

**EVALUATING  
ACADEMIC READINESS  
FOR APPRENTICESHIP TRAINING**  
Revised for  
**ACCESS TO APPRENTICESHIP**

**MATHEMATICS SKILLS  
METRIC MEASUREMENT**

**AN ACADEMIC SKILLS MANUAL  
for  
The Horticulture Trades**

This trade group includes the following trades:  
Arborist, and  
Horticulturist

*Workplace Support Services Branch  
Ontario Ministry of Training, Colleges and Universities*

*Revised 2011*

In preparing these Academic Skills Manuals we have used passages, diagrams and questions similar to those an apprentice might find in a text, guide or trade manual.

**This trade related material is not intended to instruct you in your trade. It is used only to demonstrate how understanding an academic skill will help you find and use the information you need.**

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# MATHEMATICS SKILLS

## METRIC MEASUREMENT

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*An academic skill required for the study of the  
Horticulture Trades*

### **INTRODUCTION**

The metric system is designed so that conversions between units follow a simple, consistent pattern. The pattern is based on multiplying or dividing by a multiple of ten. Most measurements and calculations in the horticultural and arborist trades use the metric system. All regulations controlling the use of pesticides are given in metric. Nursery catalogues and plant manuals list plant size and growth rates in metric. Canadian textbooks on plant biology and soil science present information using the metric system.

Although you might have to be familiar with the imperial system when talking to clients who have not fully converted, for most aspects of your work, you will use the metric system of measurement.

This skills manual looks at the basic metric units and how to convert from one unit to another. The following topics are covered:

- ◆ Basic metric units
- ◆ A chart of metric units
- ◆ Converting units
- ◆ Operations with mixed units

### **BASIC METRIC UNITS**

The common metric units measure length, weight, volume or capacity and temperature. The measurements for length, weight and capacity all have a **basic unit**. The other units are smaller or larger than the basic unit by a factor of ten.

- ◆ The **meter (m)** is the basic unit of length. In your work, you will also measure using the smaller unit, centimeters.
  - A meter is about the length of an outstretched arm.
  - A centimeter is about as long as the width of your baby finger.
- ◆ The **gram (g)** is the basic unit of weight.
  - It is a small amount; you might buy small screws in a 500 gram package.
  - The weight of a heavy object such as a steel beam is given in kilograms, a larger unit.
- ◆ The **liter (L)** is the basic unit of capacity.
  - Liquid volumes such as water and lubricant are measured in liters.

- The **degree Celsius** ( $^{\circ}\text{C}$ ) is the basic unit of temperature.
  - $0^{\circ}\text{C}$  is the freezing point of water,
  - $23^{\circ}\text{C}$  is about room temperature, and
  - $100^{\circ}\text{C}$  is the boiling point of water.

### ***Prefixes Used in the Metric System***

Units that are larger or smaller than the basic units for length, weight and capacity are formed by adding a prefix to the name of the base unit. The prefixes refer to the place value of the unit. The more common prefixes are below:

**kilo** - means 1000 times bigger than the basic unit, in the thousands place:

*examples:* kilometer (km), kilogram (kg) and kiloliter (kl)

**centi** - means 100 times smaller than the basic unit or one-hundredth or .01 of the basic unit:

*example:* centimeter (cm)

**milli** - means 1000 times smaller than the basic unit or one-thousandth or .001 of the basic unit:

*examples:* millimeter (mm), milligram (mg) and milliliter (ml)

There are other prefixes that denote very small or very large units that are used in scientific calculations.

- *Mega* means one million
- *Giga* means one billion
- *Tera* means one trillion
- *micro* means one-millionth
- *nano* means one-billionth
- *pico* means one-trillionth

### ***Moving the Decimal Point to Multiply or Divide***

In order to convert from one metric unit to another, you multiply or divide by 10, 100, or 1000.

#### **To quickly multiply by 10, 100 or 1000:**

1. Write the number to be multiplied.
2. Count the zeros in the multiplier.
3. Move the decimal point as many places to the **right** of its original position as there are zeros in the multiplier.
4. Use zeros as place holders between the number and the decimal point if needed.

**Example:**  $346.1 \times 1000$

There are three zeros in 1000. Move the decimal point three places to the right. Use two zeros as place holders. (If the decimal point is not shown, it is at the end of the right side of the number.)

$$346.1 \times 1000 = 346100$$

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**To quickly divide by 10, 100 or 1000:**

1. Write the number to be divided.
2. Count the zeros in the divisor.
3. Move the decimal point as many places to the **left** of its original position as there are zeros in the divisor.
4. Use zeros as place holders between the number and the decimal point if needed.

**Example:**  $2.45 \div 100$

There are two zeros, so move the decimal point two places to the left, using one zero as a place holder.

$$2.45 \div 100 = .0245$$

***CHART OF METRIC UNITS***

Table 1 illustrates how the metric system works. You can see how the different metric units are related to each other. You can also learn how to convert from one unit to another by following the step by step instructions given under Table 1.

First learn the base units: *meter*, *liter* and *gram*. They are found in the shaded middle of the chart.

The next most frequently used units are:

- the large units on the left which start with the prefix *kilo*,
- the units on the far right which start with the prefix *milli*, and
- the units which start with the prefix *centi* .
  - *Note: the milliliter and cubic centimeter represent the same measure of volume.*

The chart has spaces for the most common place values in the metric system. It only shows the commonly used units. To form a unit not shown, such as decimeter (1/10 of a meter), put the correct prefix (deci) in front of the basic unit.

THE METRIC SYSTEM							
BIGGER UNITS → → TO BASIC UNIT → → TO SMALLER UNITS							
<b>Place Value</b>	1000	100	10	1	1/10 or .1	1/100 or .01	1/1000 or .001
<b>Prefix</b>	Kilo	Hecto	Deca		Deci	Centi	Milli
<b>Length</b>	Kilometer (km)			Meter (m)		Centimeter (cm)	Millimeter (mm)
<b>Weight</b>	Kilogram (kg)			Gram (g)			Milligram (mg)
<b>Volume/ Capacity</b>	Kiloliter (kl)			Liter (l)			Milliliter (ml) or Cubic Centimeter (cc)

TABLE 1: THE METRIC SYSTEM

#### Converting Units Using the Chart

- Count the number of spaces from the original unit (but don't count the original unit space) to the new unit, and notice whether you have moved to the left or the right.
- In the number you are converting move the decimal point the same number of spaces in the same direction.
- Use zeros as place holders where necessary.
- Change the name of the unit.

#### Examples:

From ml to L, it's 3 places to the left; move the decimal 3 places to the left. 39 ml = .039 L

From kg to g, it's 3 places to the right; move the decimal 3 places to the right. 12.4 kg = 12400 g

From m to cm, it's 2 places to the right; move the decimal 2 places to the right. 4 m = 400 cm

### CONVERTING FROM ONE UNIT TO ANOTHER

The chart shows graphically how to move the decimal point when converting from one unit to another. To convert without a chart, there are two rules to know.

- To convert from a larger unit to a smaller unit, the number gets bigger.** Move the decimal point to the *right*.

When going to or from a basic unit, the prefix of the other unit can tell you how many places to move the decimal point.

**Examples:**

From kilo (1000) unit to basic unit → move the decimal point three places to the right.

From basic unit to milli (.001) unit → move the decimal point three places to the right.

From basic unit to centi (.01) unit → move the decimal point two places to the right.

*Note: Move the decimal point the same number of places as there are zeros in the prefix kilo or the same number as there are decimal places in the prefixes centi and milli.*

**2. To convert from a smaller unit to a larger unit, the number gets smaller.** Move the decimal to the *left*.

When going to or from a basic unit, the prefix of the other unit tells how many places to move the decimal point.

**Examples:**

From basic unit to kilo (1000) unit ← move the decimal point three places to the left.

From milli (.001) unit to basic unit ← move the decimal point three places to the left.

From centi (.01) unit to basic unit ← move the decimal point two places to the left.

*Note: Move the decimal point the same number of places as there are zeros in the prefix kilo or the same number as there are decimal places in the prefixes centi and milli.*

**To convert to or from a basic unit, you need to know two things:**

1. Whether you are going from a larger unit to a smaller unit, or from a smaller unit to a larger one.
  - This tells you what direction to move the decimal point.
2. How many zeros or decimal places are in the non-basic unit.
  - This tells you how many places to move the decimal point in the required direction.

**Example:** Change 450 gram to kilograms.

$$450 \text{ g} = .450 \text{ kg}$$

A smaller unit to larger one, so move the decimal point to the left.  
The prefix kilo has three zeros, so move the decimal point three places.

**Example:** Change .31 kilograms to grams.

$$.31 \text{ kg} = 310 \text{ g}$$

A larger unit to smaller one, move the decimal point to the right.  
A prefix kilo has three zeros, move the decimal point three places.  
Zero is used as a place holder

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**Example:** Change 1656 milliliters to liters.

$$1656 \text{ ml} = 1.656 \text{ L}$$

Smaller unit to larger one, move decimal point to the left.  
Prefix milli has three decimal places move the decimal point three places.

**Example:** Change 12 liters to milliliters.

$$12 \text{ L} = 12000 \text{ ml}$$

Larger unit to smaller one, move decimal point to the right.  
Prefix milli has three decimal places move the decimal point three places.

**Example:** Change .8 meters to centimeters.

$$.8 \text{ m} = 80 \text{ cm}$$

Larger unit to smaller one, move decimal to the right.  
Prefix centi has two decimal places, move decimal point two places.

**Example:** Change 239 centimeters to meters.

$$239 \text{ cm} = 2.39 \text{ m}$$

Smaller unit to larger one, move decimal to the left.  
Prefix centi has two decimal places, move the decimal point two places.

### **In Brief:**

To convert from a larger unit to a smaller unit:

1. The number gets bigger.
2. Move the decimal point to the right:
  - from kilo units to basic units → decimal point moves three places to the right.
  - from basic units to milli units → decimal point moves three places to the right.

To convert from a smaller unit to a larger unit:

1. The number gets smaller
2. Move the decimal point to the left
  - from basic units to kilo units ← decimal point moves three places to the left
  - from basic units to milli units ← decimal point moves three places to the left

### ***Converting Between Two Units, Neither of Which is a Basic Unit***

You can convert between two units when neither is a base unit.

If you don't know how many places there are between the two units:

1. First convert the original unit to the base unit.
  - as you convert to and from the base unit use the prefixes to tell you how many places to move.
2. Then convert to the new unit.

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**Example:** To convert kilograms to milligrams, first convert to grams and then to milligrams.

1. *Kilograms to grams:*

- Kilo means 1000. There are three zeros in 1000 and that is the number of places to move the decimal point.
- When converting from a larger unit to a smaller one, you move to the right.
- Move the decimal point three places to the right.

2. *Grams to milligrams:*

- Milli means one thousandth or .001. There are three decimal places in the prefix milli.
- You are still going from a larger to a smaller unit, so continue to move the decimal point to the right.
- Move the decimal point three places to the right.

To convert from kilograms to milligrams, move the decimal point a total of six decimal places to the right.

**Example:** Change .3118 kg to mg.

$$.3118 \text{ kg} = 311.8 \text{ g}$$

Convert kilograms to grams to milligrams.  
Kilograms to grams, move decimal three places to the right.

$$311.8 \text{ g} = 311\,800 \text{ mg}$$

Grams to milligrams, move decimal three places to the right.

**Example:** Change 2576 cm to km

$$2576 \text{ cm} = 25.76 \text{ m}$$

Convert centimeters to meters to kilometers.  
Centimeters to meters, move decimal two places to the left.

$$25.76 \text{ m} = .02576 \text{ km}$$

Meters to kilometers, move decimal three places to the left.

In converting centimeters to kilometers, the decimal point is moved a total of five places.

**Example:** Change 75 cm to mm.

$$75 \text{ cm} = 750 \text{ mm}$$

Centimeter to millimeters, larger to smaller, move decimal point one place to the right.

$$75 \text{ cm} = .75 \text{ m}$$

If you did not know that there is one place between centimeters and millimeters convert from centimeters to meters first.

$$.75 \text{ m} = 750 \text{ mm}$$

Now convert from .75 meters to millimeters.

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## **OPERATIONS WITH MIXED UNITS**

In the metric system, it is easy to convert between units. Therefore, measurements are not usually left in mixed forms.

- A dimension of 3 meters and 12 centimeters is written as 3.12 meters or 312 centimeters.

**Example:** If you have a piece of metal 3 meters long to which you must add a 12 centimeter piece, the total length will be given in meters or centimeters, either 3.12 m or 312 cm.

You may be asked to give the answer in required units.

- If a certain unit is required, change all the units to that one.
- Otherwise, change everything to the base unit.
- If none of the units is a base unit, choose one of the other units to work in.
- You can now do any mathematical operation required.

### **To do calculations with mixed units:**

1. Change all the different units to one chosen unit.
2. Do the calculation.

**Example:** Add 1 liter to 750 milliliters.

1. Change all units to liters.  
750 milliliters = .750 liters or .75 liters
2. Add the units  
1 liter + .75 liters = 1.75 liters

**Example:** (4 km 149 m) - (8 m 90 cm)

- |                                 |   |
|---------------------------------|---|
| (4000 m + 149 m) - (8 m + .9 m) | Change all units to meters.                   |
| (4149 m) - (8.9 m)              | Add the units inside brackets together.       |
| 4149 m - 8.9 m = 4140.1 m       | Remove the brackets and subtract the numbers. |

**Example:** 72 L 45 ml ÷ 9 L

- |                        |   |
|------------------------|---|
| (72 L + .045 L) ÷ 9 L  | Change all units to liters and add them together. |
| 72.045 L ÷ 9 L         |   |
| 72.045 L ÷ 9 L = 8.005 | Divide: notice the units cancel out               |

**Note:**

If you divide a quantity with a unit by another quantity **with the same unit**, the units cancel out.

If you multiply or divide a quantity with a unit by a number **with no unit**, the answer **retains the unit**.

If you multiply a unit **by the same unit**, the unit is **squared**.

**To find area**, the length and width are multiplied together. Units of area are the units of length squared.

- An area of 15 meters square is written in short form as  $15 \text{ m}^2$ .
- Centimeters, millimeters and kilometers can also be squared, giving the square units  $\text{cm}^2$ ,  $\text{mm}^2$  and  $\text{km}^2$ .

**To find volume**, three measurements of length are multiplied together. Units of volume are units of length cubed.

- A volume of 25 cubic centimeters is written in short form as 25 cc or  $25 \text{ cm}^3$ .
- Meters, millimeters and kilometers can also be cubed, giving the cubic units  $\text{m}^3$ ,  $\text{mm}^3$  and  $\text{km}^3$ .

**Note:** These units are used for *both* volume and capacity.

**To find capacity of a container**, we again use the units liter and milliliter.

In the metric system, the units of volume, and capacity are related to each other. The volume of water in cubic centimeters is also related to its weight in grams.

- The equivalent units cubic centimeter (cc) and milliliter (ml) are both used as measures of volume or capacity.
  - 1 cubic centimeter (cc) is the same volume as 1 milliliter.
  - 1 gram of water occupies 1 cc of space (gram is a measure of weight, cc is a measure of volume or capacity).

**Using Quantities with Metric Units to Solve Problems**

There are rules for doing operations with quantities that have units. If you divide a quantity with a unit by another quantity **with the same unit**, the units cancel out.

**Example:** You are to spray an area that measures  $500 \text{ m}^2$ . The label lists the rate for the product you are using as  $50 \text{ ml}/100 \text{ m}^2$ . How much product do you need?

$$500 \cancel{\text{m}^2} \times \frac{50 \text{ ml}}{100 \cancel{\text{m}^2}} \quad \text{m}^2 \text{ cancel out}$$

$$= 5 \times \frac{50 \text{ ml}}{100}$$

$$= 5 \times 50 \text{ ml}$$

$$= 250 \text{ ml}$$

If you multiply or divide a quantity with a unit by a number with no unit, the answer **retains the unit**.

**Example:** You have 10 bottles of orchid nutrients. Each contains 2.5 liters. How much product do you have altogether?

$$\begin{array}{l} 10 \times 2.5 \text{ liters} \\ = 25 \text{ liters} \end{array} \quad \text{the unit remains}$$

If you multiply a unit **by the same unit**, the unit is **squared**.

**Example:** You are going to mow a lawn that measures 200 m by 50 meters. What is the area to be mowed?

$$\begin{array}{l} 200 \text{ m} \times 50 \text{ m} \\ = 10,000 \text{ m}^2 \end{array} \text{ the unit is squared}$$

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### TO CONVERT METRIC UNITS

1. When you convert an amount in a **larger unit** to a **smaller one**, the number becomes **larger**. You move the **decimal to the right**.
  2. When you convert an amount in a **smaller unit** to a **larger one**, the number becomes **smaller**. You move the **decimal point to the left**.
  3. If going to or from a basic unit, count the number of zeros in the prefix kilo (3) or the number of decimal places in the prefixes centi (2) or milli (3) to determine how many places to move the decimal point. If neither unit is a basic unit and you do not know the number of places between them, convert first to the basic unit and then to the final unit.
  4. Use Rules 1 & 2 above to determine which direction to move the decimal point.
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**Answer these questions on the metric system. Answers are at the end of this skills manual.**

1. Change each length to meters.

a) 8.7 cm            b) .037 km            c) 46 mm            d) 85 cm

2. Change the weight to grams.

a) 34 000 mg        b) .09 kg            c) 6.7 kg            d) 35 mg

3. Change the weight to milligrams.

a) 56 g            b) .0981 kg        c) 1.365 g        d) .00443 g

4. Change the volume to liters.

a) 1 760 ml        b) 51 ml            c) 7 ml

5. Change the volume to ml.

a) 6.8 L            b) .09 L            c) 24 L

6. Change the length to cm.

a) 4.3 m            b) 600 mm        c) .25 m            d) 98 mm

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Solve the following questions with mixed measurements so that the answer has one unit.

7. a)  $3\text{ m } 45\text{ cm} + 10\text{ m } 125\text{ cm}$   
b)  $9\text{ km } 1320\text{ m} - 4\text{ km } 534\text{ m}$   
c)  $454\text{ g} + 18\text{ kg}$   
d)  $341\text{ ml} - .29\text{ L}$   
e)  $5\text{ m} - 62\text{ cm}$

**Remember:**

*If you divide a quantity with a unit by another quantity **with the same unit**, the units cancel out.*

*If you multiply or divide a quantity with a unit by a number **with no unit**, the answer **retains the unit**.*

*If you multiply a unit **by the same unit**, the unit is **squared**.*

8. a)  $45\text{ L } 800\text{ ml} \times 3$   
b)  $12\text{ kg } 220\text{ g} \div 4$   
c)  $.4\text{ m } 48.8\text{ cm} \div 12\text{ cm}$   
d)  $12\text{ m} \times 10\text{ cm}$
9. A piece of edging that is 12.4 meters long is divided into four equal pieces. How long will each piece measure?
10. Your sprayer holds 800 liters and has an output of 200 liters/ha. How many hectares will one tankful cover?
11. You are planting a bed that measures 10 meters by 4 meters. What is the area to be planted?

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**ANSWER PAGE**

1. a) .087 m            b) 37 m            c) .046 m            d) .85 m
2. a) 34 g            b) 90 g            c) 6 700 g            d) .035 g
3. a) 56 000 mg            b) 98 100 mg            c) 1 365 mg            d) 4.43 mg
4. a) 1.76 L            b) .051 L            c) .007 L
5. a) 6 800 ml            b) 90 ml            c) 24 000 ml
6. a) 430 cm            b) 60 cm            c) 25 cm            d) 9.8 cm
7. a)  $(3 \text{ m} + .45 \text{ m}) + (10 \text{ m} + 1.25 \text{ m}) = 14.70 \text{ m}$     or 1 470 cm
- b)  $(9000 \text{ m} + 1320 \text{ m}) - (4000 \text{ m} + 534 \text{ m})$   
        $= 10320 \text{ m} - 4534 \text{ m}$   
        $= 5786 \text{ m}$   
       or 5.786 km
- c)  $454 \text{ g} + 18\,000 \text{ g} = 18454 \text{ g}$             or 18.454 kg
- d)  $.341 \text{ L} - .29 \text{ L} = .051 \text{ L}$             or 51 ml
- e)  $5 \text{ m} - 62 \text{ cm}$   
        $= 500 \text{ cm} - 62 \text{ cm}$   
        $= 438 \text{ cm}$             or 4.38 m
8. a)  $(45 \text{ L} + .8 \text{ L}) \times 3$   
        $= 45.8 \text{ L} \times 3$   
        $= 137.4 \text{ L}$     or 13 400 ml
- b)  $(12\,000 \text{ g} + 220 \text{ g}) \div 4$   
        $= 12\,220 \text{ g} \div 4$   
        $= 3055 \text{ g}$             or 3.055 kg
- c)  $(40 \text{ cm} + 48.8 \text{ cm}) \div 12 \text{ cm}$   
        $= 88.8 \text{ cm} \div 12 \text{ cm}$   
        $= 7.4$
- d)  $12 \text{ m} \times .1 \text{ m} = 1.2 \text{ m}^2$     or 12 000  $\text{cm}^2$
9.  $12.4 \text{ m} \div 4 = 3.1 \text{ m}$

10.  $800 \text{ L} \div 200 \text{ L/ha}$

$$= 800 \text{ L} \times \frac{\text{ha}}{200 \text{ L}}$$

$$= 4 \text{ ha}$$

11.  $10 \text{ m} \times 4 \text{ m} = 40 \text{ m}^2$