

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

**MATHEMATICS SKILLS
IMPERIAL/METRIC CONVERSION**

**AN ACADEMIC SKILLS MANUAL
for
The Precision Machining And Tooling Trades**

This trade group includes the following trades:

General Machinist, Tool & Die Maker,
Mould Maker, Pattern Maker, and
Machine-Tool Builder Integrator

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

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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.

MATHEMATICS SKILLS

IMPERIAL/METRIC CONVERSION

*An academic skill required for the study of the
Precision Machining and Tooling Trades*

INTRODUCTION

Like most of the world, Canada has converted to the metric system of measurement. However, the sizes of many common materials were standardized when we still used the imperial system, and it is not always easy to convert the standard sizes to metric. For example, a 4 by 8 sheet is 1.22 meters by 2.44 meters in metric, an awkward size.

As the trades slowly change to metric dimensions, many materials are still supplied in imperial sizes.

Machining reference charts come with measurements in feet and inches, or in meters and centimeters. To interpret the charts clearly, such as when you need to find a specific size of bolt, you have to be familiar with both systems of measurement, and you have to know how to convert from one system to the other.

This skills manual briefly reviews the two systems of measurement and how to convert from one to the other. The following topics are covered:

- ◆ Basic units of measurement
- ◆ Converting within the imperial and metric systems
- ◆ Converting between metric and imperial units

BASIC UNITS OF MEASUREMENT

Length

In the metric system, the basic unit of length is the *meter*.

- Other linear units (units of length) include the *kilometer*, the *centimeter* and the *millimeter*.

In the imperial system the common linear units are the *inch*, *foot*, *yard* and *mile*. The unit *mil* is used to measure paint thickness. One mil is equal to one-thousandth of an inch.

Weight

The basic unit of weight in the metric system is the *gram*.

- Other units of weight include the *kilogram* and the *milligram*.

The common units of weight in the imperial system are the *ounce*, *pound* and *ton*.

Volume or Capacity

The basic unit of capacity of liquids in the metric system is the **liter**.

- The other common unit of capacity is the **milliliter**.
- The volume of both solids and liquids is indicated by cubic units of length such as a cubic centimeter, written as cc, cu cm or cm^3 .
- Volume and capacity are related in the metric system. One milliliter equals 1 cc.

The imperial system has many units of liquid capacity. They include the **cup**, **quart** and **gallon**. Dry measurements include the **quart** and **bushel**.

- Volume is also measured by cubic measurements like cubic inches, written as cu in or in^3 .

Pressure

The imperial unit of pressure is **pounds per square inch (psi)**.

In the metric system, you use the unit **kilopascals (kPa)**.

CONVERTING WITHIN THE IMPERIAL AND METRIC SYSTEMS

Sometimes you will need to convert, or change, from one system to the other. To do this, you need a chart that lists **equivalent measurements**.

Example: One inch is equal to, or equivalent to, 2.54 centimeters. Similarly, 1 centimeter is equivalent to .39 inches.

If you need to convert units between systems when working on a job, you are usually provided with the equivalents, but you will save yourself time if you know the most common equivalents.

Before we start converting between the two systems, we will briefly review how to convert within each of the systems.

Converting Within the Imperial System

Table 1 is a chart of equivalents that is used when converting within the imperial system:

TABLE 1: IMPERIAL EQUIVALENTS
1 foot (ft) = 12 inches (in)
1 yard (yd) = 3 ft
1 mile (mi) = 1760 yd
1 pound (lb) = 16 ounces (oz)
1 quart (qt) = 2 pt
1 gallon (gal) = 4 qt

In this chart, the larger units are on the left. Charts might be set up with the larger units on the right, so the first line would read 12 in = 1 ft. However, one unit, usually the larger unit, has a 1 in front of it. The other unit has a number different than 1 in front of it. This number is the **conversion factor**. To convert an imperial amount in one unit to another unit, follow these two rules.

Rule 1: To convert from a larger unit such as feet to a smaller unit such as inches, **multiply the amount of the larger unit** by the conversion factor.

Example: Convert 5 feet to inches.

The chart tells you that 1 foot = 12 inches. The conversion factor is 12. To convert 5 feet to inches (larger unit to smaller unit), multiply by the conversion factor 12.

$$\begin{aligned}1 \text{ ft} &= 12 \text{ in} \\5 \text{ ft} &= 5 \times 12 \\ &= 60 \text{ in}\end{aligned}$$

Rule 2: To convert from a smaller unit such as quarts to a larger unit such as gallons, **divide the amount of the smaller unit** by the conversion factor.

Example: Convert 10 quarts to gallons.

From the chart, 1 gallon = 4 quarts. The conversion factor is 4. Since you are going from a smaller unit to a larger one, you divide by 4.

$$\begin{aligned}1 \text{ gal} &= 4 \text{ qt} \\10 \text{ qt} &= 10 \div 4 \\ &= 2.5 \text{ gal}\end{aligned}$$

Converting Within the Metric System

To convert within the metric system, you multiply or divide by 10, or a power of 10 such as 100 or 1000. To do this, you move the decimal point to the left or right the required number of places, using zeros as place holders when necessary. (You are actually multiplying or dividing by a power of ten when you move a decimal point.)

Table 2 lists the most commonly used prefixes with the basic units for weight (gram), length (meter), and volume (litre).

Table 2: METRIC EQUIVALENTS		
Prefix	Value	Basic Unit
kilo	1000	gram metre litre
centi	$1/100 = .01$	gram metre litre
milli	$1/1000 = .001$	gram metre litre

To convert to or from the basic units of meter, gram or liter, look at the prefix in front of the non-basic unit to tell how many places to move the decimal point.

1. The prefix *kilo* means **1000** times the basic unit.
 - To change from a unit with *kilo* as its prefix to a basic unit, or to convert from a basic unit to a unit with *kilo* as its prefix, move the decimal point 3 places.
2. The prefix *milli* means **.001** times the basic unit.
 - To change from a unit with *milli* as its prefix to a basic unit, or to convert from a basic unit to a unit with *milli* as its prefix, move the decimal point 3 places.
3. The prefix *centi* means **.01** times the basic unit.
 - To change from *centi* to a basic unit, or to convert from a basic unit to a unit with *centi* as its prefix, move the decimal point 2 places.

What direction do you move the decimal point to complete the conversion? Use the following rules:

1. To convert from a **smaller** unit to a **larger** one, move the decimal in the original amount to the **left**.
2. To convert from a **larger** unit to a **smaller** one, move the decimal to the **right**.
3. The number of places to move the decimal point in the original amount when converting to or from a basic unit depends on the prefix of the other unit.
 - With the prefix **kilo**, move the decimal **three** places.
 - With the prefix **milli**, move the decimal **three** places.
 - With the prefix **centi**, move the decimal **two** places.

Example: Convert 650 millimeters to meters.

Converting from a smaller unit to a larger one, the decimal point moves to the left. The prefix milli indicates that the decimal point moves three places when going to or from a basic unit. Move the decimal point three places to the left. Change the unit to meters.

$$650 \text{ mm} = .650 \text{ m}$$

CONVERTING BETWEEN METRIC AND IMPERIAL UNITS

Sometimes you need to convert, or change, from one system to the other. To do this, you use a chart, like Table 3 below, that lists *equivalent measurements*.

To use the chart to convert an amount in one system to the other system, you need to determine the *conversion factor*.

Example: To convert an amount in centimeters to an equivalent amount in inches, look at the *Metric to Imperial side of the chart*. Find the cm to inch equivalent: 1 cm = .39 inches.

The number .39 in front of inches is the conversion factor. Multiply the original amount in centimeters by the conversion factor .39 and add the new unit, inches, to the answer. You have now converted an amount originally in centimeters to the equivalent amount in inches.

TABLE 3: MEASUREMENT EQUIVALENCIES

IMPERIAL TO METRIC EQUIVALENTS	METRIC TO IMPERIAL EQUIVALENTS
1 inch (in) = 2.54 centimeters (cm)	1 cm = .39 in
1 foot (ft) = .305 meters (m)	1 m = 39.4 in = 3.3 ft
1 yard (yd) = .914 m	1 m = 1.09 yd
1 mile (mi) = 1.6 kilometer (km)	1 km = .62 mi
1 ounce (oz) = 28.38 g	1 g = .035 oz = .0022 lb
1 pound (lb) = 454 grams (g) or .454 kg	1 kg = 2.2 lb
1 quart (qt) Canadian = 1.14 liters (L)	1 L = .88 qt
1 gallon (gal) = 4.56 L	1 L = .22 gal
1 fluid ounce (fl oz) = 28.4 ml	
degrees Fahrenheit (F) = 9/5 degrees C +32	degrees Celsius (C) = 5/9(degrees F - 32)

Converting from Imperial to Metric

Suppose you are cutting a piece of block that is 4 feet long. If you are working from metric measurements on your reference chart, you might want to convert this length to meters.

Since you want to convert an Imperial measurement to a metric equivalent, use the **Imperial to Metric side of the chart** to find the *conversion factor*. The unit with 1 in front is the unit you are converting from. The unit with the conversion factor in front is the unit you are converting to.

Example: Change 12 feet to meters.

Look at the *Imperial to Metric chart* to find the line that equates feet to meters. The chart states that 1 foot = .305 meters, so .305 is the conversion factor.

$$12 \times .305 = 3.66 \quad \text{multiply the original amount of 12 feet by the conversion factor .305}$$

$$12 \text{ feet} = 3.66 \text{ meters} \quad \text{Place the metric unit, meters, after the answer.}$$

To convert from an amount in an imperial unit to a metric unit, here are the steps:

1. Use the Metric to Imperial side of the chart
2. The conversion factor is in front of the metric unit.
3. Multiply the original imperial amount by the conversion factor.
4. Put the correct metric units after the multiplication answer.
5. The amount is now converted to metric.

Example: Find the metric equivalent of 8 gallons.

Since you are converting an imperial amount, 8 gallons, to a metric unit, use the *Imperial to Metric chart*. The chart shows 1 gal = 4.56 L. The conversion factor is 4.56. Multiply 8 times 4.56 and change the unit to liters.

$$\begin{aligned} 1 \text{ gal} &= 4.56 \text{ L} \\ 8 \text{ gal} &= 4.56 \times 8 \\ &= 36.48 \text{ L} \end{aligned}$$

If the chart doesn't show a direct equivalent, you must convert within the original system until you have a unit with a metric conversion factor. For example, if you want to convert feet to centimeters using the chart on the previous page, you must first convert the feet to inches. Then you can use the conversion factor on the chart for inches to centimeters. First convert the feet to inches, then convert inches to centimeters.

Example: Convert 5 feet to centimeters.

Table 2 does not show feet to centimeters, so first convert feet to inches.

Use Table 1, *Imperial Equivalents*.

$$\begin{aligned} 1 \text{ ft} &= 12 \text{ inches} \quad \text{conversion factor is 12} \\ 5 \text{ ft} &= 5 \times 12 \\ &= 60 \text{ in} \end{aligned}$$

Now convert 60 inches to centimeters. Use Table 3, *Imperial to Metric Equivalents*.

$$\begin{aligned} 1 \text{ in} &= 2.54 \text{ cm} \quad \text{conversion factor is 2.54} \\ 60 \text{ in} &= 2.54 \times 60 \\ &= 152.4 \text{ cm} \end{aligned}$$

Example: Let's do the same question of converting 5 feet to centimeters, but this time convert feet directly to meters and then convert the meters to centimeters.

$$\begin{aligned}1 \text{ ft} &= .305 \text{ m} \\5 \text{ ft} &= 5 \times .305 \\&= 1.525 \text{ m} \\1.525 \text{ m} &= 152.5 \text{ cm}\end{aligned}$$

Notice the answers to the same question vary slightly in the examples. This is because the conversion factors have been rounded off.

Example: If you drive 45 miles to work every day, what is the distance traveled in km?

From the Imperial to Metric Chart:

$$\begin{aligned}1 \text{ mi} &= 1.6 \text{ km} && \text{conversion factor is } 1.6 \\45 \text{ mi} &= 1.6 \times 45 \\&= 72 \text{ km}\end{aligned}$$

Converting from Metric to Imperial

You might also want to convert from metric to imperial units. Use the Metric to Imperial Equivalents side of the chart. The procedure for using the chart is the same. The unit with the 1 in front is the metric unit. The number in front of the imperial unit is the conversion factor.

Because there are fewer units in the metric system, there are sometimes several conversion factors after a metric unit. For example, 1 meter can equal 39.4 inches or 3.3 feet or 1.09 yards. To convert from meters to feet, choose the conversion factor that changes meters to feet, which is 3.3. To convert from meters to inches, choose the conversion factor 39.4.

To convert from a metric unit to an imperial unit, here are the steps:

1. The conversion factor is in front of the imperial unit in the Metric to Imperial side of the chart.
2. Multiply the original metric amount by the conversion factor.
3. Put the correct imperial unit after the multiplication answer.
4. The amount is now converted to imperial units.

Example: You are traveling to a city 450 km away. How many miles do you travel?

Since you are converting an amount, 450 km, in a metric unit to an imperial unit, use the Metric to Imperial chart. From the chart:

$$\begin{aligned}1 \text{ km} &= .62 \text{ mi} && \text{conversion factor is } .62 \\450 \text{ km} &= .62 \times 450 \\&= 279 \text{ mi}\end{aligned}$$

Example: Convert 4.5 liters to gallons.

From the Metric to Imperial chart:

$$\begin{aligned}1 \text{ L} &= .22 \text{ gal} \quad \text{conversion factor is } .22 \\4.5 \text{ L} &= 4.5 \times .22 \\&= .99 \text{ gal}\end{aligned}$$

In Brief:

1. When you convert, the first step is to check which system the amount is now in and which system you are converting to.
2. Next choose the correct chart for that conversion.
3. Find the line with the required conversion factor on it.
4. Multiply the original amount by the conversion factor.
5. The multiplication answer is the amount in the new unit.
6. The last step is to write the new unit after the converted amount.

Example: A pipe has a diameter of 5 in. What is its diameter in mm?

We are converting from imperial to metric. The chart doesn't have an inch to millimeter conversion factor, so we will convert in two steps. First convert from inches to centimeters (use Table 3). Then convert the answer to millimeters (use Table 1).

$$\begin{aligned}1 \text{ in} &= 2.54 \text{ cm} \\5 \text{ in} &= 2.54 \times 5 \\&= 12.7 \text{ cm} \\12.7 \text{ cm} &= 12.7 \times 10 \\&= 127 \text{ mm}\end{aligned}$$

Example: One liter of water weighs 1 kg. How many pounds does 4 L weigh?

There are two steps to this problem. First we need to find how much 4 L weighs in kilograms and then we need to convert the kilograms to pounds.

$$\begin{aligned}1 \text{ L weighs } &1 \text{ kg} \\4 \text{ L weigh } &4 \text{ kg}\end{aligned}$$

$$\begin{aligned}1 \text{ kg} &= 2.2 \text{ lb} \quad \text{conversion factor is } 2.2 \\4 \text{ kg} &= 2.2 \times 4 \\&= 8.8 \text{ lb} \\4 \text{ L of water weigh } &8.8 \text{ lb.}\end{aligned}$$

Example: A truck gets 30 mi/gal. How many km/L does it get?

This conversion requires several steps.

$$\begin{aligned}1 \text{ mi} &= 1.6 \text{ km} && \text{First convert mi to km.} \\30 \text{ mi} &= 1.6 \times 30 \\&= 48 \text{ km} \\30 \text{ mi/gal} &= 48 \text{ km/gal}\end{aligned}$$

$$\begin{aligned}1 \text{ gal} &= 4.56 \text{ L} && \text{Now convert gallons to liters.} \\48 \text{ km/gal} &= 48 \text{ km}/4.56 \text{ L}\end{aligned}$$

$$48 \div 4.56 = 10.5 \text{ km/L} \quad \text{Divide 48 by 4.56 to find km/L.}$$

So 30 mi/gal = 10.5 km/L. The truck gets 30 mi/gal or 10.5 km/L

Using a Chart Backwards

Sometimes you have only one conversion chart, let's say the imperial to metric one. If you are converting pounds to grams, you just follow the steps listed. But if you are converting grams to pounds or centimeters to inches, what do you do? You **divide** the amount in centimeters by the conversion factor to convert the amount to inches.

Example: Convert 4 meters to yards using only the Imperial to Metric Chart.

Find the line with yards and meters on it. The conversion factor is .914. Divide by .914.

$$4 \text{ meters} \div .914 = 4.38 \text{ yards}$$

Converting Temperature

The metric and imperial systems have different units to measure temperature. The metric system uses the Celsius (C) scale. In this scale, the freezing point of water is 0°C and the boiling point is 100°C. In the Fahrenheit scale, the freezing point of water is 32°F and the boiling point is 212°F.

Two important temperature equivalents are:

$$0^{\circ}\text{C} = 32^{\circ}\text{F}$$

$$100^{\circ}\text{C} = 212^{\circ}\text{F}$$

1. **To change from Fahrenheit to Celsius**, subtract 32 from the degrees F and multiply the answer by 5/9. Use the Celsius unit (°C) in the final answer. The formula is $^{\circ}\text{C} = \frac{5}{9} (^{\circ}\text{F} - 32)$

Example: Change 45°F to Celsius.

$$\begin{aligned} ^{\circ}\text{C} &= \frac{5}{9} (^{\circ}\text{F} - 32) \\ &= 5/9(45^{\circ} - 32) \\ &= 5/9(13^{\circ}) \\ &= 7.2^{\circ}\text{C} \end{aligned}$$

2. **To change from Celsius to Fahrenheit**, multiply the degrees C by 9/5 and add 32. Use the Fahrenheit unit (°F) in the answer. The formula is: $^{\circ}\text{F} = \frac{9}{5} (^{\circ}\text{C}) + 32$

Example: Change 33°C to Fahrenheit.

$$\begin{aligned} ^{\circ}\text{F} &= \frac{9}{5} (^{\circ}\text{C}) + 32 \\ &= 9/5(33^{\circ}) + 32 \\ &= 59.4^{\circ} + 32 \\ &= 91.4^{\circ}\text{F} \end{aligned}$$

TO CONVERT FROM IMPERIAL TO METRIC

1. Find the equivalent units on the Imperial to Metric chart.
2. Multiply the given number of imperial units by the conversion factor (the number in front of the metric unit).
3. Write the multiplication answer with metric units to get the metric equivalent.
4. If there is no direct equivalent, for example from inches to meters, convert the inches to a unit for which there is an equivalency, which in this case is feet. Now the feet can be converted to meters.

TO CONVERT FROM METRIC TO IMPERIAL

1. Find the Metric to Imperial Equivalent chart.
2. Multiply the given number of metric units by the conversion factor (the number in front of the imperial unit).
3. Write the multiplication answer with imperial units to get the imperial equivalent.
4. If there is no direct equivalency, as with millimeters to inches, convert the millimeters to a unit for which there is an equivalency, which in this case is centimeters. Now the centimeters can be converted to inches.

Answer the following conversion questions. Use the conversion charts on the preceding pages.
Answers are at the end of this skills manual.

1. What are the equivalent temperatures in Fahrenheit degrees for the following?

a) 10°C b) 29°C c) 0°C d) 22°C

2. What are the equivalent temperatures in Celsius degrees?

a) 32°F b) 212°F c) 68°F d) 131°F

3. Make the following conversions from metric to imperial.

a) 1 cm = _____ in b) 25 cm = _____ in c) 1 m = _____ in = _____ ft = _____ yd

d) 12 m = _____ yd e) .5 m = _____ in f) 1 km = _____ mi

g) 30 km = _____ mi h) 1 L = _____ qt i) 6.8 L = _____ qt

j) $1 \text{ kg} = \underline{\hspace{2cm}} \text{ lb}$ k) $5 \text{ kg} = \underline{\hspace{2cm}} \text{ lb}$ l) $1 \text{ g} = \underline{\hspace{2cm}} \text{ oz} = \underline{\hspace{2cm}} \text{ lb}$

m) $500 \text{ g} = \underline{\hspace{2cm}} \text{ lb}$ n) $200 \text{ g} = \underline{\hspace{2cm}} \text{ oz}$

4. Make the following conversions from imperial to metric:

a) $1 \text{ in} = \underline{\hspace{2cm}} \text{ cm}$ b) $15 \text{ in} = \underline{\hspace{2cm}} \text{ cm}$ c) $1 \text{ yd} = \underline{\hspace{2cm}} \text{ m}$

d) $35 \text{ yd} = \underline{\hspace{2cm}} \text{ m}$ e) $1 \text{ mi} = \underline{\hspace{2cm}} \text{ km}$ f) $60 \text{ mi} = \underline{\hspace{2cm}} \text{ km}$

g) $1 \text{ qt} = \underline{\hspace{2cm}} \text{ L}$ h) $6 \text{ qt} = \underline{\hspace{2cm}} \text{ L}$ i) $1 \text{ lb} = \underline{\hspace{2cm}} \text{ g} = \underline{\hspace{2cm}} \text{ kg}$

j) $3 \text{ lb} = \underline{\hspace{2cm}} \text{ kg}$ k) $.8 \text{ lb} = \underline{\hspace{2cm}} \text{ g}$

5. You travel 450 miles to get to work each week. What is the distance traveled in kilometers?

6. A piece of metal is 15 feet 10 inches long. You need to cut it in two equal pieces. How long in centimeters will each piece measure? (First convert the 15 ft to inches and add that amount to the 10 inches. Then divide by 2.)

7. If a screw has a diameter of .5 inches, what is its diameter in millimeters?

8. How many litres are in 4 quarts of oil? How many litres are in a gallon of oil?

9. If a hole is drilled so that its centre is 16 inches from the edge of a sheet of metal, what is the distance from the edge to the centre of the hole in centimeters?

10. A metal patch that measures 4 inches high and $2 \frac{1}{2}$ inches wide needs to be placed so that it is 70 cm at its bottom edge from the bottom of the door. How many centimeters, rounded off to one decimal place, is it from the bottom of the door to the centre of the patch?

ANSWER PAGE

1. a) 50°F b) 84.2°F c) 32°F d) 71.6°F
2. a) 0°C b) 100°C c) 20°C d) 55°C
3. a) .39 in b) 9.75 in c) 39.4 in, 3.3 ft, 1.09 yd
d) 13.08 yd e) 19.7 in f) .62 mi
g) 18.6 mi h) .88 qt i) 5.98 qt
j) 2.2 lb k) 11 lb l) .035 oz, .0022 lb
m) 1.1 lb n) 7 oz
4. a) 2.54 cm b) 38.1 cm c) .914 m
d) 31.99 m e) 1.6 km f) 96 km
g) 1.14 L h) 6.84 L i) 454 g, 454 kg
j) 1.362 kg k) 363.2 g
5. 450 mi x 1.6 = 720 km
6. 15 ft = 180 in
180 + 10 = 190 in
190 ÷ 2 = 95 in
95 in x 2.54 = 241.3 cm
7. .5 in x 2.54 = 1.27 cm
1.27 cm = 12.7 mm (move the decimal point one place to the right)
8. 4.56 L in 4 qt. Since 4 qt. = 1 gal., the answer is the same: 4.56 L
9. 16 in x 2.54 = 40.64 cm
10. From the bottom of the patch to its centre is $4 \div 2 = 2$ in.
2 in = 5.08 cm
5.08 cm rounded off to one decimal place is 5.1 cm
70 cm + 5.1 cm = 75.1 cm