MATH FOR NURSING

MEASUREMENTS

Written by: Joe Witkowski and Eileen Phillips

Section 1: Introduction

Quantities have many units, which can be used to measure them. The following table gives common units associated with certain dimensions.

Dimension	Common units
Time	seconds, minutes, hours days, months, years
Distance	inches, feet, yards centimeters, meters, kilometers
Speed	miles per hour, feet per second meters per second
Weight	ounces, pounds, micrograms, milligrams, grams, kilograms
Volume	teaspoons, tablespoons, fluid ounces, milliliters, liters, cubic centimeters, cubic meters, cubic feet, cubic yards

When using formulas it is often necessary to change units. For instance, if you had to find the distance traveled using the formula d = vt, and v = 30 miles per hour and t = 45 minutes, you would have to convert time to hours or velocity to miles per minute because the units are not the same.

Section 2: Unit Conversions

In order to convert units, treat the units just as if they were algebraic quantities. As algebraic quantities they can be multiplied and divided. For example, just focusing on units,

$$in \times \frac{ft}{in} = \cancel{in} \times \frac{ft}{\cancel{in}} = ft$$

All conversion facts that are written as equations, such as 1 ft = 12 in, can be written as a conversion factor, $\frac{1\ ft}{12\ in}$ or $\frac{12\ in}{1\ ft}$ that is equivalent to 1. These conversion factors are then used to divide out the unwanted units, leaving the desired units for the conversion. Since the conversion factors are equivalent to 1, when multiplied to a quantity, the value of the quantity does not change.

Example 1 : Convert 38 inches to feet. Round the answer to the nearest tenth of a foot.

Solution: Recall that there were two conversion factors for converting feet to inches; $\frac{1\ ft}{12\ in}$ and $\frac{12\ in}{1\ ft}$. In order to decide which one to use, look at the units in the quantity we were given to convert. Since we were given inches, we need to choose the conversion factor that has inches in the denominator so that the two units will divide out, leaving feet in the answer.

$$38\ in = 38\ in \times \frac{1\ ft}{12\ in} = \frac{38\ \cancel{in}}{1} \times \frac{1\ ft}{12\ \cancel{in}} = \frac{38 \times 1\ ft}{1 \times 12} = 3.2\ ft$$

$$(\textit{units can be divided out; } \frac{in}{in} = 1.)$$

Therefore, 38 inches = 3.2 feet.

Example 2 : Convert 60 feet per second to yards per second.

Note that 60 feet per second is the same as $\frac{60\,ft}{1\sec}$ *or* $60\ \frac{ft}{\sec}$.

Solution: Recall that 1 yard = 3 feet, which gives us two conversion factors, $\frac{1\ yd}{3\,ft}$ and $\frac{3\ ft}{1\ yd}$. Since we are asked to convert the feet to yards, we will need the feet to divide out and thus we need to choose $\frac{1\ yd}{3\,ft}$ as the conversion factor.

$$\frac{60\,ft}{1\sec} \times \frac{1\ yd}{3\,ft} = \frac{60\ \cancel{ft}}{1\sec} \times \frac{1yd}{3\ \cancel{ft}} \quad (\textit{units can be divided out; } \frac{ft}{ft} = 1.)$$

$$= \frac{60 \times 1\ yd}{3\sec} = \frac{60\ yd}{3\sec} = \frac{20\ yd}{1\sec} = 20\ \frac{yd}{\sec}$$

♦

Activity 1

---

a) If you were going to convert 96 pounds to kilograms, would you multiply by $\frac{1\ kg}{2.2\ lbs}$ or $\frac{2.2\ lbs}{1\ kg}$? Explain.

b) If you were going to convert 40 $\frac{mL}{\text{sec}}$ to $\frac{mL}{\text{min}}$, would you multiply by $\frac{1\text{min}}{60\text{sec}}$ or $\frac{60\text{sec}}{1\text{min}}$? Explain.

Please use the following conversion chart as reference for the rest of the problems contained in this unit. **These common conversion facts must be memorized**.

<table>
<tr><th colspan="4">CONVERSIONS</th></tr>
<tr><th colspan="2">METRIC</th><th colspan="2">HOUSEHOLD & APOTHECARY
EXACT VOLUME EQUIVALENTS</th></tr>
<tr><th>Volume</th><th>Weight</th><th>Volume (Liquid)</th><th>Weight (Dry)</th></tr>
<tr>
<td>Liter (L)
1 L = 1000 ml

Milliliter (ml)
1 ml = 0.001 L
1 ml = 1000 mcl
30 ml = 1 oz
5 ml = 1 tsp
15 ml = 1 Tbs

Microliter (mcl)
1 mcl = 0.001 ml
1000 mcl = 1 ml</td>
<td rowspan="3">Kilogram (kg)
1 kg = 2.2 lbs
1 kg = 1000 g

Milligrams (mg)
1 mg = 0.001 g
1 mg = 1000 mcg

Microgram (mcg)
1 mcg = 0.001 mg

Gram (g)
1 g = 1000 mg
1 g = 1 ml
1 g = 0.001 kg
453.6 g = 1 lb</td>
<td rowspan="3">Measuring cup
1 cup = 8 oz
1 cup = 240 ml
2 cups = 1 pint

Ounces (oz)
1 oz = 30 ml
1 oz = 2 Tbs
8 oz = 1 cup
16 oz = 1 pint

Tablespoons (Tbs)
1 Tbs = 3 tsp
1 Tbs = 15 ml
2 Tbs = 1 oz

Teaspoon (tsp)
1 tsp = 5 ml
3 tsp = 1 Tbs</td>
<td rowspan="3">Pounds (lb)
2.2 lbs = 1 kg
1 lb = 453.6 g
1 lb = 16 oz</td>
</tr>
<tr><th>Length</th></tr>
<tr><td>Centimeter (cm)
2.54 cm = 1 inch</td></tr>
</table>

Example 4 : How many mL are in 6 teaspoons of cough medicine?

Solution: One method would be to use the conversion factor $\frac{5\ mL}{1\ tsp}$.

$$6\ tsp = \frac{6\ tsp}{1} \times \frac{5\ mL}{1\ tsp} = \frac{6 \times 5\ mL}{1 \times 1} = 30\ mL$$

$$(units\ can\ be\ divided\ out;\ \frac{tsp}{tsp} = 1.)$$

There are 30 mL in 6 teaspoons.

A second method would be to set up a proportion.

$$\frac{1\ tsp}{6\ tsp} = \frac{5\ mL}{x\ mL}$$

$$x = 6(5) = 30$$

There are 30 mL in 6 teaspoons.

A third method would be to recognize that if 1 tsp = 5 mL, then 6 tsp would be 5 times as many or 30 mL.

♦

Example 5 : How many kilograms does a 150 pound person weigh? Round the number of kilograms to the nearest tenth.

Solution: One method would be to use the conversion factor $\frac{1\ kg}{2.2\ lbs}$.

$$150\ lbs = \frac{150\ lbs}{1} \times \frac{1\ kg}{2.2\ lbs} = \frac{150 \times 1\ kg}{1 \times 2.2} = \frac{150}{2.2} kg = 68.2\ \text{kg}.$$

There are 68.2 kg in 150 lbs.

A second method would be to set up a proportion.

$$\frac{2.2\ lbs}{150\ lbs} = \frac{1\ kg}{x\ kg}$$

$$2.2x = 150$$

$$x = \frac{150}{2.2} = 68.2$$

There are 68.2 kg in 150 lbs.

A third method would be to recognize that if 1 kg = 2.2 lbs, then 150 lbs must be divided by 2.2 lbs to determine the number of kilograms, 68.2.

♦

Activity 2

Use the conversion table on page 4 and any of the methods shown to answer the questions below. If necessary, round the answer to the nearest tenth.

a) How many ounces are in 8 pints?

b) How many inches are in 76 centimeters?

c) How many pounds are in 80 kilograms?

d) How many tablespoons are in 120 milliliters?

e) Convert 240 mL per hour to mL per minute.

Section 3: The Metric System

The metric system is very similar to our decimal number system. It is an easy system to use because calculations are based on multiples of 10. Different units of length in the metric system are obtained by combining an appropriate prefix with the base unit, which is the **meter**. The prefixes, their symbols, and their meanings are given in the following table.

Prefix	Symbol	Power of 10	Meaning
mega	M	10^6	one million times
kilo	k	10^3	one thousand times
hecto	h	10^2	one hundred times
deka	da	10^1	ten times
deci	d	10^{-1}	one tenth of
centi	c	10^{-2}	one hundredth of
milli	m	10^{-3}	one thousandth of
micro	mc	10^{-6}	one millionth of

Activity 3

Complete the following table, which gives names for different units of length along with their relationship to the meter.

Unit	Symbol	Relationship to Base Unit
kilometer	___	1000 meters
_____	___	100 meters
_____	dam	_____
meter	m	base unit
_____	dm	0.1 meter
centimeter	___	_____
_____	mm	_____

The prefixes can also be used for measurements involving mass and volume. The **mass** of an object is the quantity of material making up the object. The base unit for mass in the metric system is the **gram (g)**. The **volume** is the amount of space an object or liquid occupies. The base unit for volume in the metric system is the **liter (L)**. The prefixes work the same way with these base units as they did with the meter.

It is important to have some idea as to the size of some of these metric units. A meter is about 39 inches which is a little longer than a yard (36 inches). One centimeter is about the width of your little finger or the diameter of the head of a thumbtack. Nine football fields, including end zones, laid end to end are approximately 1 kilometer long. The thickness of a dime is about 1 millimeter. A common paper clip has a mass of about 1 gram. One grain of salt has a mass of about 1 mg. A quart of milk is a little less than a 1 liter. A teaspoon of cough medicine is about 5 mL.

Activity 4

---

a) Which metric unit (km, m, cm, or mm) should be used to measure each item?

i) Length of a pencil ____

ii) Your height ____

iii) Length of a car race ____

iv) Diameter of a nickel ____

b) Which metric unit (kg, g, or mg) should be used to measure each item?

i) Mass of a pencil _____

ii) Mass of a football player _____

c) Which metric unit (L, mL) should be used to measure each item?

i) Volume of a single serving of mouth wash _____

ii) Volume of a jug of water _____

It is important to be able to change units so that you can input the correct units when working with formulas. We will now look at some examples that convert from one metric unit to another metric unit.

To convert from metric to metric, you can use the same techniques discussed in section 2, but the metric system is based on multiples of ten so we are able to use our knowledge of decimals and simply move the decimal point to the left or right depending on which units are being converted. Memorizing the order of prefixes in the following table allows us to simply start at the unit given and move the decimal point to the converted unit. Whichever direction we move and however many spaces we move determines the direction and number of spaces we move the decimal point in the given number.

*	*	*	*	*	*	*
kilo(k)	*hecto*(h)	*deka*(da)	base unit	*deci*(d)	*centi*(c)	*milli*(m)

(base units: meter, gram, liter)

Example 6 : Change 125 mm to cm.

Solution: We would go to the table above, start at mm and move one place to the left. So to change 125 mm to cm, move the decimal point one place to the left.

125 mm = 12.5 cm

We could also use the conversion factor $\frac{1\,cm}{10\,mm}$.

$$125\,mm = \frac{125\,\cancel{mm}}{1} \times \frac{1\,cm}{10\,\cancel{mm}} = \frac{125\,cm}{10} = 12.5\,cm$$

♦

Example 7 : Change 2.34 km to cm.

Solution: According to the table above, to go from km to cm you have to move 5 places to the right. So to change 2.34 km to cm, you have to move the decimal point 5 places to the right.

2.34 km = 234,000 cm. ♦

Example 8 : Change 5.8 kg to mg.

Solution: We can use the same table as we did for length, we just need to change the meter to the gram. The prefixes stay the same. To go from kg to mg, we need to move 6 places to the right. So to change 5.8 kg to mg, we have to move the decimal point 6 places to the right.

5.8 kg = 5,800,000 mg**.**

We could also use the conversion factor method. Since we do not have a conversion fact in the chart on page 4 that takes us directly from kg to mg, we will need to multiply by two conversion factors to reach the desired units.

$$5.8\ kg = \frac{5.8\ \cancel{kg}}{1} \times \frac{1000\ \cancel{g}}{1\ \cancel{kg}} \times \frac{1000\ mg}{1\ \cancel{g}} = 5{,}800{,}000\ mg$$

♦

Note: While the first method is much quicker, learning how to use conversion factors will be helpful when you need solve dosage problems later on in nursing. You can set up as many conversion factors as you need, all multiplied together, until you reach the desired units.

Example 9 : Change 0.38 mg to mcg.

Solution: Since the table on page 9 ends at mg, we will need to recall from the conversion chart on page 4 that 1 mg = 1000 mcg. From that we can either use the conversion factor or realize that if we extend the table, mcg would be three places to the right of mg.

Using the conversion factor $\frac{1000\ mcg}{1\ mg}$, give us

$$0.38\ mg = \frac{0.38\ \cancel{mg}}{1} \times \frac{1000\ mcg}{1\ \cancel{mg}} = \frac{0.38 \times 1000\ mcg}{1} = 380\ mcg$$

Extending the table, we would move the decimal point in 0.38 mg to the right 3 places, giving us

0.38 mg = 380 mcg ♦

Example 10 : Change 135 mL to L.

Solution: We can use the same table as we did for length, we just need to change the meter to the liter. The prefixes stay the same. To go from mL to L, we need to move 3 places to the left. So to change 135 mL to L, we have to move the decimal point 3 places to the left.

135 mL = 0.135 L ♦

Activity 5

---

a) Change 2.3 km to m.

b) Change 48 cm to km.

c) Change 120 grams to kg.

d) Change 0.72 mg to mcg.

e) Change 320 mL to L.

f) Change 6.5 L to mL.

Exercises for Measurements

Do all the exercises on separate paper, showing all work neatly. If necessary, round answers to the nearest tenth.

1. Convert 8 Tbs to teaspoons.

2. Convert 170 lb to kilograms.

3. Convert 42 tsp to milliliters.

4. Convert 125 mL to ounces.

5. Convert 32 in to centimeters.

6. Convert 2 mL per minute to mL per hour.

7. A foreign car's gasoline tank holds 56 L. Convert this capacity to gallons. Use the following conversion facts: 1 L = 1.057 quarts and 4 quarts = 1 gallon.

8. Suppose a swimmer on the swim team can swim 40 yards in 30 seconds. Convert this to miles per hour. Use the following conversion facts: 1 yd = 3 ft and 1 mile = 5280 ft.

   Fill in the blanks to find the number of miles per hour:

$$\frac{40\ yd}{30\ s} \times \frac{\_\_\ ft}{\_\_\ yd} \times \frac{\_\_\ mi}{\_\_\ ft} \times \frac{\_\_\ s}{\_\_\ min} \times \frac{\_\_\ min}{\_\_\ hr} = \frac{\_\_\ miles}{hour}$$

9. Twenty grams of a medication are to be dissolved in 0.060 L of water. Convert this to milligrams per deciliter.

10. Convert the following.

    a) 4.8 L to mL b) 7.25 km to m c) 350 mL to L

    d) 25 g to mcg e) 18 mm to cm f) 0.108 mg to g

MEASUREMENTS

Activity 1:

a) You would multiply 96 pounds by $\frac{1\,kg}{2.2\,lbs}$ because the pounds would divide out, leaving kilograms.

b) You would multiply $40\frac{mL}{\text{sec}}$ by $\frac{60\,\text{sec}}{1\,\text{min}}$ because the seconds would divide out, leaving minutes.

****

Activity 2

a) $8\ pts \times \frac{16\,oz}{1\ pts} = 128\,oz$

b) $76\,cm \times \frac{1\,in}{2.54\,cm} = 29.9\,in$

c) $80\,kg \times \frac{2.2\,lbs}{1\,kg} = 176\,lbs$

d) $120\,mL \times \frac{1\,Tbs}{15\,mL} = 8\,Tbs$

e) $\frac{240\,mL}{1\,hr} \times \frac{1\,hr}{60\,\text{min}} = \frac{4\,mL}{1\,\text{min}}$ so 4 mL per minute

****

Activity 3

Unit	Symbol	Relationship to Base Unit
kilometer	*km*	1000 meters
hectometer	*hm*	100 meters
dekameter	dam	*10 meters*
meter	**m**	**base unit**
decimeter	dm	0.1 meter
centimeter	*cm*	*0.01 meter*
millimeter	mm	*0.001 meter*

****

Activity 4

a) i) mm or cm ii) cm or m iii) m or km iv) mm

b) i) m ii) kg

c) i) mL ii) L

Activity 5

$a)$ $2.3\,km \times \frac{1000\,m}{1\,km} = 2300\,m$ $b)$ $48\,cm \times \frac{1\,m}{100\,cm} \times \frac{1\,km}{1000\,m} = 0.00048\,km$

c) 120 g = 0.12 kg *move the decimal point 3 places to the left*

d) 0.72 mg = 720 mcg *move the decimal point 3 places to the right*

e) 320 mL = 0.32 L *move the decimal point 3 places to the left*

f) 6.5 L = 6500 mL *move the decimal point 3 places to the right*