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| AUTHOR | Engelbrecht, Nancy; And Others |
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ABSTRACT

This module is the 10th in a series of 12 learning modules designed to teach occupational mathematics. Blocks of informative material and rules are followed by examples and practice problems. The solutions to the practice problems are found at the end of the module. Specific topics covered include the metric concepts of mass, weight, and volume capacity and problem solving with these metric units. (YLB)

*Project Director*
*Ron Vorderstrasse*

*Project Secretary*
*Jan Wisialowski*

*Technical Consultant*
*Ray Plankinton*

*Technical Writers*
*Nancy Engelbrecht*
*Lynne Graf*
*Ann Hunter*
*Stacey Oakes*

# MODULE 10--MORE METRIC MEASUREMENT CONCEPTS

While the metric portion of Module 9 concentrated upon the length quantity, there was a little information about other types of quantities which also have metric measure. Lesson 10 contains specific sections about the metric concepts of mass, weight and volume capacity. This lesson ends with problem solving with some of the other metric units.

**MASS AND WEIGHT**

From a scientific perspective, the MASS of an object is the quantity of matter in the object. The amount of matter in a particular object is considered constant. That means that the mass of an object is constant.

The WEIGHT of an object is the measure of the gravitational pull which is acting on the object.

The general public incorrectly uses the terms mass and weight as meaning the same thing. The following illustration will show you why mass and weight are not the same thing. An Earthling astronaut lands on the moon. The amount of matter in his/her body is the same on Earth as it is on the moon. Their body mass did not change. Their mass is constant. The gravity of the moon is approximately one-fifth that of the Earth. The astronaut's moon weight is about one-fifth that of their Earth weight. Weight is dependent upon gravity.

The work of a machinist takes place on planet Earth. Earth gravity does not vary significantly between one work place and another work place. The weight of a work piece does not change significantly even if it is shipped from one factory at one altitude to another factory at another altitude. If the machine using the part is to stay at or near the surface of the Earth, then it's weight is essentially constant.

We will equate units of mass to units of weight with the premise that all measurements take place at standard Earth's gravity. In Table 6, the column headings will specify if the quantity is mass or weight. These assumptions may cause Newton to roll over but he can't get out.

**TABLE 6 MASS AND WEIGHT EQUIVALENCES**

| Mass | Mass | Weight | Weight |
|---|---|---|---|
| Metric to metric | | | |
| 1 Mg = 1,000,000 g | | | |
| 1 kg = 1000 g | | | |
| 1 hg = 100 g | | | |
| 1 dag = 10 g | | | |
| 1 dg = 0.1 g | | | |
| 1 cg = 0.01 g | | | |
| 1 mg = 0.001 g | | | |
| 1 μg = 0.000,001 g | | | |
| 1 metric ton = 1000 kg | | | |
| | **Mass** | **Weight** | |
| | 1 kg = 9.81 newtons(N) | | |
| | 1 kg = 2.20 pounds(lb) | | |
| | | **Weight** | **Weight** |
| | | 1 lb = 4.448 N | |
| | | 1 lb = 16 ounces(oz) | |
| | | 1 ton = 2000 lb | |

The 6 step approach to measurement conversions from Module 9 will be used throughout Module 10.

**EXAMPLE 1:** Change 4.186 kg to grams.

Solution:

$$4.186\ \text{kg} = \frac{4.186\ \text{kg}}{1} \times \frac{1000\ \text{g}}{1\ \text{kg}}$$

$$= (4.186)(1000)\ \text{g}$$

$$= 4{,}186\ \text{g}$$ 4 signf. digits

**EXAMPLE 2:** Change 1.87 lb into grams.

Solution:

$$1.87\ \text{lb} = \frac{1.87\ \text{lb}}{1} \times \frac{1\ \text{kg}}{2.20\ \text{lb}} \times \frac{1000\ \text{g}}{1\ \text{kg}}$$

$$= (1.87)(1000) \div 2.20\ \text{g}$$

$$= 850\ \text{g}$$

Note: The ending zero needs to be tagged to show 3 signf. digits

**EXAMPLE 3:** Change 765 N into pounds.

Solution:

$$765\text{ N} = \frac{765\ \cancel{\text{N}}}{1} \times \frac{1\text{ lb}}{4.448\ \cancel{\text{N}}}$$

$$= (765) \div 4.448\text{ lb}$$

$$= 171.9874101\text{ lb}$$

$$\approx 172\text{ lb} \qquad \text{3 signf. digits}$$

**EXAMPLE 4:** Change 1.00 metric tons into the English ton.

Solution:

$$1.00\text{ metric ton} = \frac{1\ \cancel{\text{metric ton}}}{1} \times \frac{1000\ \cancel{\text{kg}}}{1\ \cancel{\text{metric ton}}}$$

$$= \frac{1}{1} \times \frac{1000\text{ kg}}{1} \times \frac{2.20\text{ lb}}{1\ \cancel{\text{kg}}} \times \frac{1\text{ ton}}{2000\ \cancel{\text{lb}}}$$

$$= (1000)(2.2) \div 2000\text{ ton}$$

$$= 1.1\text{ ton}$$

$$= 1.10\text{ ton} \qquad \text{3 signf. digits}$$

**PRACTICE PROBLEMS:** Compute the following conversions of the unit of measure.

1. Change 875 g into kg
2. Change 4.3 g into cg
3. Change 271 mg into g
4. Change 0.025 kg into g
5. Change 86.7 kg into lb
6. Change 4,135 lb into kg
7. Change 46.2 oz into kg
8. Change 19.61 g into oz
9. Change 73.15 N into kg
10. Change 193 lb into kg
11. Change 1.72 oz into g
12. Change 2150 N into tons
13. Change 1.25 ton into kg
14. Change 3.21 ton into metric tons
15. Change 215.3 lb into N
16. Change 4,135 lb into metric tons

## VOLUME AND CAPACITY

The English system of measurement contains two different types of units of measure for volume. Examples from the two categories include the $ft^3$ and gallon units of measure. Given a metal bin, both units of measure could be applied to the bin. The $ft^3$ is a volume unit used to determine the size of the bin from the standpoint of length, width and height. The gallon volume unit is used to determine capacity, as if the metal bin were to contain a liquid (water for instance) or a gas (oxygen for instance). Volume in cubic units of length is a measure of the size of the container. Volume in quarts or gallons is a measure of the capacity of the container. Sometimes it is necessary to make a distinction between volume size and volume capacity. The English measurement system is not designed so as to allow for easy and logical conversion between the two types of volumes.

The units of measure for volume size in the metric system are those like the $m^3$ and $cm^3$ found in Module 9. The basic unit of capacity in the metric system is the liter (L). One liter (L) is just slightly more than 1 quart.

The metric system was designed so that the conversion between size volume and capacity volume would be easy. Both types of volumes also have a direct link to the gram mass unit. In the definition of metric units of measure, water was used to set the standards. At the temperature of 4°C, 1 gram of water would have the volume size of 1 $cm^3$ and fill a container of 1 mL capacity.

| TABLE 7 VOLUME EQUIVALENCES | |
|---|---|
| Capacity Volumes | |
| 1 kL = 1000 L | |
| 1 mL = 0.001 L | |
| 1 L = 1.06 qt | 3 signf. digit |
| 1 L = 1.056 qt | 4 signf. digit |
| Capacity and Size Volumes | |
| 1 mL = 1 $cm^3$ | |
| 4°C Water | Capacity, Volume vs Mass |
| 1 mL = 1 $cm^3$ $\longrightarrow$ 1 gram | |

**EXAMPLE 5:** Change 48.7 mL into L.

Solution:

$$48.7\text{ mL} = \frac{48.7\ \cancel{\text{mL}}}{1} \times \frac{0.001\text{ L}}{1\ \cancel{\text{mL}}}$$

$$= (48.7)(0.001)\text{ L}$$

$$= 0.0487\text{ L}$$

**EXAMPLE 6:** Change 87.3 mL into pints.

Solution:

$$87.3\text{ mL} = \frac{87.3\ \cancel{\text{mL}}}{1} \times \frac{0.001\ \cancel{\text{L}}}{1\ \cancel{\text{mL}}} \times \frac{1.06\ \cancel{\text{qt}}}{1\ \cancel{\text{L}}} \times \frac{2\text{ pt}}{1\ \cancel{\text{qt}}}$$

$$= (87.3)(0.001)(1.06)(2)\text{ pt}$$

$$= 0.185076\text{ pt}$$

$$= 0.185\text{ pt} \qquad \text{3 signf. digit}$$

**EXAMPLE 7:** Change 3.50 gallons into $cm^3$.

Solution:

$$3.50\text{ gal} = \frac{3.50\ \cancel{\text{gal}}}{1} \times \frac{4\ \cancel{\text{qt}}}{1\ \cancel{\text{gal}}} \times \frac{1\ \cancel{\text{L}}}{1.06\ \cancel{\text{qt}}} \times \frac{1\ \cancel{\text{mL}}}{0.001\ \cancel{\text{L}}} \times \frac{1\text{ cm}^3}{1\ \cancel{\text{mL}}}$$

$$= (3.50)(4)\div 1.06 \div 0.001\text{ cm}^3$$

$$= 13{,}207.54717\text{ cm}^3$$

$$= 13{,}200\text{ cm}^3 \qquad \text{3 signf. digit}$$

**EXAMPLE 8:** What would be the mass in grams of a 12.00 fluid ounce glass of cold water?

Solution:

$$12.00\text{ fl oz} = \frac{12\ \cancel{\text{fl oz}}}{1} \times \frac{1\ \cancel{\text{pt}}}{16\ \cancel{\text{fl oz}}} \times \frac{1\ \cancel{\text{qt}}}{2\ \cancel{\text{pt}}} \times \frac{1\ \cancel{\text{L}}}{1.056\ \cancel{\text{qt}}}$$

$$= \frac{12}{1} \times \frac{1}{16} \times \frac{1}{2} \times \frac{1\text{ L}}{1.056} \times \frac{1\text{ mL}}{0.001\text{ L}} \times \frac{1\text{ g}}{1\text{ mL}}$$

$$= (12)\div 16 \div 2 \div 1.056 \div 0.001 \div 1\text{ g}$$

$$= 355.1136364\text{ g}$$

$$= 355.1\text{ g} \qquad \text{4 signf. digits}$$

**PRACTICE PROBLEMS:** Compute the following conversions of the unit of measure.

17. Change 91.7 mL into L.
18. Change 4.93 L into mL.
19. Change 17.02 kL into L.
20. Change 21.70 $cm^3$ into mL.
21. Change 87.5 mL into $cm^3$.
22. Change 1.81 L into $cm^3$.
23. Change 27.3 mL into $in^3$.
24. Change 915.2 $mm^3$ into mL.
25. Change 38.7 $cm^3$ into L.
26. Change 307 $in^3$ into L.

For water at 4°C, compute the

27. mass in g of 1 L.
28. volume in $cm^3$ of 87.5 g.
29. volume in L of 0.735 kg.
30. weight in pounds of 4.71 L

For the technician in tool and die, the most commonly used metric units of measure are the meter length, gram mass and liter capacity. These are listed below along with some of the other metric quantities which you will likely encounter occasionally. The same table is given in Module 9.

TABLE 8 BASIC METRIC MEASUREMENT UNITS

| Quantity | Metric name | Metric Symbol |
|---|---|---|
| length | meter | m |
| area | square meter | $m^2$ |
| volume(size) | cubic meter | $m^3$ |
| volume(capacity) | liter | L |
| mass | gram | g |
| time | second | s |
| force | newton | N |
| pressure(stress) | pascal | Pa |
| temperature | degree Celsius | °C |
| velocity(speed) | meters per second | m/s |
| angles | degree | ° |
| | minute | ' |
| | second | " |
| frequency | hertz | Hz |
| electric potential | volt | V |
| electric current | ampere | A |
| elec capacitance | farad | F |

The conversion fraction needed to change a given metric measurement in a given unit to another metric measurement with a new unit depends entirely upon the number meaning of the prefix. It should not be necessary to memorize a completely new table for mass in grams, a new table for volume capacity in liters and a new table for every possible metric basic unit. Table 9 below contains some illustrations of equivalents. Notice that the prefix and number values match.

TABLE 9 EXAMPLES OF METRIC EQUIVALENTS

| Quantity | Equivalence |
|---|---|
| time | 1 ms = 0.001 s |
| electric potential | 1 kV = 1000 V |
| frequency | 1 MHz = 1,000,000 Hz |
| electric current | 1 μA = 0.000,001 A |
| force | 1 cN = 0.01 N |
| length | 1 dam = 10 m |

**EXAMPLE 9:** Change the given metric measurement into the indicated unit.

(a) Change 0.307 kHz into Hz.
(b) Change 5320 μA into mA.
(c) Change 0.0731 MV into kV.

Solution:

(a) $$0.307 \text{ kHz} = \frac{0.307 \cancel{\text{kHz}}}{1} \times \frac{1000 \text{ Hz}}{1 \cancel{\text{kHz}}}$$

$$= (0.307)(1000) \text{ Hz}$$

$$= 307 \text{ Hz}$$

(b) $$5320\ \mu\text{A} = \frac{5320\ \mu\text{A}}{1} \times \frac{0.000{,}001 \text{ A}}{1\ \cancel{\mu\text{A}}} \times \frac{1 \text{ mA}}{0.001 \cancel{\text{A}}}$$

$$= (5320)(0.000{,}001) \div 0.001 \text{ mA}$$

$$= 5.32 \text{ mA}$$

(c) $$0.0731 \text{ MV} = \frac{0.0731 \text{ MV}}{1} \times \frac{1{,}000{,}000 \text{ V}}{1 \text{ MV}} \times \frac{1 \text{ kV}}{1000 \text{ V}}$$

$$= (0.0731)(1{,}000{,}000) \div 1000 \text{ kV}$$

$$= 73.1 \text{ kV}$$

**PRACTICE PROBLEMS:** Compute the following conversions of the unit of measure.

31. Change 7.94 kV into V.
32. Change 0.025 ms into s.
33. Change 101MHz into Hz.
34. Change 1510 kHz into Hz.
35. Change 1510 kHz into MHz.
36. Change 46,200 Pa into kPa
37. Change 0.18 kA into A.
38. Change 1.5 MV into V.
39. Change 1.92 kPa into Pa.
40. Change 0.19 MPa into kPa.
41. Change 3500 μs into s.
42. Change 650 s into ks.
43. Change 28,200 μA into A.
44. Change 28,200 mA into A.
45. Change 72,000 V into kV.
46. Change 72,000 V into MV.
47. Change 93,200 Hz into MHz.
48. Change 90,400 Hz into kHz.
49. Change 8.00 hours into Ms.
50. Change 100 minutes into ks.

## PRACTICE PROBLEM SOLUTIONS -- MODULE 10

| | |
|---|---|
| 1. 0.875 kg | 2. 430 cg |
| 3. 0.271 g | 4. 25 g |
| 5. 191 lb | 6. 1880 lb |
| 7. 1.31 kg | 8. 0.6903 oz |
| 9. 7.457 kg | 10. 87.7 kg |
| 11. 0.0489 g | 12. 0.241 ton |
| 13. 1140 kg | 14. 2.92 metric ton |
| 15. 960.0 N | 16. 1.880 metric tons |
| 17. 0.0917 L | 18. 4930 mL |
| 19. 17,020 L | 20. 21.70 mL |
| 21. 87.5 $cm^3$ | 22. 1819 $cm^3$ |
| 23. 0.0387 L | 24. 0.9152 mL |
| 25. 1.67 $in^3$ | 26. 5.07 L |
| 27. 1000 g | 28. 87.5 $cm^3$ |
| 29. 0.735 L | 30. 10.4 lb |
| 31. 7940 V | 32. 0.000025 s |
| 33. 101,000,000 Hz | 34. 1,510,000 Hz |
| 35. 1.51 MHz | 36. 46.2 kPa |
| 37. 180A | 38. 1,500,000 Hz |
| 39. 1920 Pa | 40. 190 kPa |
| 41. 0.0035 s | 42. 0.65 ks |
| 43. 0.0282 A | 44. 28.2 A |
| 45. 72 kV | 46. 0.072 MV |
| 47. 0.0932 MHz | 48. 90.4 kHz |
| 49. 0.0288 Ms | 50. 6.00 ks |

END

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