METRIC SYSTEM OF MEASUREMENT

This unit is about the metric system of measurement. Topics examined are measurements and conversions. Units of length, area and volume will be studied and applied to "real world" scenarios.

Metric Units

Metric System Prefixes

Metric System Conversion Tables

Measuring with Metric Units of Length

Converting Metric Units

Metric Units of Area

Metric Units of Volume

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.

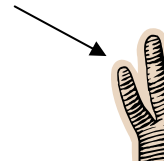*A kilometer equals 0.6 mile.*

Meter (*m*)

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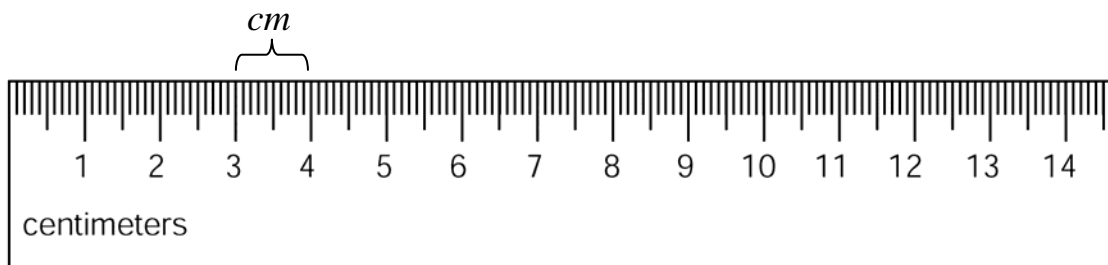- A meter stick could be used to measure the length of a room.

A meter equals 1.09 yards.

Centimeter (*cm*)

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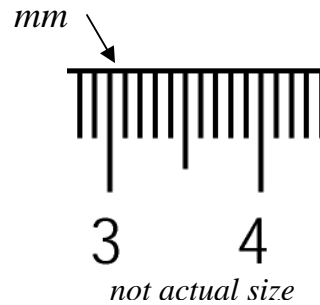- A centimeter is a little less than half an inch long.

A centimeter equals 0.39 inch, a little less than half an inch.

cm

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |

centimeters

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 two millimeters.

mm

not actual size

A millimeter equals 0.1 of a centimeter or about 0.04 inch.

Weight

Kilogram (*kg*)

- A pair of shoes could weigh about a kilogram.

A kilogram weighs 2.2 pounds.

Gram (*g*)

- The weight of a cherry is close to a gram.

A gram weighs 0.04 ounces.

Milligram (*mg*)

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

A milligram weighs 0.000035 ounces.

Capacity

Liter (*l*)
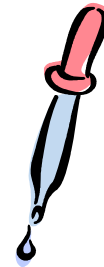
- A liter is a little more than a quart of milk.

A liter equals 1.06 quarts.

Milliliter (*ml*)

- 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.
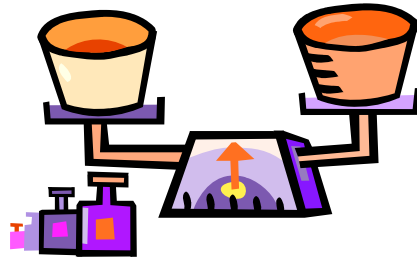
Units Larger Than the Base Unit

kilo-

Kilo means 1000 times the base unit.

- *kilo* + meter means 1000 meters
- 1 kilometer = 1000 meters

Example 1: If the base unit is gram, then kilo + gram is a kilogram.

kilo + gram means 1000 grams

1 kilogram = 1000 grams

hecto-

Hecto means 100 times the base unit.

- *hecto* + meter means 100 meters
- 1 hectometer = 100 meters

Example 2: If the base unit is gram, then hecto + gram is a hectogram.

Hecto + gram means 100 grams

1 hectogram = 100 grams

deka-

Deka means 10 times the base unit.

- *deka* + meter means 10 meters
- 1 dekameter = 10 meters

Example 3: If the base unit is liter, then deka + liter is a dekaliter.

deka + liter means 10 liters

1 dekaliter = 10 liters

Units Smaller Than the Base Unit

deci-

Deci means $\dfrac{1}{10}$ of the base unit.

- *deci* + meter means $\dfrac{1}{10}$ of a meter
- 1 decimeter = $\dfrac{1}{10}$ meter

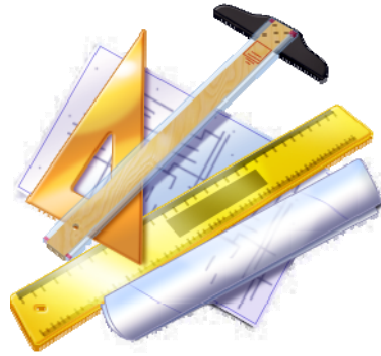*Example 4*: If the base unit is gram, then deci + gram is a decigram.

deci + gram means $\dfrac{1}{10}$ of a gram

1 decigram = $\dfrac{1}{10}$ gram

centi-

Centi means $\dfrac{1}{100}$ of the base unit.

- *centi* + meter means $\dfrac{1}{100}$ of a meter

- 1 centimeter $= \dfrac{1}{100}$ meter

Example 5: If the base unit is gram, then centi + gram is a centigram.

centi + gram means $\dfrac{1}{100}$ of a gram

1 centigram $= \dfrac{1}{100}$ gram

milli-

Milli means $\dfrac{1}{1000}$ of the base unit.

- *milli* + meter means $\dfrac{1}{1000}$ of a meter

- 1 millimeter $= \dfrac{1}{1000}$ meter

Example 6: If the base unit is liter, then milli + liter is a milliliter.

$$milli + \text{liter means } \frac{1}{1000} \text{ of a liter}$$

$$1 \text{ milliliter} = \frac{1}{1000} \text{ liter}$$

Metric System Conversion Tables

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

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

Capacity	
kiloliter (kl)	1000 liters
hectoliter (hl)	100 liters
dekaliter (dk$l$)	10 liters
liter (l)	**1 liter**
1 deciliter (dl)	$\dfrac{1}{10}$ l
1 centiliter (cl)	$\dfrac{1}{100}$ l
1 milliliter (ml)	$\dfrac{1}{1000}$ 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.

cm

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |

centimeters

mm

1 cm = 10 mm

3   4
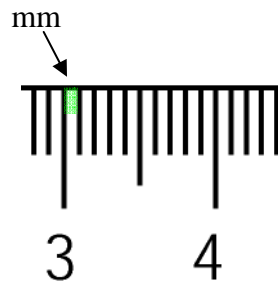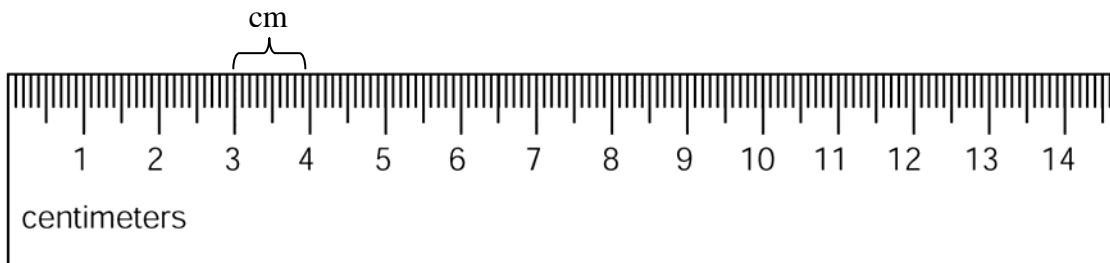
not actual size

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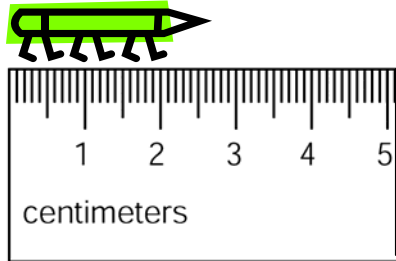
Since the pencil is a little over halfway between 2 and 3, the length of the pencil is closer to 3 cm than 2 cm. The pencil measures approximately **3 cm (centimeters)**.

Example 2: Using the same ruler shown below, determine approximately how long the pencil is in **millimeters**.
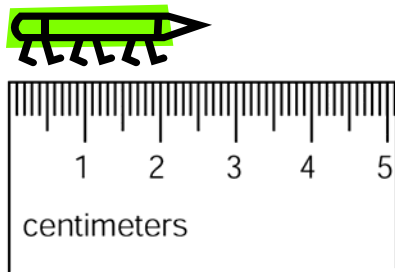
Since one centimeter equals 10 millimeters, count 10, 20 up to 2 centimeters, then count in ones. The pencil is approximately **27 mm (millimeters)** long.

Examine the "zoomed –in" view of the ruler for a closer look at reading the measurement of 27 millimeters.
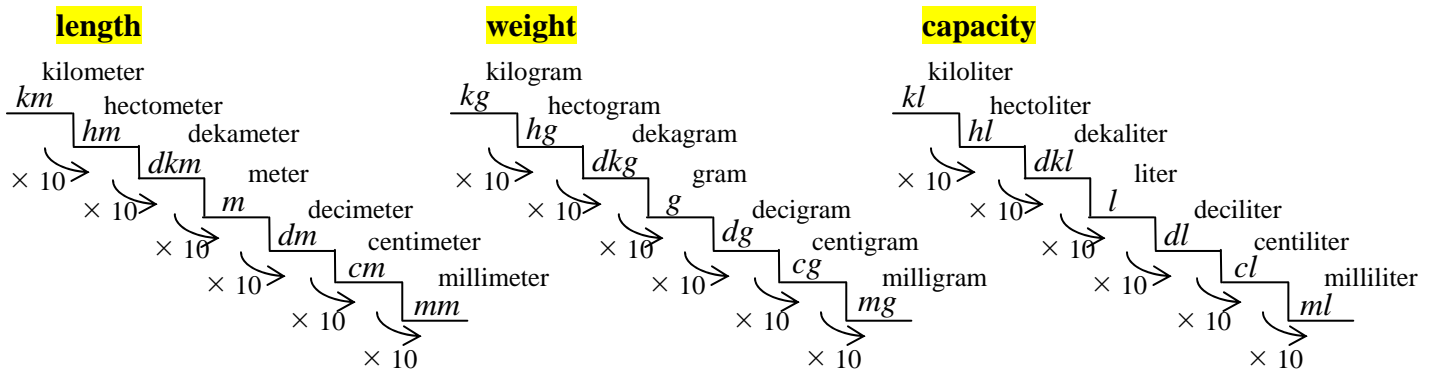

1 2 3 4 5

centimeters
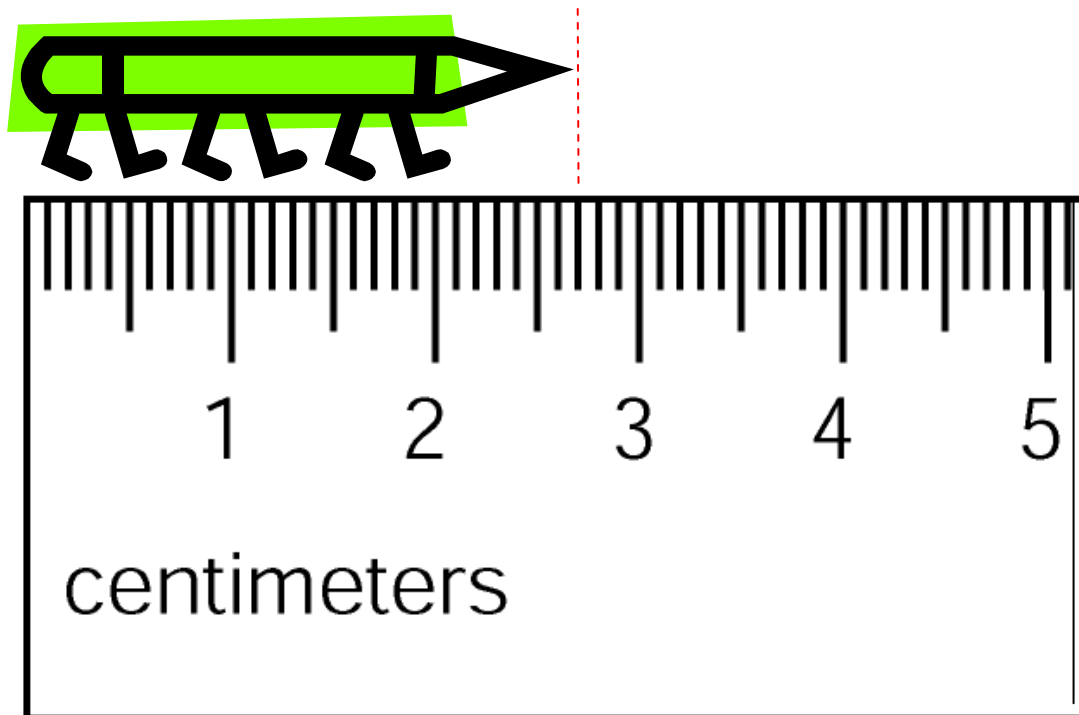
Converting Metric Units

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.

length

kilometer
km   hectometer
   hm   dekameter
$\times 10$ dkm   meter
   $\times 10$ m   decimeter
    $\times 10$ dm   centimeter
     $\times 10$ cm   millimeter
      $\times 10$ mm
       $\times 10$

weight

kilogram
kg   hectogram
   hg   dekagram
$\times 10$ dkg   gram
   $\times 10$ g   decigram
    $\times 10$ dg   centigram
     $\times 10$ cg   milligram
      $\times 10$ mg
       $\times 10$

capacity

kiloliter
kl   hectoliter
   hl   dekaliter
$\times 10$ dkl   liter
   $\times 10$ l   deciliter
    $\times 10$ dl   centiliter
     $\times 10$ cl   milliliter
      $\times 10$ ml
       $\times 10$

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)
- multiply 7 × 1000

      7 *km* = 7000 *m*

Example 2: 4.8 *g* = _____ *cg*

Using the steps,
- multiply 4.8 × 10× 10
  (two steps down)
- multiply 4.8 × 100

      4.8 *g* = 480 *cg*

Example 3: 5 *dkl* = _____ *l*
- multiply 5 × 10
  (one step down)

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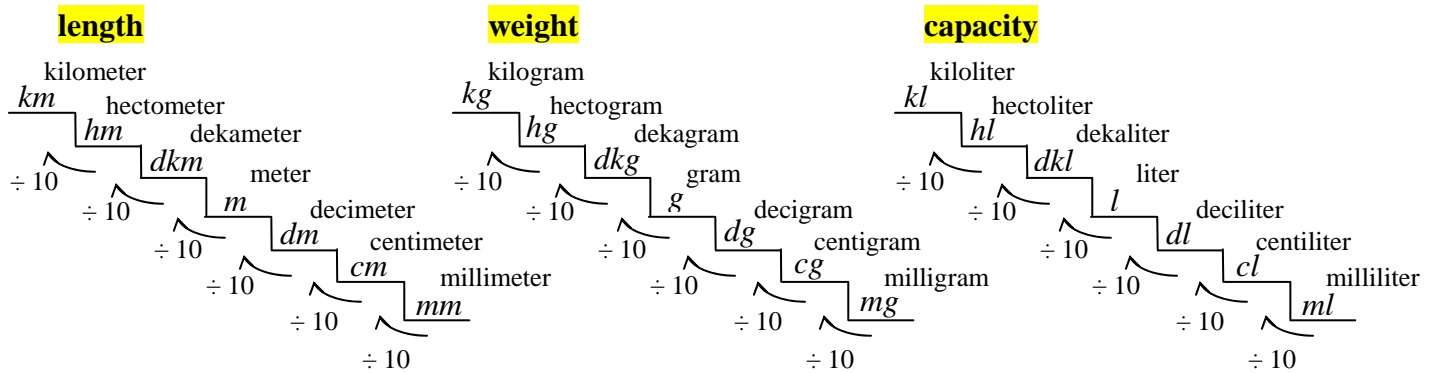
In Example 2 above, the shortcut for multiplying 4.8 by 100 is to move the decimal point two places to the right. Fill in with zeros as needed.

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

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.

kilometer
km   hectometer
   hm   dekameter
      dkm   meter
÷ 10   *m*   decimeter
   ÷ 10   *dm*   centimeter
      ÷ 10   *cm*   millimeter
         ÷ 10   *mm*
            ÷ 10

kilogram
kg   hectogram
   hg   dekagram
      dkg   gram
÷ 10   *g*   decigram
   ÷ 10   *dg*   centigram
      ÷ 10   *cg*   milligram
         ÷ 10   *mg*
            ÷ 10

kiloliter
kl   hectoliter
   hl   dekaliter
      dkl   liter
÷ 10   *l*   deciliter
   ÷ 10   *dl*   centiliter
      ÷ 10   *cl*   milliliter
         ÷ 10   *ml*
            ÷ 10

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 4: 700 *cm* = _____ *m*

Using the steps,
- compute $700 \div 10 \div 10$.
  (two steps up)
- compute $700 \div 100$.

700 *cm* = 7 *m*

Example 5: 6500 *ml* = _____ *l*
Using the steps,
- compute $6500 \div 10 \div 10 \div 10$.
  (three steps up)
- compute $6500 \div 1000$.

6500 *ml* = 6.5 *l*

Example 6: 80 *mg* = _____ *cg*

- Using the steps, divide 80 by 10.
  (one step up)

80 *mg* = 8 *cg*

*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.

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

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

$$5 \ ha = \textcolor{red}{?} \ m^2$$

Write a proportion comparing units.

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

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.

$$1 \times n = 10,000 \times 5$$
$$n = 50,000$$

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.

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

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.

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

Cross multiply.

$$1 \times n = 0.0001 \times 2000$$
$$n = 0.2$$

Two thousand square centimeters equal 0.2 square meters.

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.

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

Write a proportion comparing units.

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

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.

$$10,000 \times n = 1 \times 12,000$$
$$10,000n = 12,000$$
$$n = 1.2$$

Twelve thousand square meters equal 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.

How does one cubic meter equal one million cubic centimeters?

- From the metric units of length we know that: $1\ m = 100\ cm.$

- So, cube each side to get: $(1\ m)^3 = (100\ cm)^3$

Thus, $1\ m^3 = 100 \times 100 \times 100 = 1,000,000\ cm^3$

How does one cubic centimeter equal one-millionth of a cubic meter?

- From the metric units of length we know that: $1\ cm = \dfrac{1}{100}m$

- So, cube each side to get: $(1\ cm)^3 = (\dfrac{1}{100}m)^3$

- Thus, $1\ cm^3 = \dfrac{1}{100} \times \dfrac{1}{100} \times \dfrac{1}{100} = \dfrac{1}{1,000,000}m^3$

- Therefore, $1\ cm^3 = 0.000001\ m^3$

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.

$$500 \; m^3 = ? \; cm^3$$

Write a proportion comparing units.

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

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.

$$\frac{1 \; m^3}{1,000,000 \; cm^3} = \frac{500 \; m^3}{n}$$

Cross multiply.

$$1 \times n = 1,000,000 \times 500$$
$$n = 500,000,000$$

Five hundred cubic meters equal 500 million cubic centimeters.

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.

$$? \ m^3 = \ 900,000 \ cm^3$$

Write a proportion comparing units.

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

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.

$$\frac{1 \ cm^3}{0.000001 \ m^3} = \frac{900,000 \ cm^3}{n}$$

Cross multiply.

$$1 \times n = 0.000001 \times 900,000$$
$$n = 0.9$$

Nine hundred thousand cubic centimeters equal 0.9 cubic meters.