

Calculation of Dosages and Solutions: Dimensional Analysis

LEARNING OBJECTIVES

1. Apply dimensional analysis to solve a wide variety of dosage and solution problems.
2. Calculate oral, intramuscular, subcutaneous dosages using dimensional analysis.
3. Determine intravenous (IV) flow rates using dimensional analysis and the one-step, no-rules method of calculation.

WHAT IS DIMENSIONAL ANALYSIS?

Most schools of nursing and pharmacy teach ratio and proportion and the “desired over have” method of calculation to students. Although these methods give us accurate answers, these methods are difficult to use and remember. They tend to be a source of great confusion and consternation. When two or more conversions are needed in order to perform the calculation these methods pose very real challenges. Additionally, different methods have to be memorized in order to solve each of many types of problems.

Dimensional analysis, on the other hand, uses only one method to calculate all kinds of problems. All problems are set up and solved in the same manner. This consistency not only decreases confusion and the need to memorize many approaches, it will increase your accuracy and confidence.

This course will teach you one simple and consistent method of calculating all dosages using dimensional. There is no longer a need to

memorize cumbersome and easy-to-forget rules. Dimensional analysis easily and systematically solves a wide variety of oral, intramuscular, subcutaneous, and intravenous calculations.

Throughout the course you will get practice problems so you can master this simple calculation method. It will also teach you a one-step, no-rules method that rapidly and accurately calculates the number of drops per minute at which an ordered intravenous solution must to be run.

AN INTRODUCTION TO DIMENSIONAL ANALYSIS CALCULATIONS

In order to calculate dosages using dimensional analysis, you set up an equation that consists of:

- a *starting factor*,
- one or more *conversion factors*, and
- the *answer unit*.

Once this equation is written, the final step is to cancel out numbers using simple math and then multiply the remaining numbers.

For example, if you want to know how many dimes there are in \$3.00, you have to consider:

- the *starting factor*- the known factor of \$3.00
- the *conversion factor*- the number of dimes in each dollar, that is, 10 dimes in each dollar
- the answer unit- which is dimes

equation, each numerator label should cancel out a denominator label so that the answer in the conversion factor. Now, only "inches" in the answer unit remains.

As shown below, the unit of feet in the starting factor cancels out the feet unit in the conversion factor. The final answer is then computed by simply multiplying 12 by 12.

$$12 \text{ ft} \quad \times \quad \frac{12 \text{ inches}}{1 \text{ ft}} = 144 \text{ inches}$$

In more complex calculations, once all the units of measurement that can be canceled have been struck out, the remaining numerators are multiplied and this product, or answer, is then divided by the product of all the remaining denominators.

If the numerators and denominators can be divided by a common number, or reduced, the multiplication of the numerators and denominators as well as the final division will be somewhat simpler and less mathematically challenging. You will be taught how to reduce in this course.

The conversion factors that are used to calculate dosages and IV flow rates can consist of either established *mathematical conversion equivalents* or a *manufacturer's equivalents*.

Some examples of mathematical conversion equivalents are:

- 12 inches = 1 foot
- 2.2 lbs = 1 kg
- 15 gr = 1 g

Manufacturers produce medications of different dosages and IV tubings that deliver different amounts of fluids in each drop. Doctors will also order medications as based on body weight. Manufacturers' and ordered equivalents can include some like these:

- 1 tablet = 250 mg
- 5 gr per kg of body weight
- IV tubing that delivers 20 gtt = 1 mL

SYSTEMS OF MEASUREMENT USED IN PHARMACOLOGY

Many dosage calculations require knowledge of mathematical conversion equivalents to move from one measurement system to another. We use metric, apothecary, and household measurement systems in pharmacology.

ABBREVIATIONS FOUND IN OUR SYSTEMS OF MEASUREMENT

gr	grain
g, gm or G	gram
kg	kilogram
l	liter
mL	milliliter
cc	cubic centimeter
dr	dram

gtt	drop
lb	pound
m	minum
mg	milligram
mcg	microgram
tsp	teaspoon
oz	ounce
tbs	tablespoon
U	unit

THE METRIC SYSTEM OF MEASUREMENT

Length

The standard unit of length in the metric system is the *meter*. Other units of length and their equivalents in meters are as follows:

1 millimeter (mm) = 0.001 meter (m)

1 centimeter (cm) = 0.01 meter (m)

1 decimeter (dm) = 0.1 meter (m)

1 kilometer (km) = 1000 meters (m)

Volume

The standard unit of volume in the metric system is the *liter*. One liter is equal to 1000 cubic centimeters in volume. Other units of volume and their equivalents in liters are as follows:

1 milliliter (mL) = 0.001 liter (l)

1 centiliter (cl) = 0.01 liter (l)

1 deciliter (dl) = 0.1 liter (l)

1 kiloliter (kl) = 1000 liters (l)

1000 mL = 1 liter (l)

1 mL = 1 cubic centimeter (cc) in volume

Weight

The standard unit of mass in the metric system is the *gram*. Other units of weight or mass and their equivalents in grams are as follows:

1 milligram (mg) = 0.001 gram (g)

1 centigram (cg) = 0.01 gram (g)

1 decigram (dg) = 0.1 gram (g)

1 kilogram (kg) = 1000 grams (g)

1 kilogram (kg) = 2.2 pounds (lbs)

THE APOTHECARY SYSTEM OF MEASUREMENT

The *grain* is the basic unit of measurement in the apothecary system of measurement for *weight*. The ounce, dram and the minim are the basic units of measurement in the apothecary system of measurement for *volume*.

THE HOUSEHOLD SYSTEM OF MEASUREMENT

The basic units of measurement in the household system of measurement are *drop*, *teaspoon*, and *tablespoon*.

COMMONLY USED EQUIVALENTS

It is suggested that you refer to a table of equivalents for the less frequently used mathematical conversion equivalents and memorize the ones that you use most often. Some of the commonly used conversion equivalents are as follows:

1 gr = 60 mg
1 g = 15 gr
1G = 1000 mg
1 mL = 15 m
1 kg = 2.2 lb
1 tsp = 5 mL
1 tbsp = 15 mL
1 oz = 30 mL
1 kg = 2.2 lbs

ORAL DOSAGES USING DIMENSIONAL ANALYSIS

The following sample calculations show you how to compute oral dosage calculations using dimensional analysis.

Sample Calculation 1

Doctor's order: tetracycline syrup 250 mg po

Medication label: tetracycline syrup 50 mg/mL

How many mL should you administer?

In this example, the starting factor is the dosage in the doctor's order, that is, 250 mg. The conversion factor is 50 mg/1 mL, the number of mg that are contained in each mL of the syrup. The answer unit is the number of mL that you would administer to the patient.

Starting factor × Conversion factor = Answer unit

$$250 \text{ mg} \quad \times \quad \frac{1 \text{ mL}}{50 \text{ mg}} \quad = \quad \underline{\hspace{2cm}} \text{ mL}$$

All dimensional analysis problems are set up as an equation in the same way and the calculations are performed in the same manner.

1. Cancel out and reduce the numerators and denominators,
2. multiply all the remaining numerators and denominators, and
3. then divide to get the final answer.

Cancel out and reduce these numerators and denominators by dividing each by 50:

$$\begin{array}{r} 5 \\ 250 \text{ mg} \end{array} \quad \times \quad \frac{1 \text{ mL}}{50 \text{ mg}} \quad = \quad \underline{\hspace{2cm}} \text{ mL}$$

1

Multiply the numerators (5 × 1) and the denominators (1), and finally divide the product of the numerators by the denominator to get the final answer:

$$5 \quad \times \quad \frac{1}{1} \quad = \quad \frac{5 \text{ mL}}{1} = 5 \text{ mL}$$

Sample Calculation 2

Doctor's order: Lanoxin 0.250 mg po

Medication label: Lanoxin 0.125 mg per tablet

How many tablets should you give?

The starting factor is 0.5 mg, the conversion factor is 0.25 mg/1 tablet, and the answer unit is the number of tablets you would give.

$$\begin{array}{rclcl} \text{Starting factor} & \times & \text{Conversion factor} & = & \text{Answer unit} \\ 0.250 \text{ mg} & \times & \frac{1 \text{ tablet}}{0.125 \text{ mg}} & = & \underline{\hspace{2cm}} \text{ tablets} \end{array}$$

Cancel out and reduce the numerators and denominators:

$$\begin{array}{rclcl} 0.250 \text{ mg} & \times & \frac{1 \text{ tablet}}{0.125 \text{ mg}} & = & \underline{\hspace{2cm}} \text{ tablets} \\ 2 & & & & \\ \cancel{0.250} & \times & \frac{1 \text{ tablet}}{\cancel{0.125}} & = & \underline{\hspace{2cm}} \text{ tablets} \\ & & 1 & & \end{array}$$

Multiply the numerators and the denominators and divide their products to get the final answer:

$$2 \quad \times \quad \frac{1}{1} \quad = \quad \frac{2}{1} = 2 \text{ tablets}$$

Sample Calculation 3

Doctor's order: flucytosine 50 mg/kg/day in four divided doses. The patient weighs 40 kg.

Medication label: flucytosine 250 mg/cap

How many capsules should you give for each of the four doses?

The starting factor is 40 kg. In this example, there are two conversion factors. One of the conversion factors is the number of mg ordered for each kg, or 50 mg/kg, and the other conversion factor is the

manufacturer's equivalent, or 250 mg/cap. The answer unit is the number of caps.

Starting factor × Conversion factors = Answer unit

$$40 \text{ kg} \quad \times \quad \frac{50 \text{ mg}}{1 \text{ kg}} \quad \times \quad \frac{1 \text{ cap}}{250 \text{ mg}} \quad = \quad \underline{\hspace{2cm}} \text{ caps}$$

Cancel out and reduce the numerators and denominators:

$$40 \text{ kg} \quad \times \quad \frac{1}{\cancel{50 \text{ mg}}} \quad \times \quad \frac{1 \text{ cap}}{\cancel{250 \text{ mg}}_5} \quad = \quad \underline{\hspace{2cm}} \text{ caps}$$

Multiply the numerators and the denominators and then divide their products:

$$40 \quad \times \quad \frac{1}{1} \quad \times \quad \frac{1 \text{ cap}}{5} \quad = \quad \frac{40}{5} \quad = \quad 8 \text{ caps/day}$$

Because the doctor's order read "flucytosine 50 mg/kg/day in four divided doses," it is necessary to divide the total of 8 caps by 4 to determine the number of capsules that would be given for each of the doses:

$$\frac{8}{4} = 2 \text{ caps for each dose}$$

Now, let's take a few minutes to practice some calculations.

Practice Oral Dosages

Grab your pencil and paper and do these problems.

Practice Problem 1

Doctor's order: KCl 20 meq po
Medication label: KCl 15 meq/11.25 mL
How many mL would you administer?

Practice Problem 2

Doctor's order: Gantrisin 250 mg po
Medication label: Gantrisin 0.5 g/tab
How many tabs would you administer?

Practice Problem 3

Doctor's order: trimethoprim 5 mg/kg po. The patient weighs 80 kg.
Medication label: trimethoprim 160 mg/tab. The tabs are scored in half.
How many tabs would you administer?

Practice Problem 4

Doctor's order: nystatin 3 mg/kg po. The patient weighs 115 lb.
Medication label: nystatin 100 mg/tab
How many tabs would you administer?

Answers

1. 15 mL
2. 1/2 tab
3. 2 1/2 tabs
4. 1 1/2 tabs

Here is how each of the problems was set up and solved:

Practice Problem 1

The *starting factor* is 20 meq
The *conversion factor* is 15 meq/11.25 mL
The *answer unit* is _____ mL

$$\begin{array}{r} 4 \\ 20 \text{ meq} \end{array} \times \frac{11.25 \text{ mL}}{15 \text{ meq}} = \frac{45}{3} = 15 \text{ mL}$$

Practice Problem 2

The *starting factor* is 250 mg

The *conversion factors* are:

- 1,000 mg = 1 g
- 0.5 g/tab

The *answer unit* is _____ tabs

$$\begin{array}{ccccccc} & 1 & & & & & \\ 250 \text{ mg} & \times & \frac{1 \text{ g}}{1,000 \text{ mg}} & \times & \frac{1 \text{ tab}}{0.5 \text{ g}} & = & \frac{1}{2} = \frac{1}{2} \text{ tab} \\ & & 4 & & & & \end{array}$$

Practice Problem 3

The *starting factor* is 80 kg

The *conversion factors* are:

- 5 mg/kg
- 160 mg/tab

The *answer unit* is _____ tabs

$$\begin{array}{ccccccc} & 1 & & & & & \\ 80 \text{ kg} & \times & \frac{5 \text{ mg}}{1 \text{ kg}} & \times & \frac{1 \text{ tab}}{160 \text{ mg}} & = & \frac{80}{32} = 2 \frac{1}{2} \text{ tabs} \\ & & 32 & & & & \end{array}$$

Practice Problem 4

The *starting factor* is 115 lb

The *conversion factors* are:

- 1 kg = 2.2 lbs
- 3 mg/kg
- 100 mg/tab

The *answer unit* is _____ tabs.

$$\begin{array}{ccccccc} & 23 & & & & & \\ \frac{115 \text{ lb}}{2.2 \text{ lb}} & \times & \frac{1 \text{ kg}}{2.2 \text{ lb}} & \times & \frac{3 \text{ mg}}{1 \text{ kg}} & \times & \frac{1 \text{ tab}}{100 \text{ mg}} = \frac{69}{44} = 1.56 \text{ tabs (1 } \frac{1}{2} \text{ tabs)} \\ & & & & 20 & & \end{array}$$

**INTRAMUSCULAR AND SUBCUTANEOUS DOSAGES USING
DIMENSIONAL ANALYSIS**

Intramuscular and subcutaneous dosages are calculated in the same manner as oral dosages when you are using dimensional analysis, however, there are some additional things that you must remember.

These special considerations include:

1. It is often necessary to round off when calculating intramuscular and subcutaneous dosages. The dosage is *rounded off to the nearest hundredth (0.01) of a mL or cc* when you are using a regular syringe or a tuberculin syringe. Your arithmetic must be carried out to the thousandths place (the third decimal place) in order to round off to the hundredths place. If the number in the third decimal place, or thousandths place, is 5 or higher, you round up one number in the hundredths place to determine the dosage. For example, if you are calculating a dosage for a tuberculin syringe and your mathematical calculation gives you 0.187 mL, you would round it off to 0.19 mL because the 7 in thousandths place is greater than or more than 5.
2. Heparin is given in a tuberculin syringe using the subcutaneous route of administration.
3. Insulin is also administered via the subcutaneous route of administration. Most often the insulin is Units 100 insulin and the syringe that is used is also a Units 100 syringe. A 1cc Units 100 syringe can hold up to 100 Units of insulin; a ½ cc Units 100 syringe can hold only half of that amount, that is, it can hold up to 50 Units of insulin. At times you may encounter Units 80, Units 60, etc. insulin. There are 80 Units of Units 80 insulin per cc and 60 Units of Units 60 insulin in one cc. A matching syringe (Units 80 and Units 60 syringe) can be used to administer these

kinds of insulin, however, calculation using dimensional analysis can also be done.

4. An additional consideration for intramuscular injections is that many calculations, particularly those necessary to determine an antibiotic dosage, require a conversion factor that reflects the amount of the drug per mL after a powder is reconstituted with sterile water or normal saline solution for injection.

Below are some sample problems involving intramuscular and subcutaneous dosages. These calculations are set up and performed using dimensional analysis procedures in the same manner as that used above for the oral dosage calculations.

Sample Calculation 1

Doctor's order: meperidine 30 mg IM q4h prn for pain

Medication label: 50 mg/mL

How many mL or cc would you give?

The *starting factor* is 30 mg

The *conversion factor* is 50 mg/1 mL

The *answer unit* is _____ mL or cc

Starting factor × Conversion factor = Answer unit

30 mg × $\frac{1 \text{ mL}}{50 \text{ mg}}$ = _____ mL

~~30 mg~~ × $\frac{1 \text{ mL}}{50 \text{ mg}}$ = $\frac{3}{5}$ = 0.6 mL

Sample Calculation 2

Doctor's order: amikacin 5 mg/kg IM tid. The patient weighs 130 lb.

Medication label: amikacin 500 mg/2 mL

How many mL would you administer?

The *starting factor* is 130 lb

The *conversion factors* are:

- 1 kg/2.2 lb
- 5 mg/kg
- 500 mg/2 mL

The *answer unit* is _____ mL

Starting factor × Conversion factors = Answer unit

$$130 \text{ lb} \quad \times \quad \frac{1 \text{ kg}}{2.2 \text{ lb}} \quad \times \quad \frac{5 \text{ mg}}{1 \text{ kg}} \quad \times \quad \frac{2 \text{ mL}}{500 \text{ mg}} \quad = \quad \underline{\hspace{2cm}} \text{ mL}$$

$$130 \text{ lb} \times \frac{\cancel{1 \text{ kg}}}{2.2 \text{ lb}} \times \frac{5 \text{ mg}}{\cancel{1 \text{ kg}}} \times \frac{2 \text{ mL}}{\cancel{500 \text{ mg}}} = \frac{130}{110} = \underline{130} \text{ mL or } 1.18 \text{ mL}$$

Rounded Off to: 1.2 mL

Sample Calculation 3

Doctor's order: heparin 3,000 U subcutaneously

Medication label: 5,000 U/mL

How many mL would you administer?

The *starting factor* is 3000 U

The *conversion factor* is 5,000 U/mL

The *answer unit* is _____ mL

Starting factor × Conversion factor = Answer unit

$$3,000 \text{ U} \quad \times \quad \frac{1 \text{ mL}}{5,000 \text{ U}} \quad = \quad \underline{\hspace{1cm}} \text{ mL}$$

$$\begin{array}{r} 3 \\ 3,000 \text{ U} \end{array} \quad \times \quad \frac{1 \text{ mL}}{5,000 \text{ U}} \quad = \quad \frac{3}{5} = 0.6 \text{ mL}$$

Sample Calculation 4

Doctor's order: ticarcillin 600 mg IM

Medication label: ticarcillin reconstituted with 2 mL of sterile water to yield 1 g of ticarcillin in 2.6 mL of solution.

How many mL would you administer?

The *starting factor* is 600 mg

The *conversion factors* are:

- 1 g/2.6 mL
- 1g/1,000 mg

The *answer unit* is _____ mL

Starting factor × Conversion factors = Answer unit

$$600 \text{ mg} \quad \times \quad \frac{1 \text{ g}}{1,000 \text{ mg}} \quad \times \quad \frac{2.6 \text{ mL}}{1 \text{ g}} \quad = \quad \underline{\hspace{1cm}} \text{ mL}$$

$$\begin{array}{r} 6 \\ 600 \text{ mg} \end{array} \quad \times \quad \frac{1 \text{ g}}{1,000 \text{ mg}} \quad \times \quad \frac{2.6 \text{ mL}}{1 \text{ g}} \quad = \quad \frac{15.6}{10} = 1.56 \text{ mL}$$

Rounded Off to: 1.6 mL

Sample Calculation 5

Doctor's order: neomycin 30 mg/kg/day IM in three divided doses. The patient weighs 140 lb.

Medication label: neomycin 250 mg/mL

How many mL would you administer for each of the three doses?

The *starting factor* is 140 lb

The *conversion factors* are:

- 30 mg/1 kg
- 1 kg/lb
- 250 mg/1 mL

The *answer unit* is _____ mL

The starting factor is 120 lb. The conversion factors are, , and. The answer unit is the number of mL.

$$\begin{array}{l} \text{Starting factor} \quad \times \quad \text{Conversion factors} \quad = \quad \text{Answer unit} \\ 140 \text{ lb} \quad \times \quad \frac{1 \text{ kg}}{2.2 \text{ lb}} \quad \times \quad \frac{30 \text{ mg}}{1 \text{ kg}} \quad \times \quad \frac{1 \text{ mL}}{250 \text{ mg}} \quad = \quad \text{_____ mL} \end{array}$$

$$\begin{array}{l} 70 \\ \cancel{140 \text{ lb}} \quad \times \quad \frac{1 \text{ kg}}{\cancel{2.2 \text{ lb}} \quad 1.1} \quad \times \quad \frac{6}{\cancel{30 \text{ mg}} \quad 1 \text{ kg}} \quad \times \quad \frac{1 \text{ mL}}{\cancel{250 \text{ mg}} \quad 50} \quad = \quad \text{_____ mL} \end{array}$$

$$70 \quad \times \quad \frac{1}{1.1} \quad \times \quad \frac{6}{1} \quad \times \quad \frac{1}{\cancel{50}} \quad = \quad \frac{42}{5.5} \quad = 7.63 \text{ mL}$$

Because the doctor ordered 30 mg/kg over one day in three divided doses, it is necessary to divide the **7.63** mL for the day by 3 to determine how many mL would be given in each of the doses:

$$\frac{7.63}{3} = 2.54, \text{ or } 2.5 \text{ mL per dose}$$

Practice Intramuscular and Subcutaneous Dosages

Now try these intramuscular and subcutaneous dosage calculations:

Practice Problem 1

Doctor's order: heparin 3,000 U subcutaneously

Medication label: 4,500 U/ mL

How many mL would you administer?

Practice Problem 2

Doctor's order: cefuroxime 500 mg IM

Medication label: The addition of 3.2 mL of sterile water yields a suspension of 750 mg in 4.2 mL

How many mL would you administer?

Practice Problem 3

Doctor's order: cephalothin 400 mg IM

Medication label: The addition of 4 mL of sterile water yields 0.5 g in 2.2 mL of suspension.

How many mL would you administer?

Practice Problem 4

Doctor's order: neomycin 20 mg/kg/day IM in three divided doses. The patient weighs 120 lb.

Medication label: neomycin 250 mg/mL

How many mL would you administer for each of the three doses?

Practice Problem 5

Doctor's order: 450,000 U of ampicillin

Medication label: 250,000 U/mL

How many mL would you administer?

Now, check your answers. The answers are:

Answers

1. 0.7 mL

2. 2.8 mL
3. 1.8 mL
4. 1.4 mL
5. 1.8 mL

Here is how each of the problems is set up and solved:

Practice Problem 1

The *starting factor* is 3,000 U

The *conversion factor* is 1mL/4,500 U

The *answer unit* is _____ mL

$$\begin{array}{r} 6 \\ 3,000 \text{ U} \end{array} \times \frac{1 \text{ mL}}{\begin{array}{r} 4,500 \text{ U} \\ 9 \end{array}} = \frac{6}{9} = 0.66 \text{ mL}$$

Rounded Off to: 0.7 mL

Practice Problem 2

The *starting factor* is 500 mg

The *conversion factor* is 750 mg/4.2 mL

The *answer unit* is _____ mL

$$\begin{array}{r} 2 \\ 500 \text{ mg} \end{array} \times \frac{4.2 \text{ mL}}{\begin{array}{r} 750 \text{ mg} \\ 3 \end{array}} = \frac{8.4}{3} = 2.8 \text{ mL} \text{ or with more cancellations:}$$

$$\begin{array}{r} 2 \\ 500 \text{ mg} \end{array} \times \frac{\begin{array}{r} 1.4 \\ 4.2 \text{ mL} \end{array}}{\begin{array}{r} 750 \text{ mg} \\ 3 \\ 1 \end{array}} = \frac{2.8}{1} = 2.8 \text{ mL}$$

Practice Problem 3

The *starting factor* is 400 mg

The *conversion factors* are:

- 1g/1,000 mg
- 0.5g/2.2 mL

The *answer unit* is _____ mL

$$400\text{mg} \times \frac{1\text{g}}{1,000\text{mg}} \times \frac{2.2\text{ mL}}{0.5\text{g}} = \frac{4.4\text{ mL}}{2.5} = 1.76\text{ mL}$$

Rounded Off to: 1.8 mL

Practice Problem 4

The *starting factor* is 120 lb

The *conversion factors* are:

- 1 kg/2.2 lbs
- 20 mg/1 kg
- 250 mg/1 mL

The *answer unit* is _____

$$120\text{ lb} \times \frac{1\text{ kg}}{2.2\text{ lb}} \times \frac{20\text{ mg}}{1\text{ kg}} \times \frac{1\text{ mL}}{250\text{ mg}} = \frac{24\text{ mL}}{5.5} = 4.36\text{ mL}$$

Because the doctor ordered 20 mg/kg over one day in three divided doses, it is necessary to divide the 4.36 mL for the day by 3 to determine how many mL would be given in each of the doses:

$$\frac{4.36\text{ mL}}{3} = 1.45\text{ mL rounded off to: } 1.4\text{ mL}$$

Practice Problem 5

The *starting factor* is 450,000 U

The *conversion factor* is 250,000 U/1 mL

The *answer unit* is _____ mL

$$450,000 \cancel{\text{U}} \times \frac{1 \text{ mL}}{250,000 \cancel{\text{Units}} \cdot 5} = \frac{9}{5} = 1.8 \text{ mL}$$

CALCULATING IV FLOW RATES USING DIMENSIONAL ANALYSIS AND THE ONE-STEP, NO-RULES METHOD

This final portion of this course will teach you:

- how to calculate, or compute, IV flow rates and other IV dosage calculations using dimensional analysis and also
- a one-step, no-rules IV flow rate method to determine the number of drops per minute when you know the ordered number of cc per hour.

IV Flow Rates Using Dimensional Analysis

As you probably know, IV tubing is manufactured by a number of different companies. Each tubing set has a drop factor that indicates whether it delivers 10, 15, 20, or 60 drops (gtt) per mL of solution. The 60 gtt per mL tubing, which is often referred to as *microdrop* tubing or pediatric tubing, delivers the smallest drops of all the sets. The 10 gtt/mL tubing delivers the largest drops of solution.

When calculating the number of drops per minutes, the number of drops is rounded off to the nearest whole drop.

The IV flow rate calculations immediately below are set up and performed using dimensional analysis.

Sample Calculation 1

Doctor's order: 0.9% NaCl solution at 100 mL per hour

How many gtt per minute would you give if the tubing delivered 20 gtt/mL?

The *starting factor* is 1 minute

The *conversion factors* are:

- 1 h/ 60 min
- 100 mL/ h
- 20 gtt/ 1 mL

The *answer unit* is _____ gtt/min

Starting factor × Conversion factors = Answer unit

$$1 \text{ min} \quad \times \quad \frac{1 \text{ h}}{60 \text{ min}} \quad \times \quad \frac{100 \text{ mL}}{1 \text{ h}} \quad \times \quad \frac{20 \text{ gtt}}{1 \text{ mL}} \quad = \quad \text{_____ gtt}$$

$$1 \text{ min} \quad \times \quad \frac{1 \text{ h}}{60 \text{ min}} \quad \times \quad \frac{100 \text{ mL}}{1 \text{ h}} \quad \times \quad \frac{20 \text{ gtt}}{1 \text{ mL}} = \frac{100}{3} = 33.3 \text{ gtt}$$

5
10
6
3

Rounded Off to: 33 gtt/min

Sample Calculation 2

Doctor's order: 1,000 mL of 5% D 0.45 normal saline solution to infuse over 4 hours

How many gtt per minute would you give if the tubing delivers 10 gtt/mL?

The *starting factor* is 1 minute

The *conversion factors* are:

- 1 h/ 60 min
- 1000 mL/ 4 h
- 10 gtt/ 1 mL

The *answer unit* is _____ gtt/min

Starting factor × Conversion factors = Answer unit

$$1 \text{ min} \quad \times \frac{1 \text{ h}}{60 \text{ min}} \quad \times \frac{1,000 \text{ mL}}{4 \text{ h}} \quad \frac{10 \text{ gtt}}{1 \text{ mL}} = \text{_____ gtt}$$

$$1 \text{ min} \quad \times \frac{1 \text{ h}}{60 \text{ min}} \quad \times \frac{250}{6} \times \frac{1,000 \text{ mL}}{4 \text{ h}} \quad \times \frac{1}{1 \text{ mL}} \quad \frac{10 \text{ gtt}}{6} = \frac{250}{6} = 41.6 \text{ or } 42 \text{ gtt}$$

Sample Calculation 3

Doctor's order: 30 mL/h of 5% D 0.45 normal saline solution

How many gtt per minute would you give if the tubing delivered 60 gtt/mL?

The *starting factor* is 1 minute

The *conversion factors* are:

- 1 h/ 60 min
- 30 mL/h
- 60 gtt/ 1 mL

The *answer unit* is _____ gtt/min

Starting factor × Conversion factors = Answer unit

$$1 \text{ min} \quad \times \frac{1 \text{ h}}{60 \text{ min}} \quad \times \frac{30 \text{ mL}}{1 \text{ h}} \quad \times \frac{60 \text{ gtt}}{1 \text{ mL}} = \text{_____ gtt}$$

$$1 \text{ min} \quad \times \frac{1 \text{ h}}{60 \text{ min}} \quad \times \frac{30 \text{ mL}}{1 \text{ h}} \quad \times \frac{1}{1 \text{ mL}} \quad \frac{60 \text{ gtt}}{1 \text{ mL}} = 30 \text{ gtt}$$

Sample Calculation 4

Doctor's order: 25 mL/h of 5% D 0.45 normal saline solution

How many gtt per minute would you give if the tubing delivered 60 gtt/mL?

The *starting factor* is 1 minute

The *conversion factors* are:

- 1 h/ 60 min
- 25 mL/h
- 60 gtt/ 1 mL

The *answer unit* is _____ gtt/min

Starting factor × Conversion factors = Answer unit

$$1 \text{ min} \quad \times \quad \frac{1 \text{ h}}{60 \text{ min}} \quad \times \quad \frac{25 \text{ mL}}{1 \text{ h}} \quad \times \quad \frac{60 \text{ gtt}}{1 \text{ mL}} \quad = \quad \underline{\hspace{1cm}} \text{ gtt}$$

$$1 \text{ min} \quad \times \quad \frac{1 \text{ h}}{\cancel{60 \text{ min}} \atop 1} \quad \times \quad \frac{\cancel{25 \text{ mL}}}{1 \text{ h}} \quad \times \quad \frac{1}{\cancel{60 \text{ gtt}} \atop 1 \text{ mL}} \quad = \quad 25 \text{ gtt}$$

Did you notice that the last two calculations, which use the microdrop or 60 gtt/mL IV tubing, yielded the same number of gtt per minute as the number of mL per hour that was ordered? Good observation!

Specifically, the first doctor's order was for 30 mL per hour. You would have to run the IV solution at 30 gtt per minute to deliver 30 mL per hour. The second doctor's order called for 25 mL per hour. You would have to run the IV solution at 25 gtt per minute in order to deliver 25 mL an hour.

If you look closely at these two calculations, you will see that the conversion factor of 60 min = 1 h cancels out the conversion factor of

60 gtt per mL. We will now move one step further with this observation.

IV Flow Rates Using the One-Step, No-Rules Method

In order to calculate using the one-step, no-rules method, you need to know the number of mL per hour ordered. Occasionally, the doctor's order clearly states the number of mL per hour, which is the easiest scenario. If the doctor's order specifies the number of mL per 8 hours, 12 hours, or any other number of hours rather than the number of mL for each hour, it is necessary to first determine the number of mL to be administered per hour.

For example, if the doctor orders 1,000 mL in 8 hours, you must divide 1,000 mL by 8 to determine the number of mL per hour. The answer is 125 mL/h.

Likewise, if the doctor orders 2 liters of IV fluid over 12 hours, the calculation to determine the number of mL per hour is as follows:
 $2,000 \text{ mL} / 12 = 166.6 \text{ mL}$, which rounds off to 167 mL/h.

Once you have observed that the number of mL/h is identical to the number of gtt/min, something that never changes when you are using a 60 gtt/mL tubing, it soon becomes apparent that for tubing with other drop factors (10 gtt/mL, 15 gtt/mL, and 20 gtt/mL), you must simply look at the relationship of the drop factor to the ever-present 60, the never-changing number of minutes in an hour.

For example, if you are using IV tubing with a 20 gtt/mL drop factor, you have to look at the relationship between the 20 in the tubing drop factor and the ever-present 60, the number of minutes in an hour. The relationship between 60 and 20 is 3; in other words, $60 / 20 = 3$.

Similarly, if you are using IV tubing with a 10 gtt/mL drop factor, you have to look at the relationship between the 10 in the tubing drop factor and the number 60. The relationship between 60 and 10 is 6: $60/10 = 6$. Finally, if you are using IV tubing that delivers 15 gtt/min, the relationship of 60 to 15, or 4, requires you to divide the number of mL an hour by 4.

Now that you know all the possible relationships, it is only necessary to divide the number of mL an hour:

- By 3 for a 20 gtt/mL drop factor tubing
- By 6 for a 10 gtt/mL drop factor tubing, and
- By 4 for a 15 gtt/mL drop factor tubing.

All you have to do is *one* step. There are no rules to forget, no complicated formulas, and no unnecessary steps!

Here are some examples:

If you are using a 10 gtt/mL set, the number of drops per minute will always be the number of mL an hour divided by 6.

100 mL/h: $100/6 = 16.6 = 17$ gtt/min rounded off

125 mL/h: $125/6 = 20.8 = 21$ gtt/min rounded off

150 mL/h: $150/6 = 25$ gtt/min

If you are using 20 gtt/mL IV tubing, the number of drops per minute will always be the number of mL an hour divided by 3.

100 mL/h: $100/3 = 33.3 = 33$ gtt/min rounded off

125 mL/h: $125/3 = 41.6 = 42$ gtt/min rounded off

150 mL/h: $150/3 = 50$ gtt/min

And, finally, if you are using 15 gtt/mL tubing, the number of drops per minute will be the number of mL an hour divided by 4.

100 mL/h: $100/4 = 25$ gtt/min

125 mL/h: $125/4 = 31.2 = 31$ gtt/min rounded off

150 mL/h: $150/4 = 37.5 = 38$ gtt/min

This one-step, no-rules method of calculating the number of IV drops per minute works all the time because there are always 60 minutes in an hour. The one step involved in calculating the number of drops per minute consists of dividing the relationship number for the specific IV tubing set into the number of mL per hour ordered by the doctor.

Pediatric (60 gtt/mL) tubing has an identity relationship; therefore, the number of drops per minute will always exactly match the number of mL per hour.

This one-step method is particularly useful because nurses caring for patients with IV infusions should count and verify the number of drops per minute at the bedside with each patient contact. Volumetric controllers and pumps are not always accurate and do not always function properly.

OTHER IV CALCULATIONS USING DIMENSIONAL ANALYSIS

Calculating the number of drops per minute, or the flow rate, is probably the most frequently used IV calculation in nursing, however, there are other IV computations that you will also have to know. These include calculating the following:

- total infusion time;
- the concentration of a medication in an IV solution that should be given; and
- IV flow rates based on body weight.

Calculating Total Infusion Time

When you have adjusted an IV solution to run at a certain number of drops per minute, you will always want to know when the solution is should finish infusing so that you can anticipate the need to hang another bag of solution, if so ordered. Additionally, even when you are using a controller the accuracy of the flow rate is not always fail proof. Machines fail. You must, therefore, be able to calculate the total infusion time for the presently infusing bag.

Following is an example of how this type of calculation is accomplished using dimensional analysis.

Total volume of IV fluid: 800 mL

Infusion rate: 23 gtt/min

Drop factor: 10 gtt/mL

When will the liter of fluid run out?

The *starting factor* is 800 mL

The *conversion factors* are:

- 10 gtt/ 1 mL
- 23 gtt/ 1 min
- The *answer unit* is _____ a unit of time (min and/or hr and/or hr and min).

Starting factor × Conversion factors = Answer unit

$$800 \text{ mL} \quad \times \quad \frac{10 \text{ gtt}}{1 \text{ mL}} \quad \times \quad \frac{1 \text{ min}}{23 \text{ gtt}} \quad \times \quad \frac{1 \text{ h}}{60 \text{ min}} \quad = \quad \underline{\hspace{2cm}} \text{ h}$$

$$800 \text{ mL} \times \frac{10 \text{ gtt}}{1 \text{ mL}} \times \frac{1 \text{ min}}{23 \text{ gtt}} \times \frac{1 \text{ h}}{60 \text{ min}} = \frac{800}{138} = 5.79 \text{ h (5 h 47 min)}$$

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For example, if you are caring for a patient that weighs 250 lb and the doctor orders 5 mcg/kg/min of a medication intravenously infused via 500 mL of an IV fluid that contains 250 mg of the medication, you would perform the following computation to determine the number of mL per minute or hour that the patient will receive.

The *starting factor* is 250 lb

The *conversion factors* are:

- 1 kg/2.2 lb
- 5 mcg/1 kg
- 1 mg = 1,000 mcg
- 250 mg/500 mL

The *answer unit* is _____ mL

Starting factor × Conversion factors = Answer unit

$$250 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{5 \text{ mcg}}{1 \text{ kg}} \times \frac{1 \text{ mg}}{1,000 \text{ mcg}} \times \frac{500 \text{ mL}}{250 \text{ mg}} = \text{_____ mL}$$

$$\overset{1}{250 \text{ lb}} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{5 \text{ mcg}}{1 \text{ kg}} \times \frac{1 \text{ mg}}{1,000 \text{ mcg}} \times \frac{500 \text{ mL}}{250 \text{ mg}} \overset{1}{=} \frac{5}{4.4} = 1.136 \text{ mL}$$

The number of mL to be administered per hour = 1.136 × 60 = 68.16 mL

Rounded Off to: 68.2 mL

Practice Problem 1

Total volume of IV fluid at the beginning of your shift: 350 mL

Infusion rate: 21 gtt/min

Drop factor: 15 gtt/mL

When will this fluid run out?

Practice Problem 2

How many mL/h would you administer if the doctor orders 30 U/h of a medication that has been diluted in a solution with a total of 250 U in 1,000 mL?

Practice Problem 3

If your patient weighs 100 lb and the doctor orders 5 mcg/kg/min of a medication intravenously infused via 500 mL of an IV fluid that contains 250 mg of the medication, how many mL/min and mL/h would you administer?

Here are the Answers

1. 4 h 10 min
2. 120 mL/h
3. 0.45 mL/h and 27 mL/h

Practice Problem 1

The *starting factor* is 350 mL

The *conversion factors* are:

- 15 gtts/1 mL
- 21 gtts/ 1 min
- 1 h/ 60 min

The *answer unit* is _____ h or min

$$350 \text{ mL} \quad \times \quad \frac{15 \text{ gtt}}{1 \text{ mL}} \quad \times \quad \frac{1 \text{ min}}{21 \text{ gtt}} \quad \times \quad \frac{1 \text{ h}}{60 \text{ min}} \quad = \quad \underline{\hspace{2cm}} \text{ h}$$

$$350 \text{ mL} \times \frac{15 \text{ gtt}}{1 \text{ mL}} \times \frac{1 \text{ min}}{21 \text{ gtt}} \times \frac{1 \text{ h}}{60 \text{ min}} = \frac{350}{84} = 4.16 \text{ h (4 h 10 min)}$$

Practice Problem 2

The *starting factor* is 30 U

The *conversion factor* is 250 U/1,000 mL
 The *answer unit* is _____ mL/h

$$30 \text{ U} \times \frac{1,000 \text{ mL}}{250 \text{ U}} = \underline{\hspace{2cm}} \text{ mL}$$

$$\begin{array}{c} 3 \\ 30 \text{ U} \end{array} \times \frac{1,000 \text{ mL}}{250 \text{ U}} = \frac{3,000}{25} = 120 \text{ mL/h}$$

Practice Problem 3

The *starting factor* is 100 lb
 The *conversion factors* are:

- 1 kg/ 2.2 lb
- 5mcg/1kg
- 1 mg/1,000 mcg
- 500 mL/ 50 mg

The *answer unit* is _____ mL/min and mL/h

Per minute:

$$100 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{5 \text{ mcg}}{1 \text{ kg}} \times \frac{1 \text{ mg}}{1,000 \text{ mcg}} \times \frac{500 \text{ mL}}{250 \text{ mg}} = \underline{\hspace{2cm}} \text{ mL}$$

$$\begin{array}{c} 1 \\ 100 \text{ lb} \end{array} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} \times \frac{5 \text{ mcg}}{1 \text{ kg}} \times \frac{1 \text{ mg}}{1,000 \text{ mcg}} \times \frac{500 \text{ mL}}{50 \text{ mg}} = \frac{1}{2.2} = 0.45 \text{ mL}$$

Per hour:

$$0.45 \times 60 = 27 \text{ mL/h}$$

SUMMARY

Dimensional analysis is a highly useful way to calculate dosage and solution problems of all types. It is an orderly and systematic mathematical process that results in consistent accuracy, provided the

equation is set up correctly and careless mathematical errors are avoided.

If you would like to learn the ratio and proportion method of calculations, take our course entitled "*Calculation of Dosages and Solutions: Ratio and Proportion*".