

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

**MATHEMATICS SKILLS
IMPERIAL MEASUREMENT**

**AN ACADEMIC SKILLS MANUAL
for**

The Motive Power Service Trades

This trade group includes the following trades:
Automotive Service Technician, Heavy Duty Equipment Mechanic,
Motive Power Parts Person, Transmission Mechanic,
Truck & Coach Technician, and Truck & Trailer Service Technician

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

Revised 2011

In preparing these Academic Skill 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 SKILL

IMPERIAL MEASUREMENT

*An academic skill required for the study of the
Motive Power Service Trades*

INTRODUCTION

The earliest systems of measurement of length were based on parts of the human body. An inch was about the size of a thumb while a foot was about the size of a man's foot. With the advance of trade, 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*.

Canada now officially uses the metric system, but most industries have not fully switched over to metric measurements. The standard sizes for some materials have not yet been converted to metric. Vehicles 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.

In the motive power trades, you need to be familiar with the imperial system. You need to know feet, inches and fractions of an inch to read measurements. You have to read charts that list trade data such as the U.S. pitch system which identifies bolts by the number of threads per inch. You need to be familiar with imperial units used to give information on engine specifics such as pound-feet, pounds per square inch, BTU's, horsepower and miles per gallon.

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
 - operations with mixed units including adding, subtracting, multiplying and dividing
- ◆ Other imperial units

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 measurements. 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.

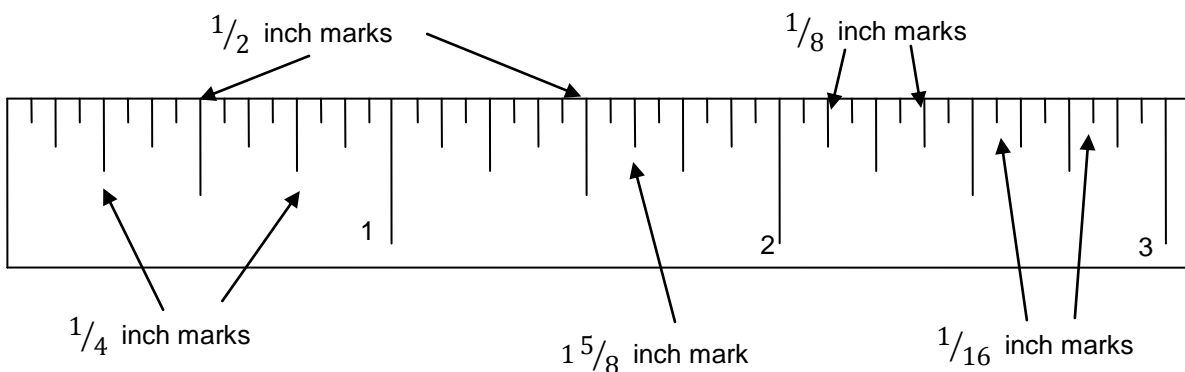


Figure 1: Imperial Ruler

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 ft^2).

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 ft³).

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.

IMPERIAL CONVERSION

At times you will work with measurements that are in different units. 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, convert the amount in feet to an equivalent amount in 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 of 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

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.

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

Example: Convert 8 yards to feet.

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

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.

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

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.*

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.

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

$= 2 \text{ lb } 8 \text{ oz.}$ the remainder is the amount of the smaller unit

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

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

$= 7 \text{ ft } 4 \text{ in.}$ 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.

$108 \text{ inches} \div 12 = 9 \text{ feet}$ 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.

Decimals and fractions: Occasionally you will need to convert an imperial measurement which is expressed in a decimal form.

To do this conversion, multiply the decimal or fraction by the conversion factor from the chart of Imperial Equivalents.

Example: Convert 2.8 ft to a measurement using feet and inches

$.8 \times 12 = 9.6$ conversion factor is 12.
multiply the decimal by 12.
The measurement is 2 ft 9.6 in or 2 ft 9 $\frac{2}{5}$ in.

Example: Change $3\frac{1}{5}$ ft so the fraction is in inches.

$$\begin{aligned} \frac{1}{5} \times 12 &= 2.4 && \text{multiply the fraction by 12} \\ 2.2 \text{ ft} &= 3 \text{ ft } 2.4 \text{ in, or} \\ 3.2 \text{ ft} &= 3 \text{ ft } 2\frac{1}{5} \text{ in} \end{aligned}$$

Example: Change 4.5 yds so the decimal is in feet.

$$\begin{aligned} .5 \times 3 &= 1.5 && \text{conversion factor is 3.} \\ &&& \text{multiply the decimal by 3.} \\ 4.5 \text{ yds} &= 4 \text{ yds } 1.5 \text{ ft} \end{aligned}$$

Example: Change $2\frac{1}{2}$ lb so the fraction is in ounces.

$$\begin{aligned} \frac{1}{2} \times 16 &= 8 && \text{conversion factor is 16} \\ &&& \text{multiply the fraction by 16} \\ 2\frac{1}{2} \text{ lb} &= 2 \text{ lb } 8 \text{ oz} \end{aligned}$$

Example: Change 1.3 gallons so the decimal part is in quarts.

$$\begin{aligned} .3 \times 4 &= 1.2 && \text{conversion factor is 4.} \\ &&& \text{multiply the decimal by 4} \\ 1.3 \text{ gal} &= 1 \text{ gal } 1.2 \text{ qt} \end{aligned}$$

Operations With Mixed Units

You will be asked to solve questions involving measurements that are in mixed units.

Example: Find the total length of two pipes, one measuring 3 ft 4 in and the other measuring 6 ft 10 in.

Method 1 for working with mixed units

1. Convert all the amounts expressed in units to the unit easiest to work with.
2. For each number, add the two amounts, now both expressed in the same unit.
3. Then do the necessary mathematical operations.
4. Change the answer back to mixed units if you want by *dividing* by the conversion factor.
5. The whole number answer is the amount of the larger unit. Any remainder is the amount of the smaller unit.

Example: Find the total length of two steel rods, one measuring 3 ft 4 in and the other measuring 6 ft 10 in.

Choose to change all measurements to inches so calculations can be done with whole numbers.

The first steel rod is 3 ft 4 in.

1. Change the 3 ft to 36 in ($3 \times 12 = 36$ in).
2. Add the 4 inches to the 36 inches to get 40 in.

The second steel rod is 6 ft 10 in.

1. Change the 6 ft to 72 in ($6 \times 12 = 72$ in).
2. Add the 10 inches to get 82 in.

3. The total length of the two rods is $40 + 82 = 122$ in.

4. To convert the inches to mixed units, divide by the conversion factor 12.
 $122 \div 12 = 10$ remainder 2.

5. The whole number 10 in the division answer is the amount in feet.
The remainder 2 is the amount in inches.

122 inches expressed as a mixed number is 10 ft 2 in.

Method 1 works, whether you are adding, subtracting, multiplying or dividing.

Change the amounts of the larger unit to the smaller unit and add this to the original amounts of the smaller unit in all the measurements. Then carry out whatever operations you need to do.

You can use the first method to do all operations with mixed numbers, but we will also look at other methods so you will have a choice.

Method 2 for working with mixed units

In this method work with the units separately. In other words you will work with all of the inches together, and all of the feet together. Only after you have done the operations (add, subtract, multiply or divide) will you recombine the units.

The steps for using the Method 2:

1. Do the operation separately with the amounts in each unit.
2. The answers will be in the two different units.
3. If the amount of the smaller unit is equal to or greater than the conversion factor to the larger unit, divide the number of the smaller unit by the conversion factor.
4. Add the answer to the division question to the amount of the larger unit. Any remainder forms the amount of the original, smaller unit.

Adding mixed units with Method 2

To add measurements with mixed units, add each set of units together. If the answer to any smaller unit is equal to or greater than the conversion factor, change it to the larger unit. Keep any remainder as the smaller unit.

Example: One box of screws weighs 3 lb 12 oz. A second box weighs 6 lb 10 oz. What is the total weight of the two boxes?

1. First add the pounds together and then the ounces together.

3 lb add the pounds
6 lb
9 lb

$$\begin{array}{r} 12 \text{ oz} \quad \text{add the ounces} \\ \underline{10 \text{ oz}} \\ 22 \text{ oz} \end{array}$$

- The amount of the smaller unit, 22 ounces, is more than the conversion factor 16.
- Divide the number of ounces by the conversion factor 16:

$$22 \div 16 = 1 \text{ with } 6 \text{ remainder} \quad \text{the remainder is the number of ounces} \\ = 1 \text{ lb } 6 \text{ oz}$$

- Add the answer of the division question (1) to the number of pounds:

$$9 \text{ lb} + 1 \text{ lb } 6 \text{ oz} = 10 \text{ lb } 6 \text{ oz}$$

If the amount of the smaller unit is less than the conversion factor to the larger unit, leave the amounts of the units as they are.

Example: Add 4 ft 5 in to 2 ft 6 in.

$$\begin{array}{r} 4 \text{ ft} + 2 \text{ ft} = 6 \text{ ft} \quad \text{Add the feet.} \\ 5 \text{ in} + 6 \text{ in} = 11 \text{ in.} \quad \text{Add the inches.} \end{array}$$

The conversion factor for inches to feet is 12.
The number of inches, 11, is less than the conversion factor.
The number of the two units can remain as they are.

The answer is: 6 ft 11 in

Example: Add 3 gallons 2 quarts to 7 gallons 2 quarts.

$$\begin{array}{r} 3 \text{ gal} + 7 \text{ gal} = 10 \text{ gal} \quad \text{Add the gallons.} \\ 2 \text{ qt} + 2 \text{ qt} = 4 \text{ qt} \quad \text{Add the quarts.} \end{array}$$

The number of the smaller unit is equal to 4 which is the conversion factor.
Divide the number of quarts by the conversion factor:

$$\begin{array}{r} 4 \text{ qt} \div 4 = 1 \text{ gal} \quad (\text{There is no remainder}) \\ 10 \text{ gal} + 1 \text{ gal} = 11 \text{ gal} \end{array}$$

Subtracting mixed units using Method 2

Subtract like units, starting with the smallest unit:

- If the answer of a smaller unit is equal to or greater than the conversion factor to the next larger unit, convert it.
- Keep any remainder as the smaller unit.

You may have to borrow when you subtract two measurements.

Example: 6 yd 1 ft - 4 yd 2 ft

1. You can't subtract 2 feet from 1 foot but you can borrow 1 yard from the number of yards in the larger number, making the number of yards now smaller by 1. The 6 yd is now 5 yd.
2. Convert that borrowed 1 yard to 3 feet and add it to the 1 foot already there, changing the first number into its equivalent 5 yd 4 ft.

Now you can subtract:

$$5 \text{ yd } 4 \text{ ft} - 4 \text{ yd } 2 \text{ ft} = 1 \text{ yd } 2 \text{ ft}$$

Multiplying mixed units using Method 2

To multiply measurements with mixed units:

1. Multiply each unit by the multiplier.

If the answer to any smaller unit is equal to or greater than the conversion factor convert it to the larger unit, it is divided in the same way as an addition answer.

Example: Multiply 7 ft 3 in by 5

$$\begin{aligned} 7 \text{ ft} \times 5 &= 35 \text{ ft} \\ 3 \text{ in} \times 5 &= 15 \text{ in} \end{aligned}$$

15 inches is bigger than the conversion factor 12

$$\begin{aligned} 15 \text{ in} \div 12 &= 1 \text{ ft } 3 \text{ in} \\ 35 \text{ ft} + 1 \text{ ft } 3 \text{ in} &= 36 \text{ ft } 3 \text{ in} \end{aligned}$$

Dividing mixed units using Method 2

If you can divide the amount of each unit evenly by the divisor, divide the amount of each unit separately, keeping the separate units in the answer.

Example: 2 ft 8 in \div 2

$$\begin{aligned} 2 \text{ ft} \div 2 &= 1 \text{ ft} \\ 8 \text{ in} \div 2 &= 4 \text{ in} \\ 2 \text{ ft } 8 \text{ in} \div 2 &= 1 \text{ ft } 4 \text{ in} \end{aligned}$$

If the divisor does not divide evenly into both parts, it is easier to use Method 1 to divide.

To use Method 1:

1. Convert the larger unit to the smaller unit in each number,
2. Add the amounts of each number together.
3. Then divide the new numbers.
4. The answer is expressed only in the smaller unit.
5. Convert the answer back to the larger unit if necessary by dividing by the conversion factor.

Example: 12 ft 10 in \div 3

$$12 \text{ ft} \times 12 = 144 \text{ in}$$

$$144 \text{ in} + 10 \text{ in} = 154 \text{ in}$$

$$154 \text{ in} \div 3 = 51.33 \text{ in}$$

Change ft to in.

Add to the original number of inches in the question.

Divide:

Round off to 51 in

To convert back to feet:

$$51 \text{ in} \div 12 = 4 \text{ ft remainder } 3 \text{ in}$$

$$12 \text{ ft } 10 \text{ in} \div 3 = 4 \text{ ft } 3 \text{ in}$$

Method 3 for working with mixed units

The third method of doing operations with mixed numbers is to convert the smaller unit, usually inches, to a decimal part of the larger unit, which is usually feet.

To convert inches to *decimal feet*, as this conversion is called:

1. Divide the amount in inches by the conversion factor 12.
2. The division answer is added to the whole number of feet.

Example: Convert 10 ft 6 in to decimal feet.

$$6 \text{ in} \div 12 = .5 \text{ ft}$$

$$10 \text{ ft} + .5 \text{ ft} = 10.5 \text{ ft}$$

Divide the inches by the conversion factor 12.

Add the decimal feet to the whole number of feet.

OTHER IMPERIAL UNITS

In your work, you will constantly be referring to measurements along with their units.

- ◆ You need to know linear units to measure items such as the cable that carries power from the battery to the lights or to calculate the area of a circle or the volume of a cylinder.
- ◆ You need to know units of weight to understand vehicle weight classifications.
- ◆ You need to know units of capacity to interpret the specifications for automobiles that use propane fuel systems.
- ◆ You need to know units of temperature when calculating the amount of charge on a battery or when interpreting a welding flame.

However, there are other scientific units you will meet in your courses and at work. We will look at a few of these units.

Pressure is the measure of a force per unit area. Force is measured in pounds in the imperial system. So pressure is *pounds per square inch*, shortened to *psi*.

- The amount of pressure present is an important consideration in many situations, including the pressure of an oxygen or an acetylene tank.

Torque is the turning force developed by the engine. It is a measure of the engines's ability to do work. *Work* is calculated by multiplying the force exerted by the distance it is exerted over.

To find the torque of an engine multiply the *force* exerted by the piston by the *length* of the connecting rod. Since force is measured in pounds and length in feet, units of torque are *pound-feet* (lb-ft).

- This force applied to the crankshaft along the length of the connecting rod causes the crankshaft to rotate, resulting in a certain number of rotations per minute (rpm).

Power is a measure of the rate of doing work. It is calculated by dividing the work done in lb-ft by the time it takes in seconds.

The unit of power is the *horsepower*, which is 500 lb-ft per sec.

- Since horsepower is a measure of how fast an engine works, the quicker the engine speed, the more horsepower there is.
- However, for a certain horsepower, the faster the engine speed (rpm), the less torque (lb-ft) and vice versa.

One way of calculating the amount of work done by an engine is based on the fuel heat value. A **BTU** is the quantity of heat needed to raise the temperature of one pound of water one Fahrenheit degree. Fuel heat value is the number of British thermal units or BTU's in the fuel used.

- A lighter fuel will have less heat value than a heavier fuel.
- A fuel of an average weight will have about 140,000 BTU's per gallon.

The performance of an engine might be given in imperial units by listing the engine speed in rpms, the engine power in hp, the engine torque in lb-ft, the engine pressure in psi, and the fuel consumption in mpg.

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:

IMPERIAL EQUIVALENTS
____ 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. Convert the following into feet and inches:

- a) 3.25 ft b) 8.5 ft c) 12.75 ft

5. Convert the following into feet and inches:

- a) 5 1/2 ft b) 15 3/4 ft c) 6 1/3 ft d) 9 1/12 ft

6. Add, using whatever method you prefer. Express your answer in mixed units:

- a) $5 \text{ ft } 2 \text{ in} + 3 \text{ ft } 8 \text{ in}$ b) $1 \text{ gal } 3 \text{ qt} + 2 \text{ gal } 1 \text{ qt}$
c) $5 \text{ lb } 12 \text{ oz} + 6 \text{ lb } 9 \text{ oz}$ d) $10 \text{ ft } 9 \text{ in} + 5 \text{ ft } 7 \text{ in}$
e) $4 \text{ ft } 4 \text{ in} + 10 \text{ in} + 8 \text{ ft } 6 \text{ in}$

7. Subtract, using whatever method you prefer. Express your answer in mixed units:

1. $6 \text{ lb } 10 \text{ oz} - 4 \text{ lb } 8 \text{ oz}$. b) $6 \text{ ft } 10 \text{ in} - 3 \text{ ft } 5 \text{ in}$
c) $12 \text{ ft } 6 \text{ in} - 9 \text{ ft } 8 \text{ in}$ d) $4 \text{ ft } 3 \text{ in} - 3 \text{ ft } 7 \text{ in}$

8. Multiply, using whatever method you prefer. Express your answer in mixed units:

1. $4 \text{ gal } 2 \text{ qt} \times 2$ b) $3 \text{ ft } 9 \text{ in} \times 5$
c) $6 \text{ ft } 2 \text{ in} \times 10$ d) $8 \text{ ft } 4 \text{ in} \times 3$
e) $12 \text{ ft } 6 \text{ in} \times 4$

9. Divide, using whatever method you prefer. Express your answer in mixed units:

- a) $2 \text{ lb } 8 \text{ oz} \div 2$ b) $12 \text{ ft } 6 \text{ in} \div 3$
c) $7 \text{ ft } 9 \text{ in} \div 2$ d) $20 \text{ ft } 10 \text{ in} \div 5$
e) $4 \text{ ft } 9 \text{ in} \div 3$

10. Change the decimal part of the following numbers to a fraction:

- a) 15.4 ft b) 2.5 ft c) 3.75 ft

11. Convert to decimal feet:

- a) 7 ft 9 in b) 5 ft 6 in c) 15 ft 3 in

ANSWER PAGE

1.

IMPERIAL EQUIVALENTS
<u>12</u> inches (in) = 1 foot (ft)
3 <u>ft</u> = 1 yard (yd)
1760 yd = <u>1</u> mile (mi)
<u>16</u> ounces (oz) = 1 pound (lb)
<u>8</u> fluid oz (fl oz) = 1 cup (c)
2 pt = 1 <u>quart (qt)</u>
<u>4</u> 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. a) 3 ft 3 in
b) 8 ft 6 in
c) 12 ft 9 in

5. a) 5 ft 6 in
b) 15 ft 9 in
c) 6 ft 4 in
d) 9 ft 1 in

6. a) 8 ft 10 in
b) 4 gal
c) 12 lb 5 oz
d) 16 ft 4 in
e) 13 ft 8 in
7. a) 2 lb 2 oz
b) 3 ft 5 in
c) 2 ft 10 in
d) 8 in
8. a) 9 gal
b) 18 ft 9 in
c) 61 ft 8 in
d) 25 ft
e) 50 ft
9. a) 1 lb 4 oz
b) 4 ft 2 in
c) 3 ft 10.5 in
d) 4 ft 2 in
e) 1 ft 7 in
10. a) $15 \frac{2}{5}$ ft
b) $2 \frac{1}{2}$ ft
c) $3 \frac{3}{4}$ ft
11. a) 7.75 ft
b) 5.5 ft
c) 15.25 ft