

Critical Thinking: Nursing Calculations Part 2

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Note: All dosages given are for adults unless otherwise stated. The information on medications contained in this course is not meant to be prescriptive or all-encompassing. You are encouraged to consult with physicians and pharmacists about all medication issues for your patients.

Acknowledgements

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Purpose and Objectives

The purpose of Critical Thinking: Nursing Calculations Part 2 is to provide information about basic facts and principles of calculations related to conversions between different measurement systems, and calculations of drug dosages.

After successful completion of this course, you will be able to:

1. Identify reasons why nurses need to maintain competency in performing selected calculations even though technology and pharmacy support relieves nurses of performing calculations in many situations.
2. Describe selected basic concepts, facts and principles of algebra and mathematics.
3. Perform calculations correctly using:
 - A. Formula (where applicable).
 - B. Ratio and proportion.
4. Identify advantages and disadvantages of the different calculation methods:
 - A. Formula (where applicable).
 - B. Ratio and proportion.
5. Convert correctly between selected units of measure:
 - A. Within the metric system.
 - B. Between United States Customary measures and the metric system.
 - C. Between selected cooking measures and the metric system.
 - D. Between Celsius (centigrade) and Fahrenheit temperature scales.
6. Calculate drug dosages correctly, finding correct dosages and correct amounts to administer given prescriber orders, selected patient parameters, and concentrations and amounts on hand.

Introduction

As a healthcare professional, medication safety is a critical part of your job. Patients' safety and lives depend on receiving the correct dose of medications. This two-part series of courses reviews basic skills related to safely calculating medication dosages.

Part 1 of the series deals with the metric system and conversions to and from the metric system. Part 2 considers calculations related to medications.

Part 2 of this series reviews the conversions from Part 1 and puts these concepts to use in common clinical situations. Concepts that are necessary to correctly calculate oral and medication for injection is also addressed.

Keys to Calculation Success

Top Ten Reasons

Why Healthcare Professionals Don't Think They Need to Maintain Competency in Calculations

- The computer does it
- The pharmacy does it
- The IV infusion pump does it
- We have charts and tables that do it
- The drug companies take care of it
- We use unit dose
- It's just a nursing school exercise
- We have a unit-based pharmacist
- Math is just not one of my strengths
- It's not a good use of my time

Keys to Calculation Success

Some of those "Top Ten" may apply to your work situation – at least partially. And to add further support to the list, initiatives directed toward improving medication safety recommend that calculations be performed by computer algorithm rather than by practitioners using calculators or paper and pencil (Durham, 2015). HOWEVER, responsible professionals cannot afford to become complacent and place blind trust in technology - particularly nurses, who assume accountability for all drugs they administer. The Institute for Safe Medication Practices (ISMP) recommends the use of redundancies, such as independent double checks, of high alert medications due to the increased risk for patient harm (ISMP, 2014). This includes independent calculations for dose and rates of medication. The list of high alert medications can be found at <http://www.ismp.org/tools/institutionalhighAlert.asp>

True or False?

Nurses are accountable for all drugs they administer.

Answer: True

Did You Know?

One cross-sectional study was done with 203 nurses to examine medication knowledge and the risk of medical errors. Participants were from acute care hospitals and primary care settings. As part of the study, each was provided a test on pharmacology, drug management, and drug calculations. The study showed that the participants had a 39% moderate risk and 11% high risk for pharmacology

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knowledge, 33% moderate risk and 26% high risk with drug management, and 32% moderate risk and 7% high risk with drug calculations (Simonsen, Johansson, Daehlin, Osvik, & Farup, 2011).

Relying on Technology

As previously mentioned, relying on technology alone can be detrimental to patients. Nurses are often the last measure to keep patients safe. High risk medications and high risk populations, such as neonatal patients or those on chemotherapy are particularly at risk. Accurate calculations of medications are vital. In addition, the considerations of converting values to the metric system to input into devices, such as intravenous (IV) pumps is essential (American Association of Health-System Pharmacists, 2015; National Association of Neonatal Nurses, 2011). Examples of errors include inputting the patient's height (cm) into a pump rather than the weight (kg) (ISMP, 2011).

Maintaining a State of Risk Awareness

To prepare and administer medications safely, healthcare professionals must avoid total dependence on technology to perform calculations. Safe practitioners question themselves to eliminate risks of harm to patients. Sample questions include:

- I set the pump to infuse at 125 mL/hr – is what I see in the drip chamber consistent with that rate?
- This dose is ten times what I usually see for this type of patient – could a decimal point be out of place?
- How could one mg/kg amount to that large a dose for such a small patient?
- If I prepare that dose with these tablets, I'll be giving the patient 10 tablets – does that make sense?
- If you input "170" into the pump; this would mean that the patient's weight is 374 lbs. Does that look right?

The safe practitioner maintains a state of risk-awareness – continuously evaluating that the nursing action they are about to perform is correct.

Responsibility Means Competency

Just as hospitals have emergency generators to supply electrical power in the event of a power outage, the healthcare professional must be prepared to back up some of the technology involved in safe administration of medications – to know how to calculate the correct dose of medication for example.

Unit dose preparations by drug manufacturers and by pharmacists help to assure safety. Occasions may arise when unit dose preparations are not available, when the pharmacist cannot respond as quickly as necessary or when limited pharmacy resources restrict unit dose preparation by pharmacists.

Even when all systems are go – when the technology works well and pharmacy support is optimal – the nurse still remains responsible for safe administration of medications directly to patients. To fulfill

this responsibility, the nurse must maintain competency in basic medication calculations (Durham, 2015).

Research Findings

Of the medical errors reported, approximately 32% are medication errors (Anderson & Townsend, 2010). It is estimated that over one million medication errors occur each year (Leapfrog Hospital Survey, 2011). Research findings implicate calculation errors as the reason for many medication errors.

In addition, it was reported that errors in preparing and administering IV medications account for many of all medication errors and pediatric patients are three times more likely to experience medication errors than adults (Anderson & Townsend, 2010).

For most drug calculation problems, there is more than one method for arriving at the correct answer.

During your basic training, you undoubtedly learned at least one approach for each type of problem. This course will give you an additional opportunity to refresh your previous knowledge of calculations and gain new insights and techniques for approaching calculations.

Test Yourself

Which statement is true about drug calculations?

- A. They are not necessary due to technology
- B. There is usually more than one method to arrive at the correct answer**
- C. Nurses are not responsible for drug calculations

Effective Methods for Calculations

For most drug calculation problems, there is more than one method for arriving at the correct answer. During your basic training, you undoubtedly learned at least one approach for each type of problem. This course gives you an opportunity to refresh your previous knowledge of calculations and gain new insights and techniques for approaching calculations.

TO USE THIS SERIES MOST EFFECTIVELY:

1. At intervals throughout the course you will find “Abbreviation Alerts!!!” Although abbreviations do not enter into the calculation procedure directly, unclear abbreviations have been implicated in medication errors. Safety experts at the Institute for Safe Medication Practices (ISMP), The Joint Commission (TJC) and the National Coordinating Council for Medication Errors (NCCMERP) have recommended that healthcare professionals discontinue the use of certain common abbreviations. Follow these recommendations when writing in medical records and communicating among health team members. Encourage prescribers and colleagues to follow these recommendations.
2. The safest approach to drug calculation is to use the same method for the same type of problem each time. And, this course strongly recommends that you do exactly that in your practice. However, when you are studying this course and working the problems that this course contains,

try out the alternative approaches. You may find advantages to some of the methods that you have not used previously.

3. Work through the topics in the order which the course presents them. Explanations for certain mathematical and algebraic concepts appear early in the course. If you skip around amongst topics of the course, you will lose the benefit of explanation and practice along the way.
4. Practice the problems that the course presents. When it comes to learning calculations, there is no substitute for active practice. Reading through the examples and solutions will not be sufficient to refine your skills.
5. Take it slow! The recommended speed for this series is slow and steady. Complete just one section at a sitting and take time to work through the examples and practice problems.

Conversions

The most common conversions needed for drug calculations involve:

- Conversions within the metric system, such as milligrams to micrograms.
- Conversions between selected units of the U.S. Customary System and metric units, such as ounces (oz.) to milliliters (mL).
- Conversions between selected units of Cooking Measures and metric units, such as teaspoons (tsp.) to milliliters (mL).
- Conversions between the Celsius and Fahrenheit temperature scales.

Use your critical thinking skills as you study this section and throughout the course. Ask yourself:

- Does this number make sense?
- Which should be larger?
- Why is the “amount” of the dose so small?

All these are important questions to ask yourself in order to be certain you have made a correct calculation.

Overview of Healthcare Related Conversions

Although the metric system is used regularly in nursing practice, we occasionally forget the “why” of a calculation. This refresher will remind you of the unit prefixes and symbols that are the basics of the metric system.

- Note that within the unshaded levels in the scale, the value of each level is ten times the value of level below it and also 1/10 the value of the level above it.
- Therefore, converting between two measures that are contiguous (next to one another) in the unshaded levels of the scale requires moving the decimal point one place for each step:
 - One place to the right for each step up the scale.
 - One place to the left for each step down the scale.
- The shaded levels of the scale at each the high end (mega) and low end (micro) of this scale are separated from the next level by a multiple of 1,000.



The Metric Scale

Prefix	Symbol	Multiply By
Mega	M	1,000,000
Kilo	k	1,000
Hecto	h	100
Deka	da	10
Unit: • Gram • Meter □ Liter • Second	Unit: □ g • m • L • s	1
Deci	d	0.1
Centi	c	0.01
Milli	m	0.001
Micro	mc or μ	0.000001

Mnemonic Memory Helper

Some people find a mnemonic (a memory helper) useful. The order of the levels in the metric scale and the 3-place separation at each end is represented in the mnemonic:

3 kids happily dived under docks; caught mermaids 3.

Mega (M)	kilo (k)	Hecto (h)	deka (da)	Unit: Gram (g) Meter (m) Liter (L) Second (s)	deci (d)	centi (c)	milli (m)	micro (mcg or μ)
3	kids	Happily	dived	Under	docks;	caught	mermaids	3
1,000,000	1000	100	10	1	0.1	0.01	0.001	0.000001



Conversions for Medication Administration

For the purposes of medication administration, conversions within the metric system most frequently involve conversions among micrograms, milligrams and grams.

1 milligram (mg) = 1,000 micrograms (mcg or μg)
1 gram (g) = 1,000 milligrams (mg)
1 kilogram (kg) = 1,000 grams (g)

U.S. Customary System and Metric Unit Conversions

For the purposes of medication administration, conversions between selected units of the U.S. Customary System the metric system most frequently involve conversions between:

- pounds (lb.) and kilograms (kg)
- inches (in.) and centimeters (cm)
- fluid ounces (oz.) and milliliters (mL)

Critical Thinking Tip

Don't let decimal fractions of pounds, hours, inches or ounces trick you into making an error. In the United States, nurses are accustomed to working within the U.S. Customary System, which is NOT based on multiples of 10. When you are making calculations and your answer comes out to a decimal fraction of a pound, hour, foot/yard or fluid value (gallon, quart, cup, etc.) don't mistake that fraction for a number of ounces, minutes, or other values. For example, 1 kilogram = 2.2 pounds. NOT 2 pounds, 2 ounces.

1 kilogram (kg) = 2.2 pounds (lb.)
1 inch (in) = 2.54 centimeters (cm)
1 centimeter (cm) = 0.394 inch (in.)
1 ounce (oz..) = 30 milliliters (mL)
1 tablespoon (Tbsp.) = 15 mL
1 teaspoon (tsp) = 5 mL

Test Yourself!

How many ounces does 0.2 pound equal?

(To answer this question, you must know that a pound is equal to 16 ounces. Then, multiply to find the number of ounces in 0.2 pound. The same rules apply for converting the other measure.)

16 X 0.2 = 3.2 ounces.
So, 2.2 pounds = 2 pounds, 3 ounces (rounded).

Conversions between the Celsius and Fahrenheit Temperature Scales

$$\text{Fahrenheit Temperature (}^{\circ}\text{F)} = 9/5 (\text{Centigrade Temperature or }^{\circ}\text{C)} + 32$$

$$\text{Centigrade Temperature (}^{\circ}\text{C)} = 5/9 (\text{Fahrenheit Temperature or }^{\circ}\text{F)} - 32$$

OR

$$\text{Fahrenheit Temperature (}^{\circ}\text{F)} = (\text{Celsius Temperature or }^{\circ}\text{C} \times 1.8) + 32$$

$$\text{Celsius Temperature (}^{\circ}\text{C)} = (\text{Fahrenheit Temperature or }^{\circ}\text{F} - 32) / 1.8$$

The centigrade scale is also known as the Celsius scale. For simplicity, the course uses the term: Celsius.

When converting between Fahrenheit and Celsius temperature scales, it is simplest to follow the formula.

For more practice on converting to metric system measurements, see RN.com's *Nursing Calculations Part 1*.

Test Yourself

The basic unit in the metric system (g, m, L, s) is the equivalent of what?

- A. 1
- B. 10
- C. 100

Conversion Math: Equivalents

The simplest way to perform conversions involving metric quantities is to memorize the equivalents and move the decimal point to multiply or divide.

When performing ANY conversion or calculation, first ask yourself "Which unit is larger?" In this example conversion you know that milligrams are larger than micrograms and so the correct answer will be a number larger than the number of milligrams. Similarly when computing more complicated problems involving dosages, ask yourself first if the correct amount will be greater or less than 1 tablet, 1 milliliter, 1 milligram or whatever unit of measure is appropriate to the problem.

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A 50 mg tablet contains how many micrograms?

If 1 mg = 1,000 mcg, then you multiply 50 X 1,000, by moving the decimal point 3 places to the right (one place for each zero).

$$50.000 \times 1,000 = 50,000 \text{ mcg}$$

Conversion Math: Ratio/Proportion

Another method to convert mg to mcg is to create a proportion. When you create a proportion, you are creating two fractions which are equal to each other. In this case, use the equivalent 1 mg = 1,000 mcg.

For the purposes of creating proportions and fractions, think of the equal sign as equivalent to “per.” In other words, 1 milligram per 1,000 micrograms. When you change equivalents into fractions, the “per” separates the numerator from the denominator.



Set up the problem using this equivalent:

$$\frac{1 \text{ mg}}{1,000 \text{ mcg}} = \frac{50 \text{ mg}}{x \text{ mcg}}$$

Use “x” to represent the number of micrograms because that is the unknown quantity that you are computing.

Conversion Math: Ratio/Proportion

In the language of mathematics, these two numbers (the denominator of the first fraction and the numerator of the second fraction) are called “means.”

$$\frac{1 \text{ mg}}{1,000 \text{ mcg}} = \frac{50 \text{ mg}}{x \text{ mcg}}$$

$$\frac{1 \text{ mg}}{1,000 \text{ mcg}} = \frac{50 \text{ mg}}{x \text{ mcg}}$$

In the language of mathematics, these two numbers (the numerator of the first fraction and the denominator of the second fraction) are called "extremes."

Critical Thinking Tip:

Always begin your calculation by using "x" to represent the quantity which will be your answer. In this case "How many micrograms (mcg)?" translates into "x" micrograms (mcg).

Means = Extremes

When two fractions are equal to each other, the product of the means equals the product of the extremes. The product is the result of multiplying two numbers together. For example, the product of 2 X 3 is 6.

To prove to yourself that the product of the means = the product of the extremes when two fractions are equal, choose two fractions that you know to be equivalent. For example, $\frac{4}{8} = \frac{1}{2}$. If you multiply the means (8 X 1) and multiply the extremes (4 X 2), you can see that each of the two products equals 8.

$$\frac{1 \text{ mg}}{1,000 \text{ mcg}} = \frac{50 \text{ mg}}{x \text{ mcg}}$$

To solve the equation and find the value of x mcg, cross-multiply the means and the extremes.

$$\begin{array}{ccc} \frac{1 \text{ mg}}{1,000 \text{ mcg}} & = & \frac{50 \text{ mg}}{x \text{ mcg}} \\ & \swarrow \quad \searrow & \nearrow \quad \nwarrow \\ & 1,000 \times 50 & = 50,000 \end{array}$$

$$50,000 = x \text{ mcg}$$

Critical Thinking Tip:

When setting up an equation (or two equivalent fractions), place like units in the same position in the two fractions. In the example, both "mg" are in the numerator and both "mcg" are in the denominator.

Conversion Math: Formula Method

A third method for solving medication calculation problems is to use the "Formula Method"

The formula method can be useful for solving calculation problems initially or to check your math from another method. It is also quite useful for liquid preparations

$$\frac{D}{H} * Q = X$$

D = desired dosage (ordered)
H = dosage strength available
Q = quantity/volume dosage strength is contained in
X = the volume desired

For instance, the provider orders 50 mg of Drug C. Drug C comes in 100 mg tablets.

Conversion Math: Formula Method

Example 1

For instance, the provider orders 50 mg of Drug C. Drug C comes in 100 mg tablets.

Using the formula method, you set up the calculation as seen below:

Desired Dose Quantity/volume dosage strength is contained in

$$\frac{50 \text{ mg}}{100 \text{ mg}} * 1 \text{ tablet} = X$$

Dosage Strength Available

$$\frac{50 * 1 \text{ tablet}}{100} = 0.5 \text{ tablet}$$

You will administer 0.5 or ½ tablet.

Critical Thinking Tip:

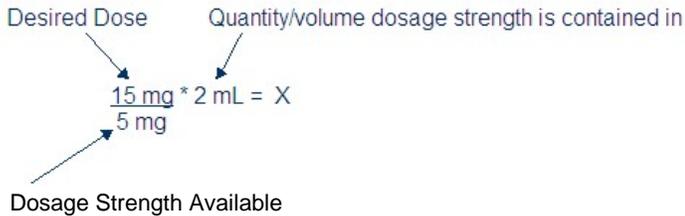
Note that the Ratio Proportion Method and the Formula Method are quite similar. You may want to consider trying both out and deciding on one that works better for you. You can also use both methods to confirm that your answer is correct.

Conversion Math: Formula Method

Example 2

A second example could be:
The provider orders 15 mg of Drug D. Liquid Drug D comes in 5 mg/2 mL

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$$3\text{mg}/1\text{mg} * 2\text{mL} = X \text{ mL}$$

$$6\text{mLs} = X$$

You will administer 6 mL

Test Yourself

In the components needed for the formula method, what does the “D” stand for?

- A. **Desired dose**
- B. Available dosage strength
- C. Quantity or volume

Conversion Math: Dimensional Analysis

Another method that will answer the question, “A 50 mg tablet contains how many micrograms (mcg)?” is called dimensional analysis. If you have studied drug calculations recently, this technique may be familiar.

1. Determine the GIVEN QUANTITY.
In the example, the GIVEN QUANTITY is 50 mg.
2. Determine the unit of measure for the WANTED QUANTITY. In the example, the WANTED QUANTITY is in mcg.
3. Determine what CONVERSION FACTORS you will need to use.
In the example, the CONVERSION FACTOR is 1 mg equals 1,000 mcg, or 1 mg per 1,000 mcg or 1mg/1,000 mcg.
4. Now you are ready to SET UP the problem. Dimensional Analysis problems are set up like fractions, with a numerator (top number) and a denominator (bottom number).
In dimensional analysis, you set up the problem so that the unwanted units are canceled out. Cancel out units by having one in the numerator and a matching one in the denominator. So, if you have mg on top, and you want the answer in mcg, set up the problem using the mg to mcg conversion. Place mg on the bottom, so the mg cancel out. Separate the numbers with a multiplication sign.

$$\frac{50 \text{ mg} \times 1,000 \text{ mcg}}{1 \text{ mg}} = \text{_____ mcg}$$

5. CROSS OUT the units which cancel out, leaving nothing but the WANTED QUANTITY.

$$\frac{50 \cancel{\text{mg}} \times 1,000 \text{ mcg}}{1 \cancel{\text{mg}}} = \underline{\hspace{2cm}} \text{ mcg}$$

6. DO THE BASIC MATH. Solve the problem by using basic math (no algebra required). Multiply the numbers across. Divide the top number by the bottom number.

$$\frac{50 \cancel{\text{mg}} \times 1,000 \text{ mcg}}{1 \cancel{\text{mg}}} = 50,000 \text{ mcg}$$

Admittedly, dimensional analysis is an extremely long and complex way to solve this simple conversion problem. However, dimensional analysis will be more useful later in the course for more complicated calculations. If you master the procedure on this simple conversion, you will find it easier to apply the technique to more complicated problems.

Test Yourself

With dimensional analysis, units are crossed out so that what is left?

- A. mg
- B. Given quantity
- C. Wanted quantity

Conversions in Healthcare Practice

Finding an efficient and reliable system for calculating dosages is critical to patient safety. As noted below, even when each step is extremely reliable, the number of steps increases the likelihood of error.

Probability of Success of Process When Each Step is 99% Reliable
Vincent, 2011

# of Steps in Process	Error Probability Rate
1	1%
25	22%
50	39%

100	63%
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The next section of this course allows you to take a sample of clinical situations and put the calculations skills you have learned into practice. By practicing on “true-life” situations, you can further enhance your skills.

You have a solution of dobutamine 500 mg per liter.

How many mcg of dobutamine dose each mL of your solution contain?

One method to consider:

1 liter = 1,000 mL

500 mg per 1,000 mL or 500/1,000 (*Remember “per” implies a fraction*)

$$\frac{500 \text{ mg}}{1000 \text{ mL}} = \frac{x \text{ mg}}{1 \text{ mL}}$$
$$1000 x = 500$$
$$x = 0.5 \text{ mg/mL obtained by dividing 500 by 1000}$$

But the question asks how many mcg.

So now the question is 0.5 mg = ____mcg.

Since 1 mg = 1,000 mcg move the decimal three places to the left.

The correct answer is 500 mcg/mL

Critical Thinking Tip:

Anytime you are calculating mg/L, the number of mg/L will equal the number of mcg/mL

$$\mathbf{1 \text{ mg} = 1,000 \text{ mcg} = 1 \text{ L} = 1,000 \text{ mL}}$$

Therefore, you multiply both the numerator and the denominator by 1,000 and as a result the 1,000 multiplier in the numerator and the 1,000 multiplier in the denominator cancel one another, leaving the value of mg/L the same as the number of mcg/mL.

Practice Problem: Converting mgs to mcg

Your patient has been receiving a daily dose of levothyroxine (Synthroid) 125 mcg p.o. Today, on early morning rounds, her doctor reviews her lab work and mentions that her TSH level is elevated indicating lower thyroid function. Her doctor orders:

Synthroid 0.15 mg p.o. q am

Is it likely that the doctor has made an error?

To answer this question, convert the newly ordered dose to mcg.

0.15 mg = 150 mcg.

Or, convert the previous dose to mg.

0.125 mg = 125 mcg.

No, a provider error is not likely. Most likely, the provider has increased the dose by 25 mcg. Synthroid doses are usually increased incrementally until adequate levels of thyroid hormone (T4) and normal levels of thyroid stimulating hormone (TSH) are achieved. Tablets in strengths of 25 mcg up to 200 mcg are supplied in increments of 25 mcg, though some intermediate strengths are available: 88 mcg, 112 mcg, 137 mcg. In this case the provider increased the dose by one increment – by 25 mcg.

If there will be a delay in receiving the new unit dose strength, is it reasonable for you to give her newly ordered dose this morning using the tablets which you have on hand (125 mcg per tablet)?

The new order converted to mcg equals 150 mcg. This dose would require 1 +1/5 tablets of 125 mcg strength. It would be difficult to slice the tablet into 5ths, so it is safer to wait for the unit dose. Although generally you would wait for a new unit dose, there may be occasions where you can use a portion of a tablet, or two tablets, etc. depending on the drug, dose change, and urgency. Check with your facility policy on these issue.

Practice Problem: Temperature Conversions

You are a new nurse at Lakeview Hospital. Your previous facility used Fahrenheit for recording patient temperatures, but at Lakeview they use Celsius. Your patient's temperature is 38.5 °C. You want to know what this "translates" to in the Fahrenheit system.

When converting between Fahrenheit and Celsius temperature scales, it is simplest to follow the formula. Inserting the formula into ratio and proportion or dimensional analysis complicates the conversion and might lead to error.

$$^{\circ}\text{F} = 9/5 (38.5) + 32$$

$$^{\circ}\text{F} = \frac{9 \times 38.5 + 32}{5}$$

$$^{\circ}\text{F} = \frac{346.5 + 32}{5} = 69.3 + 32$$

Answer: $^{\circ}\text{F} = 101.3$

Critical Thinking Tip:

How to associate the correct formula with conversion to Fahrenheit or Celsius.

- On the Centigrade temperature scale, 0°C of the freezing point of water.
- The freezing point of water on the Fahrenheit scale is 32°F . Since the Fahrenheit scale is the more familiar scale in the United States, you probably know this fact.

One of the formulae involves subtracting and then multiplying by a smaller fraction – which will result in an answer smaller than the number to be converted.

Because $0^{\circ}\text{C} = 32^{\circ}\text{F}$, you know that the Celsius value must be smaller than the equivalent Fahrenheit value. Therefore, to go to Celsius, subtract 32 and use the smaller fraction (5/9). (Also, an “S” sound to help you remember: Celsius – subtract – smaller fraction).

When converting to Fahrenheit, the answer will be a larger number than the Celsius – so, use the larger fraction (9/5) and add 32.

NOTE: From Celsius to Fahrenheit, multiply THEN add.

From Fahrenheit to Celsius, subtract THEN multiply “Subtract to Celsius” (the “s” sound) may help you remember to subtract first.

Temperature Conversions, con’t

An alternative way to convert between Celsius and Fahrenheit scales is to use the factor of 1.8. Formulas using this factor are as follows:

$\text{Fahrenheit Temperature } (^{\circ}\text{F}) = (\text{Celsius Temperature or } ^{\circ}\text{C} \times 1.8) + 32$
$\text{Celsius Temperature } (^{\circ}\text{C}) = (\text{Fahrenheit Temperature or } ^{\circ}\text{F} - 32) / 1.8$

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Using the same example used above of 38.5 °C, this is how this conversion can be applied:

$$^{\circ}\text{F} = (38.5 \times 1.8) + 32$$

$$^{\circ}\text{F} = 69.3 + 32$$

Answer: $^{\circ}\text{F} = 101.3$

Practice Problem: Calculating mg/mL

You have an order to administer phenytoin (Dilantin) oral suspension 100 mg TID per feeding tube. Dilantin oral suspension is supplied to you in a 5 mL bottle which contains 125 mg/mL

How many mL per dose will you administer?

Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{125 \text{ mg}}{1 \text{ mL}} = \frac{100 \text{ mg}}{x \text{ mL}}$ <p><i>Cross-multiply and solve for x.</i></p> $\frac{125 \text{ mg}}{1 \text{ mL}} \times x \text{ mL} = \frac{100 \text{ mg}}{1} \times 1 \text{ mL}$ $125x = 100$ $x = 100/125 \quad x = 0.8 \text{ mL}$	$\frac{100 \text{ mg}}{125 \text{ mg}} \times 1 \text{ mL} = x \text{ mL}$ <p><i>Solve for x.</i></p> $100/125 = x$ $x = 0.8 \text{ mL}$

After performing a medication calculation:

- Ask yourself, "Should the answer be more or less than one mL?" You have a solution that contains 125 mg/mL and you need only 100 mg – therefore you will need less than one mL. Although the more or less than one mL question is an easy one in this case, in more complex calculations, that basic question is sometimes lost in the shuffle and ignored, leading to error. The "more or less than one unit of measure" question is an important safety step.

- Note that the “amount on hand” equals the unit which contains the “dose on hand.” That is, the solution on hand contains 125 mg/mL. So the amount on hand is 1 mL. The amount on hand is NOT 5 mL, the amount that the bottle contains when it is full.

Practice Problem: Intake in mL

You need to calculate intake in mL for your patient. For lunch they had:

- 8 oz. apple juice
- 7 tsp. of chicken broth
- 1 cup of Jello

How much intake did your patient have in mL?

Calculations for 8 oz apple juice

Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{30 \text{ mL}}{1 \text{ oz}} = \frac{x \text{ mL}}{8 \text{ oz}}$ <p>Cross-multiply and solve for x.</p> $\frac{30 \text{ mL}}{1 \text{ oz}} = \frac{x \text{ mL}}{8 \text{ oz}}$ $x = 240 \text{ mL}$	$8 \text{ oz} \times \frac{30 \text{ mL}}{1 \text{ oz}} = x$ $8 \times 30 \text{ mL} = 240 \text{ mL}$ $x = 240 \text{ mL}$

Calculations for 7 tsp of chicken broth

Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{5 \text{ mL}}{1 \text{ tsp}} = \frac{x \text{ mL}}{7 \text{ tsp}}$ <p>Cross-multiply and solve for x.</p> $\frac{5 \text{ mL}}{1 \text{ tsp}} = \frac{x \text{ mL}}{7 \text{ tsp}}$ $x = 35 \text{ mL}$	$7 \text{ tsp} \times \frac{5 \text{ mL}}{1 \text{ tsp}} = x$ $7 \times 5 \text{ mL} = 35 \text{ mL}$ $x = 35 \text{ mL}$

Calculations for 1 cup of jello

Method #1: Ratio Proportion	Method #2: Formula Method
<p>1 cup = 8 oz</p> $\frac{1 \text{ oz}}{30 \text{ mL}} = \frac{8 \text{ oz (1 cup)}}{x \text{ mL}}$ <p>Cross-multiply to find x.</p> $\frac{1 \text{ oz}}{30 \text{ mL}} \times \frac{8 \text{ oz (1 cup)}}{x \text{ mL}}$ <p>x = 240 mL</p>	<p>1 cup = 8 oz</p> $8 \text{ oz} \times \frac{30 \text{ mL}}{1 \text{ oz}} = x$ <p>x = 240 mL</p>

Practice Problem: Pediatric Dose Calculation

Your 4 year old pediatric patient weighs 40 pounds. She is febrile. You need to administer acetaminophen (Tylenol) 15mg/kg. How many mg will you administer?

First convert 40 pounds into kilograms.



Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{1 \text{ kg}}{2.2 \text{ pounds}} = \frac{x \text{ kg}}{40 \text{ pounds}}$ <p>Cross-multiply and solve for x.</p> $\frac{1 \text{ kg}}{2.2 \text{ pounds}} \times \frac{x \text{ kg}}{40 \text{ pounds}}$ $2.2x = 40$ <p>x = 18.18 kg</p>	$\frac{40 \text{ pounds}}{2.2 \text{ pounds}} \times 1 \text{ kg} = x \text{ kg}$ <p>x = 18.18 kg</p>

Since you will administer 15mg of acetaminophen per 1 kg, you should multiply 15mg with the weight of 18.18 kg.
 $15\text{mg} \times 18.18\text{kg} = 272.7$. **You will administer 272.7 mg.**

Practice Problem: Liquid Dosage Calculation

The acetaminophen (Tylenol) packages come in liquid form 160 mg/5 mL. How many mL will you administer to your 40 pound patient?



(You know you need 272.7 mg from the previous question)

Method #1: Ratio Proportion

$$\frac{160 \text{ mg}}{5 \text{ mL}} = \frac{272.7 \text{ mg}}{x \text{ mL}}$$

Cross-multiply and solve for x.

$$\frac{160 \text{ mg}}{5 \text{ mL}} \times x \text{ mL} = \frac{272.7 \text{ mg}}{1} \times 1$$

$$160x = 1363.5$$

$$x = 8.521875 \text{ mL}$$

Round off. **You will administer 8.5 mL.**

Method #2: Formula Method

$$\frac{272.7 \text{ mg}}{160 \text{ mg}} \times 5 \text{ mL} = x \text{ mL}$$

$$x = 8.521875 \text{ mL}$$

Round this down to 8.5 mL.

You will administer 8.5 mL

You will administer 8.5 mL.

Practice Problem: Units/mL

You have an order for 25000 units of heparin to be placed in a bag of 500 mL of D5W. The vial of heparin contains 20,000 units per mL. How much heparin will you add to the bag of D5W?

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Method#1: Ratio Proportion	Method#2: Formula Proportion
$\frac{25,000 \text{ units}}{20,000 \text{ units}} = \frac{x \text{ mL}}{1 \text{ mL}}$ <p>Cross-multiply to solve for x</p> $\frac{25,000 \text{ units}}{20,000 \text{ units}} \times \frac{x \text{ mL}}{1 \text{ mL}}$ $25,000 = 20,000 x$ $1.25 \text{ mL} = x$	$\frac{25,000 \text{ units}}{20,000 \text{ units}} \times 1 \text{ mL} = x$ $1.25 \text{ mL} = x$

You will add 1.25 mL of heparin to the bag of D5W

Practice Problem: mg/mL

Your patient has an order for terbutaline (Brethine) 0.25 mg sub-q. The pharmacy delivers a syringe with 1mg/mL. How much will you waste in order to give the correct dose?

Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{1 \text{ mL}}{1 \text{ mg}} = \frac{x \text{ mL}}{0.25 \text{ mg}}$ <p>Cross-multiply and solve for x.</p> $\frac{1 \text{ mL}}{1 \text{ mg}} \times \frac{x \text{ mL}}{0.25 \text{ mg}}$ $0.25 x = 1$ $x = 0.25 \text{ mL}$	$\frac{0.25 \text{ mg}}{1 \text{ mg}} \times 1 \text{ mL} = x \text{ mL}$ $x = 0.25 \text{ mL}$

Abbreviation Alert!

SC or SQ are not recommended abbreviations for subcutaneous.
The use of "Q" may be mistaken to represent "every."

In handwriting, a lower case “c” may be mistaken for an “l,” indicating sublingual. The recommendation is to use “sub-q” or write the word subcutaneous (AHRQ, 2013).

Since you are given a syringe with 1 mg/mL and you only need 0.25 mg, then you also just need 0.25 mL. Because the syringe is pre-filled to 1 mL, you need to dispose of (waste) 0.75 mL and then administer the rest of the syringe to the patient. **You will waste 0.75 mL.**

Practice Problem: Tablets

Your hospice patient has an order for 7.5 mg of oxycodone (OxyContin) q 6 hours PRN. The tablets provided are 15 mg tablets. How many tablets will you give for each dose?



Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{15 \text{ mg}}{1 \text{ tablet}} = \frac{7.5 \text{ mg}}{x \text{ tablet}}$	$\frac{7.5 \text{ mg} \times 1 \text{ tablet}}{15 \text{ mg}} = x \text{ tablet}$
Cross-multiply and solve for x.	Solve for x.
$\frac{15 \text{ mg}}{1 \text{ tablet}} = \frac{7.5 \text{ mg}}{x \text{ tablet}}$	$x = 0.5 \text{ tablet}$
$15x = 7.5$	
$x = 0.5 \text{ (or } \frac{1}{2} \text{ tablet)}$	

You will administer one-half a tablet.

Practice Problem: mg/mL

You receive an order for 60 mg of meperidine (Demerol) IM for your post-surgical patient. The injection syringe is pre-packaged with 75 mg/ mL. How much will you administer?



Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{75 \text{ mg}}{1 \text{ mL}} = \frac{60 \text{ mg}}{x \text{ mL}}$ <p>Cross-multiply and solve for x.</p> $\frac{75 \text{ mg}}{1 \text{ mL}} \times x \text{ mL} = \frac{60 \text{ mg}}{1} \times 1$ $75x = 60$ $x = 0.8 \text{ mL}$	$\frac{60 \text{ mg}}{75 \text{ mg}} \times 1 \text{ mL} = x \text{ mL}$ <p>Solve for x.</p> $x = 0.8 \text{ mL}$

You will administer 0.8 mL.

Practice Problem: mcg to mg

Your patient has been receiving digoxin (Lanoxin) 125 mcg po q am. Today his doctor writes a new order: Digoxin 0.25 mg po q am, start now. How many 125 mcg tablets will you administer?

Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{125 \text{ mcg}}{1 \text{ tablet}} = \frac{0.25 \text{ mg}}{x \text{ tablet}}$ <p>Cross multiply, convert to similar units and solve for x.</p> $125 \text{ mcg} \times x = 0.25 \text{ mg}$ $x = \frac{0.25 \text{ mg}}{125 \text{ mcg}}$ <p>Since 1mg = 1,000 mcgs, convert to similar units:</p> $x = \frac{250 \text{ mcgs}}{125 \text{ mcgs}}$ $x = 2 \text{ tablets of 125 mcgs each}$	$\frac{0.25 \text{ mg}}{125 \text{ mcg}} \times 1 = x$ <p>Since 1mg = 1,000 mcgs, convert to similar units:</p> $\frac{250 \text{ mcgs}}{125 \text{ mcgs}} = x$ $2 \text{ tablets} = x$

You will administer 2 tablets.

Practice Problem: Units to mL

Your patient has an order for vasopressin (Pitressin) 5 units sub-q TID. You have on hand a 0.5 mL vial labeled 20 units/mL. How many mL will you administer?

Method #1: Ratio Proportion	Method #2: Formula Method
$\frac{20 \text{ units}}{1 \text{ mL}} = \frac{5 \text{ units}}{x \text{ mL}}$	$\frac{5 \text{ units}}{20 \text{ units}} \times 1 \text{ mL} = x \text{ mL}$
Cross-multiply and solve for x.	Solve for x.
$\frac{20 \text{ units}}{1 \text{ mL}} \times x \text{ mL} = \frac{5 \text{ units}}{x \text{ mL}} \times 1 \text{ mL}$	$x = \frac{5}{20} \times 1 = \frac{1}{4} \times 1 = \frac{0.5}{4}$
$20x = 5$	$x = 0.25 \text{ mL}$
$x = 5/20 \quad x = 0.25 \text{ mL}$	

You will administer 0.25 mL of vasopressin.

Remember, the amount in the vial (in this case 0.5 mL) does not enter into the calculation. The important point is the concentration (the amount of drug per mL).

Abbreviation Alert!

Experts recommend that you write out the word “units” instead of using the abbreviation “U” or “u.” The use of U or u carries risk of confusion with cc and μ . Also U has been misread as a zero, creating a 10-fold overdose (4U, read as 40) and u has been misread as a four (4u, read as 44). IU, intended to mean international units, has been misread as IV (AHRQ, 2013).

Practice Calculations

1. The provider orders morphine 2 mg IV push. The morphine is available in 5 mg/mL. How many mL do you administer? _____
Answer: 0.4 mL
2. Your patient has an order for metoprolol 12.5 mg po bid. The pharmacy stocks metoprolol 25 mg tablets. How many tablets do you administer with each dose?
Answer: $\frac{1}{2}$ tablet
3. Your patient drinks 4 oz. of orange juice. You need to enter her intake in mL. How many mL of orange juice did she consume?
Answer: 120 mL
4. The provider has ordered levofloxacin (Levaquin) 750 mg po daily. You have 500 mg tablets available. How many tablets will you administer?
Answer: 1 and $\frac{1}{2}$ tablets

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5. For your pediatric patient, the provider orders ampicillin 50mg/kg/day po, divided into q 6 hour doses. Your patient's weight is 22 kg.
- What is the daily dose of ampicillin for this patient?
Answer: 1,100 mg
 - How much ampicillin will you administer q 6 hours?
Answer: 275 mg (dose is four times per day)
 - The ampicillin is available in 250 mg/mL. How many mL of ampicillin will you administer per dose?
Answer: 1.1 mL

IV Calculations

There are a few calculations to consider when administering IV fluids. The first is to determine how many mL/h should be administered. And the second is how many drips (gtt) per minute should be infusing via the drip chamber.

Calculating how many mL/hour is straightforward. For example, if the order is to administer 1000 mL over 8 hours, the calculation is:

$$\frac{1000 \text{ mL}}{8 \text{ hours}} = \frac{x \text{ mL}}{1 \text{ hour}}$$

$$1000/8 = x$$

Your rate is 125 mL/hour

In another example, Ancef is ordered, to be administered over 30 min. The medication comes mixed in a 250 mL bag. The calculation is:

$$\frac{250 \text{ mL}}{0.5 \text{ hour}} = \frac{x \text{ mL}}{1 \text{ hour}}$$

$$250/0.5 = x$$

Your rate is 500 mL/hour

IV Calculations

Calculating flow rates can be a bit trickier. First, you need to know what kind of infusion set is being used, and the associated drop rate (gtt/min). For most adult patients, a macrodrip chamber is used, that is either 10 gtt/min or 15 gtt/min. For pediatric patients, a microdrip chamber is more common, which infuses at 60 gtt/min. Second, you need to know your hourly infusion rate in mL/hour.

The calculations of the IV drip rate is as follows:

$$\frac{\text{volume (mL)}}{\text{time (min)}} \times \text{drop rate (gtt/min)} = \text{flow rate (gtt/min)}$$

So, if you need to infuse 150 mL/hour with a macrodrip chamber that provides 10 gtt/min, the calculation is:

$$\frac{150 \text{ mL}}{60 \text{ min}} \times 10 \text{ gtt/min} = x \text{ gtt/min}$$

$$2.5 \times 10 = x \text{ gtt/min}$$

$$25 \text{ gtt/min} = x$$

Your flow rate is 25 gtt/min

Here's another example. You have an order to infuse 500 mL over 4 hours. Your infusion set is a macrodrip chamber that provides 15 gtt/min. This will be a two-step calculation:

First, calculate how many mL/hour you will be infusing:

$$\frac{500 \text{ mL}}{4 \text{ hours}} = \frac{x \text{ mL}}{1 \text{ hour}}$$

$$500/4 = x$$

$$125 \text{ mL} = x$$

Your rate is 125 mL/hour.

Second, calculate your flow rate in gtt/min:

$$\frac{125 \text{ mL}}{60 \text{ min}} \times 10 \text{ gtt/min} = x \text{ gtt/min}$$

$$2.08 \times 10 = x \text{ gtt/min}$$

$$20.8 \text{ or } 21 \text{ gtt/min} = x$$

Your flow rate is 21 gtt/min

Practice Calculations: IV

- The provider has ordered 500 mL of packed red blood cells, to be administered over 2 hours.
 - What is the hourly rate, in mL/hour?
Answer: 250 mL/h
 - What is the flow rate, if it will be infused with a macrodrip chamber that provides 15 gtt/min?
Answer: 62.5 gtt/min
- Your pediatric patient is to receive gentamicin, to be administered over 30 min. The medication comes mixed in a 50 mL bag.
 - What is the hourly rate, in mL/hour?

Answer: 100 mL/h

- b. What is the flow rate, if it will be infused with a microdrip chamber that provides 60 gtt/min?

Answer: 100 gtt/min

3. Your patient has an order for 1 L of normal saline, to be administered over 6 hours.

- a. What is the hourly rate, in mL/hour?

Answer: 166.67 or 167 mL/h

- b. What is the flow rate, if it will be infused with a macrodrip chamber that provides 10 gtt/min?

Answer: 27.7 or 28 gtt/min

Summary

The absolute safest approach to administering medications, IV fluids and performing other interventions requiring calculation is to AVOID CALCULATION UNLESS ABSOLUTELY NECESSARY. This is because there is always potential for human error and there is often the potential for distraction while calculating which can lead to error. Ways to avoid calculation include:

- The use of computer algorithms.
- Completion of most calculations by the pharmacy.
- Posting durable (e.g., laminated) references that give the calculated amounts, rates or other answers for frequently used drugs.

Calculation Tips

When calculation is unavoidable, the following tips can help assure calculation safety:

- Always use the same method to approach the same type of problem.
- Always have your answer verified by an RN colleague. Assure that your colleague actually performs the calculation.
- Assert your need to concentrate by eliminating distractions while performing calculations.
- Before beginning the calculation procedure, identify some of the parameters of a sensible answer – for example: Should the correct answer be more or less than one mL? Then compare the answer you obtain with your common sense parameter.
- Assure that you have taken into account all of the relevant conversion factors – for example: If you have obtained a rate in mL, have you obtained mL per hour or mL per minute?
- Validate your calculated answer with an appropriate up-to-date drug reference. That is, does your calculated answer fall within recommended guidelines?

Conclusion

This course has offered evidence to support the need for nurses to maintain competency in performing selected calculations. The course has presented basic principles of math, algebra and a variety of examples and solutions for calculation problems common in nursing practice. An opportunity for practice with as many as three methods for solving particular problems was also presented.

Resources

For abbreviations toolkit:

<http://www.ismp.org/Tools/abbreviations/default.asp>

For calculation practice:

http://www.manuelsweb.com/nrs_calculators.htm

<http://www.dosagehelp.com/>

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