

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

**MATHEMATICS SKILLS  
IMPERIAL MEASUREMENT**

**AN ACADEMIC SKILLS MANUAL**  
for  
**The Construction Trades: Mechanical Systems**

This trade group includes the following trades:  
Electrician (Construction, Maintenance & Industrial),  
Network Cabling Specialist,  
Plumber, Refrigeration & Air Conditioning Mechanic,  
Sprinkler & Fire Protection, and Steamfitter,

*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

## IMPERIAL MEASUREMENT

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*An academic skill required for the study of the  
Construction Trades: Mechanical Systems*

### **INTRODUCTION**

The earliest systems of measurement of length were based on parts of the human body because they were always handy. Other measurements suited local conditions. With the advance of trade, the need for standard units of measurement grew. Common measurements became more or less standardized throughout nations that traded with each other. These common sizes gradually developed into *the imperial or customary system of measurement*. In the imperial system, there is no simple relationship between different units of the same type of measurements such as inches and feet.

Canada now uses the more logical metric system, but most industries have not fully switched over to metric measurements. Standard sizes in many trades are based on the old imperial system. The sizes of some materials have not yet been converted to metric. Equipment and parts move between Canada and the United States, which has not yet switched to metric. As a result, supplies come in a mixture of imperial and metric measurements. Also, textbooks and manuals from the U.S. are written using imperial units.

As a structural mechanical trades person, you have to be familiar with both the metric and imperial system. In your work, you will constantly refer to measurements with their units. You need to know linear units such as feet and inches to measure the length of pipe or a wire to be cut or the diameter of a hole to be drilled. You need to know the difference in weight of different types of wire, cable and cord. You need to know the recommended temperature range for operating certain equipment.

In this skills manual, the following aspects of the imperial system are covered:

- ◆ The basic units of length, weight, volume and temperature
- ◆ Imperial conversion, including
  - a chart of imperial equivalents
  - rules for converting
  - examples of converting from one imperial unit to another

## BASIC UNITS OF MEASUREMENT

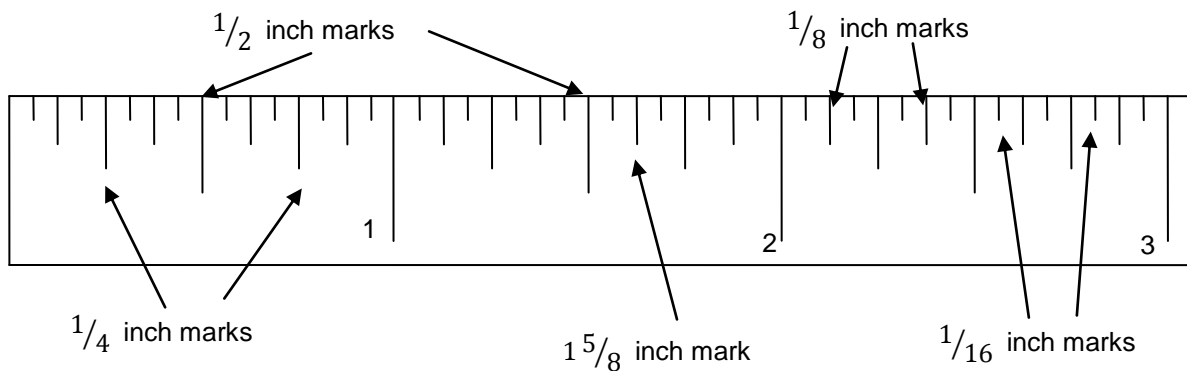
The basic units of measurement include those for **length, area, weight, volume or capacity, and temperature.**

**Length:** Units of length are called linear units. The imperial system has a variety of linear units. The most common are the **inch, foot, yard** and **mile**. A common symbol used to represent inches is " , while feet are represented by the symbol ' .

You work with linear measurements whenever you use a ruler or a micrometer to find the distance between two parts or the length of an object such as a bolt.

Imperial rulers or measuring tapes are divided into inches.

- The inches are subdivided into  $\frac{1}{2}$ , or half inches,  $\frac{1}{4}$ , or quarter inches,  $\frac{1}{8}$ , or one-eighth inches,  $\frac{1}{16}$ , or one-sixteenth inches and sometimes as small as  $\frac{1}{32}$  or one thirty-second inches.
- Most of these subdivisions are shown in Figure 1.



**Figure 1: Imperial Ruler**

To measure a length such as  $1 \frac{5}{8}$  inch, find the 1 inch division.

- Starting at the first  $\frac{1}{8}$  division mark past the 1 inch mark, count 5 of the  $\frac{1}{8}$  division marks.
- This brings you to  $1 \frac{5}{8}$  inches.

Notice that the second  $\frac{1}{8}$  division mark is the same as the first  $\frac{1}{4}$  mark and the fourth  $\frac{1}{8}$  division mark is the same as the  $\frac{1}{2}$  mark.

A longer tape measure will also show divisions for feet. To measure 7 feet  $5 \frac{3}{4}$  inches, find the 7 foot division mark.

- Next, find the 5 inch division mark past the 7 feet.
- Then count 3 of the  $\frac{1}{4}$  marks (including the larger  $\frac{1}{2}$  mark but not the smaller  $\frac{1}{8}$  and  $\frac{1}{16}$  division marks).
- This will bring you to the 7 ft  $5 \frac{3}{4}$  in division mark.

**Area:** Area is the amount of surface space enclosed by a linear boundary.

- The area of a metal panel can be found by multiplying the length by the width.
- If the length and width are measured in feet, the unit, feet, is **squared**; the unit of area is **squared feet** (sq ft or  $\text{ft}^2$ ).

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**Weight:** The imperial units of weight include the *ounce*, *pound* and *ton*. They are measured using a weigh scale.

**Capacity and Volume:**

*Units of capacity* are used to measure the amount an object can hold. The units vary depending on whether you are measuring a liquid or a dry material.

Liquid capacity units include the *fluid ounce*, *teaspoon*, *cup*, *pint*, *quart* and *gallon*.

- They are measured using various containers such as a graduated liquid measuring cup.

Dry measurements of capacity include all of these units except the fluid ounce.

*Units of volume* are used to measure the size of a three dimensional space occupied by or enclosed by an object.

The volume of a regularly shaped object is measured by the cubic space it occupies.

- The volume of a box is found by multiplying *the length times the width times the height*.
- If the unit of measure is feet, then the unit of volume is cubic feet (cu ft or ft<sup>3</sup>).

**Temperature:** The unit used to measure temperature in the imperial system is the Fahrenheit degree (°F).

- Water freezes at 32° F and boils at 212° F.
- You need to be aware of temperatures for heating and cooling applications.
- Temperature can also affect how a wiring system will work.
- Overheating can cause equipment damage.

**IMPERIAL CONVERSION**

Often you will work with measurements that are in different units, such as a length that is 10' 5". To make calculations such as finding the area, the measurements must be in the same units. You can't multiply feet and inches to find area. You have to convert one of the units so the units are all the same. Likely, you will convert the feet to inches.

To change a measurement from feet to inches, you convert the amount in feet to an equivalent amount in inches. A length of 1 foot is the same distance as a length of 12 inches. One foot and 12 inches are exactly the same length. They are **equivalent** amounts that have different units.

A **conversion factor** is used to convert one unit to the other. Each conversion factor relates equivalent amounts in different units. Some imperial conversion factors are listed in the Chart of Imperial Equivalents. In this chart, the larger unit usually has the number 1 in front of it. The number in front of the other unit is the conversion factor used to convert the units.

12 inches (in)	=	1 foot (ft)
3 ft	=	1 yard (yd)
1760 yd	=	1 mile (mi)
16 ounces (oz)	=	1 pound (lb)
2000 lb	=	1 ton
3 teaspoons (tsp)	=	1 tablespoon (tbsp)
16 tbsp = 1 cup (c)	=	8 fluid oz (fl oz)
2 c	=	1 pint (pt)
2 pt	=	1 quart (qt)
4 qt	=	1 gallon (gal)

Before you can convert from one unit to another, you need to memorize the conversion factor or have a chart you can refer to. In the chart above, the conversion factor is the number in front of the unit that doesn't have 1 in front of it.

**Example:** The chart shows that 3 feet is equal to 1 yard. The conversion factor for feet and yards is 3.

### **Equivalents of length**

The imperial units of length are inches (in), feet (ft), yards (yd) and miles (mi). Here are common equivalents for length from the chart. The conversion factors are the numbers in front of the units that don't have a one in front of them:

- 12 inches = 1 foot
- 3 feet = 1 yard
- 1760 yards = 1 mile

### **Equivalents of weight**

Here are the common equivalents for weight from the chart:

- 16 oz = 1 lb
- 2000 lb = 1 ton

### **Equivalents of capacity**

Some equivalents of capacity are:

- 3 teaspoons (tsp) = 1 tablespoon (tbsp)
- 16 tbsp = 1 cup
- 1 cup = 8 fluid ounces (fl oz)
- 2 cups = 1 pint
- 2 pints = 1 quart
- 4 quarts = 1 U.S. gallon

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**Note:** The difference between fluid ounces, a unit of volume, and ounces, a unit of weight, can cause confusion. Ounces marked on a measuring cup are fluid ounces, which measure capacity. Ounces on a scale are a unit of weight. In most cases, fluid ounces are not interchangeable with ounces of weight.

### Rules for Converting

To convert from one unit to another in the imperial system:

1. Divide or multiply the amount in the original unit by the **conversion factor**.
  - This changes the original amount to an equivalent amount in the other unit.
  - Whether you multiply or divide depends on whether the conversion is from a larger unit such as pounds to a smaller unit such as ounces, or from a smaller unit such as inches to a larger one such as feet.

There are two general rules to follow when using an imperial conversion chart:

- ◆ To convert from a **smaller** unit to a **larger** one, **divide** by the conversion factor.
- ◆ To convert from a **larger** unit to a **smaller** one, **multiply** by the conversion factor.

**Example:** Convert 48 inches to feet.

$$\begin{array}{ll} 48 \text{ in} \div 12 & \text{From the chart, the conversion factor is 12.} \\ = 4 \text{ ft} & \text{a smaller unit to a larger one, } \mathbf{divide} \text{ the quantity by the} \\ & \text{conversion factor} \end{array}$$

**Example:** Convert 8 yards to feet.

$$\begin{array}{ll} 8 \text{ yd} \times 3 & \text{a larger unit to a smaller one, } \mathbf{multiply} \text{ the quantity by the} \\ = 24 \text{ ft} & \text{conversion factor} \end{array}$$

**Example:** Convert 3 feet to inches.

$$\begin{array}{ll} 3 \text{ ft} \times 12 & \text{a larger unit to a smaller one, } \mathbf{multiply} \text{ by the conversion factor.} \\ = 36 \text{ inches} & \end{array}$$

**Example:** Change 3.5 gallons to quarts.

$$\begin{array}{ll} 3.5 \text{ gallons} \times 4 & \text{a larger unit to a smaller one, } \mathbf{multiply} \text{ by the conversion factor} \\ = 14 \text{ quarts} & \end{array}$$

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**Example:** Convert 75 inches to feet.

To convert inches to feet, a smaller unit to a larger one, **divide** the amount in inches by the conversion factor 12.

$$75 \div 12 = 6 \text{ remainder } 3$$

To express the remainder as a fraction, put it as the numerator of a fraction with 12 as the denominator.

$$6 \text{ remainder } 3 = 6 \frac{3}{12} \text{ feet}$$

Reduce to lowest terms.

$$6 \frac{3}{12} = 6 \frac{1}{4} \text{ feet}$$

If you are dividing with a calculator, it will give the answer 6.25 feet.

An amount expressed in mixed units has part of the answer in a larger unit and part in a smaller unit. **To express your answer using mixed units, follow these steps:**

1. The whole number part of the division answer is the amount of the larger unit.
2. The remainder is the amount of the smaller unit.

**Example:** 75 inches becomes 6 feet 3 inches.

**Example:** Convert 65 inches to feet.

To convert inches to feet, a smaller unit to a larger one, **divide** the amount in inches by the conversion factor 12.

$$\begin{aligned} 65 \div 12 &= 5 \text{ ft remainder } 5 \\ &= 5 \text{ ft } 5 \text{ in} \end{aligned}$$

If you divide using a calculator, the answer is:

$$65 \text{ in} \div 12 = 5.41666... \text{ ft} \quad \text{This repeating decimal can be } \textit{rounded off}.$$

**Rounding off:** Often a decimal answer is rounded off to two places, although you might choose to round off to the nearest whole number or to one decimal place. To round off to two decimal places:

1. Look at the digit in the third decimal place.
2. You have two choices:
  - a. If the third digit is 5 or more, drop it and round up the digit in the second decimal place to make it one digit higher.
  - b. If the third digit is less than 5, drop it and leave the second digit as it is.
3. Write the answer; *drop all other digits to the right.*

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**Example:** Round .333... off to two decimal places.

1. The digit in the third decimal place (three places to the right of the decimal point) is 3.
  - a. It is less than five, drop it and leave the second digit as it is.

.333... rounded to two places is .33

To round off to any other number of places, look at the digit **one past where you are rounding off to**. Then proceed in the same way.

**Example:** Round off .666... to one place.

1. The digit past the first decimal place is 6.
  - a. 6 is greater than 5, so the digit in the first decimal place becomes one digit higher, 7.
2. Drop the other digits.

.666... rounded to one place is .7

**Example:** Round off .6995 to three places.

1. The fourth digit past the decimal point is 5,
2. The third digit, 9, becomes one larger, which makes it 10.
3. The zero is written in the place where the 9 was.
  - The 1 is added to the 9 in the next place to the left which also makes it 10.
  - The zero is written in place of the 9 and the 1 is added to the 6, which changes it to 7.

.6995 rounded off to three places becomes .700

**Example:** Convert 65 inches to feet.

For this question, if you divide using a calculator, the answer is:

$$65 \text{ in} \div 12 = 5.41666... \text{ ft} \quad \text{round off.}$$

$$5.4166... \text{ rounded off to two places is } 5.42 \text{ ft}$$

To convert ounces to pounds, a smaller unit to a larger one, **divide** by the conversion factor 16.

- If your answer includes a remainder, the remainder can be expressed as a decimal number, a fraction or an amount with mixed units.
- If you use a calculator, any remainder will be shown as a decimal number.

**Example:** Convert 40 ounces to pounds.

$$40 \text{ oz} \div 16 = 2.5 \text{ lb}$$

If you divide 40 by 16 by hand, you will get an answer of 2 with a remainder of 8.

- You can continue dividing to get the answer 2.5 lb.
- You can also express the remainder as a fraction by placing it over the divisor 16, getting the answer  $2 \frac{8}{16}$ , reduced to  $2 \frac{1}{2}$  lb.

An amount expressed in mixed units has part of the answer in a larger unit and part in a smaller unit.

**To express your answer using mixed units, follow these steps:**

1. The whole number part of the division answer is the amount of the larger unit.
2. The remainder is the amount of the smaller unit.

**Example:** Convert 40 ounces to pounds.

$$40 \text{ oz} \div 16 = 2 \text{ remainder } 8 \quad \text{the whole number is the amount of the larger unit.}$$
$$= 2 \text{ lb } 8 \text{ oz.} \quad \text{the remainder is the amount of the smaller unit}$$

**Example:** Convert 88 inches to a mixed unit with feet and inches.

$$88 \div 12 = 7 \text{ R}4 \quad \text{the whole number is the amount of the larger unit.}$$
$$= 7 \text{ ft } 4 \text{ in.} \quad \text{the remainder is the amount of the smaller unit}$$

88 inches is 7 feet 4 inches.

You can convert between units that aren't next to each other on the chart.

- ◆ If you don't know all the conversion factors, work up or down from one unit to the next until you reach the unit you need.
  - To convert inches to yards, first convert inches to feet, then feet to yards.

**Example:** Convert 108 inches to yards.

$$108 \text{ inches} \div 12 = 9 \text{ feet} \quad \text{convert 108 inches to feet, then feet to yards.}$$
$$9 \text{ feet} \div 3 = 3 \text{ yards}$$

If you know the conversion factor 36 inches = 1 yard, you can convert directly.

Divide 108 inches by 36 to get 3 yards.

**In Brief: the steps in converting from one imperial unit to another:**

- Equivalent amounts are shown on a conversion chart.
  - Usually the larger unit has the number 1 in front of it.
  - The number in front of the other unit is the conversion factor.
- To convert from a smaller unit to a larger one, divide by the conversion factor.
- To convert from a larger unit to a smaller one, multiply by the conversion factor.
- If the conversion answer isn't a whole number, the remainder can be expressed as a decimal, a fraction or a mixed unit.

**Answer the following questions on converting from one imperial unit to another. The answers are at the end of this sheet. Check your answers as you proceed.**

1. Fill in the blanks in the table below:

<b>IMPERIAL EQUIVALENTS</b>
____ inches (in) = 1 foot (ft)
3 ____ = 1 yard (yd)
1760 yd = ____ mile (mi)
____ ounces (oz) = 1 pound (lb)
____ fluid ounces (fl oz) = 1 cup (c)
2 pt = 1 _____
____ qt = 1 gallon (gal)

2. Convert as indicated.

- |                 |                  |                 |
|-----------------|------------------|-----------------|
| a) 132 in to ft | b) 4 lb to oz    | c) 32 oz to lb  |
| d) 12 ft to yd  | e) 12 c to qt    | f) 44 qt to gal |
| g) 7 ft to in   | h) 3520 yd to mi | i) 10 yd to in  |
| j) 144 in to yd | k) 15 yd to ft   | l) 78 in to ft  |

3. Convert the following into feet and inches.

- |          |          |           |          |
|----------|----------|-----------|----------|
| a) 82 in | b) 25 in | c) 112 in | d) 66 in |
|----------|----------|-----------|----------|

4. If a job requires 20 pieces of wire, each 1 feet 3 inches long, what is the total length needed?

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**ANSWER PAGE**

1.

<b>IMPERIAL EQUIVALENTS</b>
<b><u>12</u></b> inches (in) = 1 foot (ft)
3 <b><u>ft</u></b> = 1 yard (yd)
1760 yd = <b><u>1</u></b> mile (mi)
<b><u>16</u></b> ounces (oz) = 1 pound (lb)
<b><u>8</u></b> fluid oz (fl oz) = 1 cup (c)
2 pt = 1 <b><u>quart (qt)</u></b>
<b><u>4</u></b> qt = 1 gallon (gal)

2. a) 11 ft  
b) 64 oz  
c) 2 lb  
d) 4 yd  
e) 3 qt  
f) 11 gal  
g) 84 in  
h) 2 mi  
i) 360 in  
j) 4 yd  
k) 45 ft  
l) 6.5 ft

3. a) 6 ft 10 in  
b) 2 ft 1 in  
c) 9 ft 4 in  
d) 5 ft 6 in

4.  $3 \text{ in} \div 12 = .25 \text{ ft}$   
 $1 \text{ ft} + .25 \text{ ft} = 1.25 \text{ ft}$   
 $1.25 \text{ ft} \times 20 = 25 \text{ ft}$   
The total length of wire needed is 25 ft.