n = (1,000,000)(500)$ -simplify

$n = 500,000,000$

500 cu m = 500,000,000 cu cm

Example 2: __________ cubic meters = 900,000 cubic centimeters

- Given: 900,000 cubic centimeters.
- From the conversion table, 1 cubic centimeter = 0.000001 cubic meters.
- Set up a proportion and solve.

$? \text{ m}^3 = 900,000 \text{ cm}^3$

Write a proportion comparing units.

$$\frac{\text{m}^3}{\text{cm}^3} = \frac{\text{m}^3}{\text{cm}^3}$$

Substitute the conversion data from the chart (1 cu cm = 0.000001 cu m) and the information given in the problem (900,000 cu cm) into the proportion. Let *n* represent the number of cubic meters.

$$\frac{0.000001}{1} = \frac{n}{900,000}$$

Cross multiply.

$$(1)n = (0.000001)(900,000) \qquad \text{-simplify}$$
$$n = 0.9$$

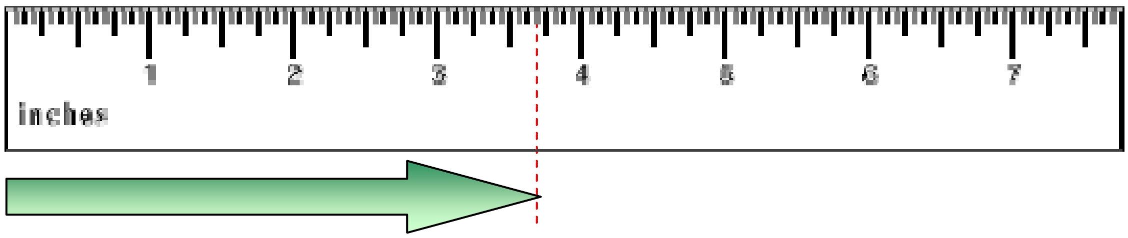
900,000 cu cm = 0.9 cu m

Measuring to the Nearest 16th Inch

This ruler is divided into 16ths of an inch.

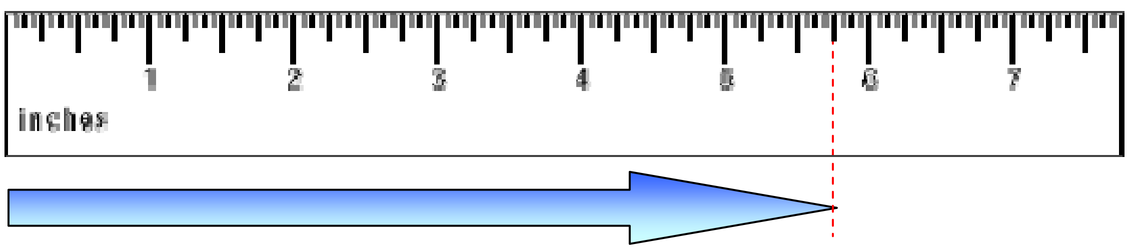
To measure to the nearest sixteenth of an inch, count the **spaces** between the mark from the beginning of one whole inch up to the mark of the measurement. Write the measurement in 16ths, and then reduce if possible.

Example 1: How long is the green arrow?



The arrow's tip falls on $\frac{11}{16}$; therefore, the arrow's length is $3\frac{11}{16}$ inches.

Example 2: How long is the blue arrow?



The arrow's tip falls on $\frac{12}{16}$; thus, the arrow's length is $5\frac{12}{16}$ inches, which reduces to $5\frac{3}{4}$ inches.

Customary and Metric Units Conversion Charts

Use these customary unit equivalences to compute and make conversions.

Units of Length	Customary Unit Equivalence	Metric Unit Equivalence
1 foot (ft)	12 inches (in)	30.48 cm
1 yard (yd)	3 ft or 36 in	0.91 m
1 mile (mi)	1760 yd or 5280 ft	1.61 km

Units of Weight	Customary Unit Equivalence	Metric Unit Equivalence
1 ounce (oz)		28.35 g
1 pound (lb)	16 ounces (oz)	0.45 kg
1 ton (T)	2000 lb	907.18 kg

Units of Capacity	Customary Unit Equivalence	Metric Unit Equivalence
1 fluid ounce (fl oz)		29.57 *ml*
1 cup (c)	8 fluid ounces (fl oz)	236.59 *ml*
1 pint (pt)	2 c	0.47 *l*
1 quart (qt)	2 pt	0.95 *l*
1 gallon (gal)	4 qt	3.79 *l*

Units of time – seconds, minutes, hours, days, week, months, years	
1 minute (min)	60 seconds (s)
1 hour (hr)	60 min
1 day (d)	24 hr
1 week (wk)	7 d
1 year (y)	52 wk, 12 months (mo), 365 d

Customary Units Conversions and Computations

To express a **larger unit as a smaller unit**, **MULTIPLY** by the conversion factor.

Example 1: How many ounces are in 7 pounds?

$7 \times 16 = 112$ **(1 lb = 16 oz)**

There are 112 ounces in 7 pounds.

Example 2: How many inches are in 5 feet 4 inches?

5 feet $\times$ **12** = 60 inches **+ 4 extra inches** equals 64 inches. **(1 ft = 12 in)**

There are 64 inches in 5 feet 4 inches.

To express a **smaller unit as a larger unit**, **DIVIDE** by the conversion factor.

Example 3: How many gallons are equal to 18 quarts?

18 qt $\div$ **4** = $4\frac{1}{2}$ gal **(1 gal = 4 qt)**

$$\begin{array}{r} 4\tfrac{2}{4} = 4\tfrac{1}{2} \\ 4\overline{)18} \\ \underline{16} \\ 2 \end{array}$$

There are 4 1/2 gallons in 18 quarts.

Here are some sample problems for computing within the customary system of measurement.

Example 4: Add.

$$\begin{array}{r} \text{5 feet 7 inches} \\ \underline{+\text{2 feet 8 inches}} \\ \text{7 feet 15 inches} \end{array}$$

Simplify

7 feet 15 in = 7 ft + 1 ft + 3 in

15 inches =
12 inches + 3 inches =
1 foot 3 inches

8 feet 3 inches

The sum of 5 feet 7 inches and 2 feet 8 inches equals 8 fee 3 inches.

Example 5: Subtract.

Since 22 is smaller than 45, borrow1 hour from the 6 hours, leaving 5 hours. Convert the 1 hour to 60 minutes, and then combine with the 22 minutes.
Thus, 6 hr 22 min equals 5 hr 82 min.

6 hr 22 min =	5 hr 82 min
-3 hr 45 min =	3 hr 45 min
	2 hr 37 min

6 hr 22 min = 5 hr + 1 hr + 22 min =
5 hr + 60 min + 22 min =
5 hr + 82 min

The difference between 6 hours 22 minutes and 3 hours 45 minutes is 2 hours 37 minutes.

Customary Units of Area

Use the table of customary units of area to find equivalent areas.

Unit	Abbreviation	Customary Unit Equivalence	Metric Unit Equivalence
square mile	sq mi or mi^2	1 sq mi = 640 acres 1 sq mi =102,400 square rods	
acre		1 acre = 4840 square yards 1 acre = 43,560 square feet	1 acre = 0.407 hectares
square rod	sq rd or rd^2	1 sq rd = 30.25 square yards 1 sq rd = 0.006 acres	
square yard	sq yd or yd^2	1 sq yd = 1296 square inches 1 sq yd = 9 square feet	1 sq yd = 0.8361 square meters
square foot	sq ft or ft^2	1 sq ft = 144 square inches 1 sq ft = 0.111 square yards	
square inch	sq in or in^2	1 sq in = 0.007 square feet 1 sq in = 0.00077 square yards	1 sq in = 6.4516 sq cm.

Example 1:

5 square yards = ___________ square feet

$$\frac{1}{9} = \frac{5}{n} \quad \rightarrow \quad \text{Cross-multiply}$$

n = 45 sq ft

Following the **conversion chart**, we state square yards to square feet on both sides of the proportion.
On the left, we compare 1 sq yd to 9 sq ft.
On the right, we compare 5 sq yd to "*n*" sq ft.
We then cross-multiply to solve.

Example 2:

72 square inches = ___________ square feet

$$\frac{1}{0.007} = \frac{72}{n} \quad \rightarrow \quad \text{Cross-multiply}$$

n = 0.504 sq ft or about a half of a square foot.

Following the **conversion chart**, we state square inches to square feet on both sides of the proportion.
On the left, we compare 1 sq in to .007 sq ft.
On the right, we compare 72 sq in to "*n*" sq ft.
We then cross-multiply to solve.

Example 3:

2420 square yards = ___________ acres

$$\frac{1}{4840} = \frac{n}{2420} \quad \text{Cross-multiply}$$

$4840\,n = 2420$

$n = 2420 \div 4840$

$n = 0.5$ or $\frac{1}{2}$ acre

Following the **conversion chart**, we state acres to square yards on both sides of the proportion.
On the left, we compare 1 acre to 4840 sq yd
On the right, we compare "*n*" acres to 2420 sq yd.
We then cross-multiply and divide to solve.

Customary Units of Volume

Unit	Abbreviation	Customary Unit Equivalence	Metric Unit Equivalence
cubic yard	cu yd or yd^3	1 cu yd = 27 cubic feet 1 cu yd = 46,656 cubic inches	1 cu yd = 0.7646 cubic meter
cubic foot	cu ft or ft^3	1 cu ft = 1728 cubic inches 1 cu ft = 0.0370 cubic yards	
cubic inch	cu in or in^3	1 cu in = 0.00058 cubic feet 1 cu in = 0.000021 cubic yards	1 cu in = 16.39 cubic centimeters

Example:

10 cubic yards = ___________ cubic feet

$\frac{1}{27} = \frac{10}{n}$ $\rightarrow$ Cross-multiply

n = 270 cubic feet

Following the **conversion chart**, we state cubic yards to cubic feet on both sides of the proportion.
On the left, we compare 1 cu yd to 27 cu ft.
On the right, we compare 10 cu yd to "n" cu ft.
We then cross-multiply to solve.

Unit Analysis Conversions

Unit Analysis is used by scientists to make conversions between units. You may encounter this method of conversion in some of your science classes.

To convert, multiply the rate (as a ratio) by fractions that represent conversion factors so that the given units will cancel out.

Example 1: Express 70 MPH as FPS (feet per second)

Write 70MPH as $\dfrac{70\text{ mi}}{1\text{ hr}}$.

Consider the conversion factors for this problem. We must convert from miles to feet. We must also change hours to seconds.

1 hr = 60 min **1 min = 60 s** **1 mi = 5280 ft**

Write the conversion factors as fractions.

$$\frac{1\text{ hr}}{60\text{ min}} \text{ or } \frac{60\text{ min}}{1\text{ hour}} \qquad \frac{1\text{ min}}{60\text{ s}} \text{ or } \frac{60\text{ s}}{1\text{ min}} \qquad \frac{1\text{ mi}}{5280\text{ ft}} \text{ or } \frac{5280\text{ ft}}{1\text{ mi}}$$

Set up the problem. **Make sure to write the conversion fractions so that the units will cancel out.**

To cancel out the hour unit, we write 1 hr in the numerator and 60 min in the denominator.

$$\frac{70\ \cancel{\text{mi}}}{1\ \cancel{\text{hr}}} \times \frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}} \times \frac{1\ \cancel{\text{min}}}{60\text{ s}} \times \frac{5280\text{ ft}}{1\ \cancel{\text{mi}}}$$

To cancel out the minute unit, we write 1 min in the numerator and 60 s in the denominator.

To cancel out the mile unit, we write 5280 ft in the numerator and 1 mi in the denominator.

Now we are ready to finish the problem.

Write all of the remaining numbers and units that are in both the numerator and denominator, and then simplify.

$$\frac{70\,(5280)\text{ ft}}{60\,(60)\text{ s}} = \frac{369,600\text{ ft}}{3600\text{ s}}$$

Divide to get the number of feet per second.

$$369,600\text{ ft} \div 3600\text{ s} = 102.7\text{ FPS}$$

Seventy miles per hour equals 102.7 feet per second.

Example 2: Express 100 meters in 9.78 seconds as KPH (kilometers per hour)
Note: Tim Montgomery set this world record on September 14, 2002.

Write the given speed as a ratio: $\frac{100\text{ m}}{9.78\text{ s}}$

Consider the conversion factors for this problem. We must convert from meters to kilometers. We must also change seconds to hours.

60 s = 1 min **60 min = 1 hr** **1000 m = 1 km**

Write the conversion factors as fractions.

$$\frac{1\text{ min}}{60\text{ s}} \text{ or } \frac{60\text{ s}}{1\text{ min}} \qquad \frac{1\text{ hr}}{60\text{ min}} \text{ or } \frac{60\text{ min}}{1\text{ hour}} \qquad \frac{1\text{ km}}{1000\text{ m}} \text{ or } \frac{1000\text{ m}}{1\text{ km}}$$

Set up the problem. **Make sure to write the conversion fractions so that the units will cancel out.**

To cancel out the second unit, we write 1 min in the denominator and 60 s in the numerator.

To cancel out the minute unit, we write 1 hr in the denominator and 60 min in the numerator.

$$\frac{100\,\cancel{m}}{9.78\,\cancel{s}} \times \frac{60\,\cancel{s}}{1\,\cancel{min}} \times \frac{60\,\cancel{min}}{1\,hr} \times \frac{1\,km}{1000\,\cancel{m}}$$

To cancel out the meter unit, we write 1000 m in the denominator and 1 km in the denominator.

Now we are ready to finish the problem.

Write all of the remaining numbers and units that are in both the numerator and denominator, and then simplify.

$$\frac{100\,(60)\,(60)\,km}{9.78\,(1000)\,hr} = \frac{360,000\,km}{9780\,hr} = 36.8\,KPH$$

Divide to get the number of kilometers per hour.

$$360,000\,km \div 9780\,hr = 36.8\,KPH$$

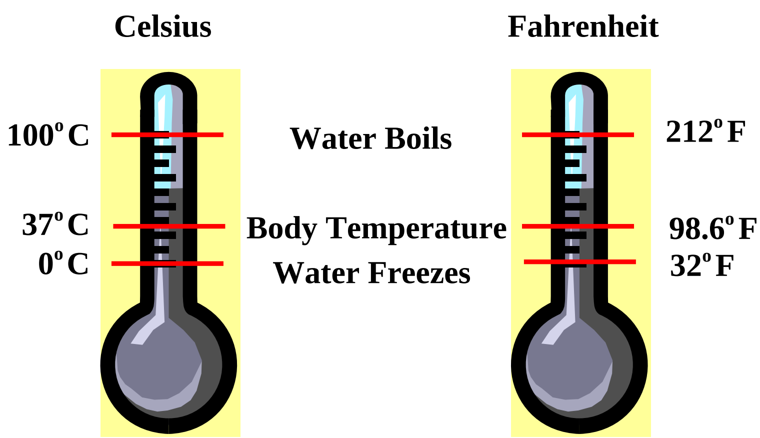
Think about this!

$$\frac{36.8\,\cancel{km}}{1\,hr} \times \frac{0.6\,mi}{1\,\cancel{km}} \approx 22\,MPH\text{ (speed of the fastest human)}$$

(1 kilometer = 0.6 mile)

Temperature and Formulas

Temperature is commonly measured in degrees Celsius (^{o}**C**) or degrees Fahrenheit (^{o}**F**). A Celsius thermometer and Fahrenheit thermometer are shown below.



The formulas shown below calculate the conversion between temperature scales.

- **Celsius to Fahrenheit:** $\boldsymbol{F = \frac{9}{5} \times C + 32}$
- **Fahrenheit to Celsius:** $\boldsymbol{C = \frac{5}{9} \times (F - 32)}$

Example 1: Sheila and her friends went to Daytona Beach for spring break. She sent a post card to her parents and told them that the temperature was about $25°C$ every day. What was the temperature in Fahrenheit degrees?

Convert from Celsius to Fahrenheit:

$F = \frac{9}{5}C + 32$	Celsius to Fahrenheit Formula
$F = \frac{9}{\cancel{5}}(\overset{5}{\cancel{25}}) + 32$	Substitute 25 for C and cancel.
$F = 9(5) + 32$	Simplify
$F = 77$	Simplify

25° Celsius equals 77° Fahrenheit.

Example 2: Convert 102° Fahrenheit to Celsius.

$C = \frac{5}{9}(F - 32)$ Fahrenheit to Celsius Formula

$C = \frac{5}{9}(102 - 32)$ Substitute 102 for F.

$C = \frac{5}{9}(70)$ Simplify

$C = \frac{350}{9} \approx 39$ Simplify

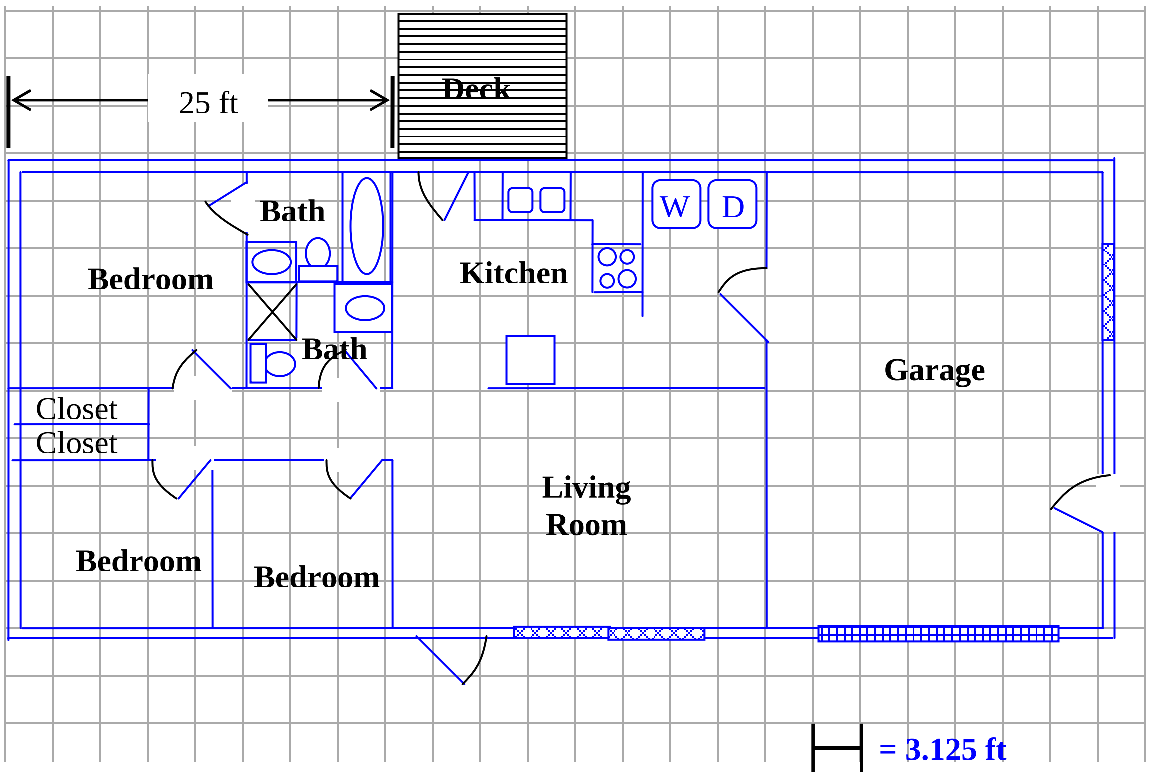
102 degrees Fahrenheit is about 39 degrees Celsius.

Scale Drawings and Maps

A **scale drawing** or a **scale model** is used to represent an object that is too large or too small to be drawn or built at actual size. Examples are blueprints, maps, models of vehicles, and models of animal anatomy.

A **scale** is determined by the ratio of a given length on a drawing or model to its corresponding actual length.

The blueprint for a house is given below and is superimposed on a grid.



Example 1: Verify that the given scale is accurate.

Consider the following:

(a) How many units wide is the largest bedroom including the bath?

Count the units. It is 8 units wide.

(b) The actual width of the master bedroom is 25 feet given in the blueprint. Write a ratio comparing the drawing width to the actual width.

8 units : 25 feet

(c) Simplify the ratio above and compare it to the scale shown at the bottom of the drawing.

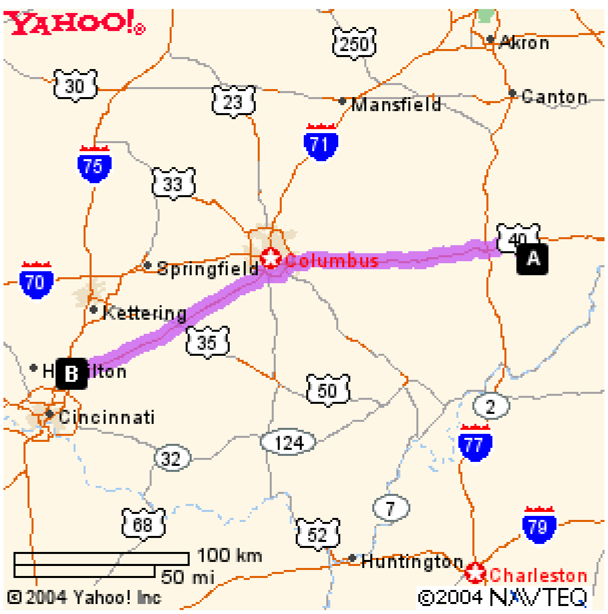
$$8 \text{ units} : 25 \text{ feet} = 8 \text{ to } 25 = \frac{8}{25} = \frac{8 \div 8}{25 \div 8} = \frac{1}{3.125} = 1 : 3.125$$

According to the blueprint, 1 unit = 3.125 feet. Therefore, the ratio and the scale are in agreement and indicate that one unit on the drawing is equal to 3.125 feet in reality.

Distances on a scale drawing are proportional to distances in real-life.

NOTE: Scales and scale factors are written so that the drawing length comes first in the ratio.

Example 2: The following map was generated at *http://maps.yahoo.com*. Point A represents Quaker City, OH. Point B represents Mason, OH. What is the actual distance between the two communities?



Key: ├──────┤ **= 50 miles**

It takes about 3 of plus another $\frac{3}{4}$ of to get from point A to point B. Let x represent the actual distance between the two communities.

Write a proportion.

$$\frac{\text{scale length}}{\text{actual length}} \rightarrow \quad \frac{1}{50} = \frac{3.75}{x}$$

Solve.

$$\frac{1}{50} = \frac{3.75}{x}$$

$(1)x = (50)(3.75)$ Cross Multiply

$x = 187.5$ Simplify

The actual distance from Quaker City, OH, to Mason, OH, is about 187.5 miles.