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Don’t Make Me Think:
Essential Pharmacy Math for Pharmacy Technicians
Made Easy

BY

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Course Cost: $9.00 (to be paid at time of testing)
ACPE Number: 066-999-05-023-H04
Average Time to Complete: Approximately Two (2) hours including testing.
Course Value: Two (2) Contact Hours (0.2 CEU’s)
Preface

This course is written specifically for the pharmacy technician who has trouble with math. Most of the concepts here are written on a level that will allow the pharmacy technician to catch up on any concepts that may need refreshing. The examples used are very simple and allows the reader to focus on the information rather than the fundamental math involved.

Objectives

1. Understand the fundamental concepts of proportions and ratios.
2. Review fractions and their decimal equivalents.
3. Compare and contrast different systems of measurement.
4. Exam a few mathematic concepts used in liquid dosage calculations.
5. Exam a few mathematic concepts used in solid dosage calculations.
Calculations involving proportions and ratios are very important in the dispensing and compounding of medications.

A **ratio** is a comparison of two numbers or like quantities. A colon usually separates the two numbers. For example, a ratio of 4 and 5 is usually written 4:5 or 4/5 or *four to five*. A ratio can therefore be defined as a relation in number between two like things.

A **quotient** is the number obtained by dividing one quantity by another. For example, \(45 \div 15 = 3\). In this example the quotient is 3.

A **fraction** indicates a portion of a whole number. Fractions contain two numbers: the bottom number referred to as the *denominator* and the top number is referred to as the *numerator*. The denominator is the total number of parts into which the whole is divided. The numerator indicates how many of these parts are considered.

A **decimal** is another way of expressing a fractional amount. The difference with decimals is that they always have a denominator of 10 or a multiple of 10.

\[
\begin{align*}
\text{Example:} & \quad 0.5 = \frac{5}{10} \\
& \quad 0.07 = \frac{7}{100} \\
& \quad 0.003 = \frac{3}{1000}
\end{align*}
\]

Each position to the left of the decimal is ten times the previous place, and each position to the right is one-tenth the previous place. The position to the left or right of the decimal point is referred to as place value.

Two equal fractions can be written as a proportion. A proportion is an expression with a ratio on each side. It is a statement that two ratios are equal. An example of a proportion is \(2/10 = 4/20\).

Proportions are routinely used in dosage calculations. For example, how many milligrams of the drug ibuprofen are present in 10 milliliters (10 mL) when there are 20mg of ibuprofen in each mL. A proportion can be set as:

\[
\frac{1 (\text{mL})}{10 (\text{mL})} = \frac{20 (\text{mg})}{x (\text{mg})}
\]

\[
x = \frac{10 \times 20}{1} = 200 \text{mg}
\]
Use of proportions is very common in dosage calculations, especially in finding out the drug concentration per teaspoonful or in the preparation of bulk or stock solutions of certain medications. In a given proportion, when any three terms are known, the missing term can be determined. For example, if \( \frac{a}{b} = \frac{c}{d} \), then \( a = \frac{bc}{d} \), or any other term can be calculated from the other three known terms.

For example, to find out how many milligrams of a drug is present in 5 mL when there are 20 mg of that drug in 1 mL, a proportion can be set as:

\[
\text{Drug: volume} = \text{drug: volume}
\]

\[
20\text{mg}:1\text{mL} = X\text{mg}:5\text{mL}
\]

\[
X = 20 \times 5 = 100\text{mg}
\]

**Percentage**

The word percent mean “hundredths of a whole” and is express with a % symbol. Consequently 1% is the same as the fraction 1/100 or the decimal 0.01.

To convert a fraction to a percent, divide the numerator of the fraction by the denominator, multiply by 100 (move the decimal point two places to the right), round the answer to the desired precision if necessary, and place the % symbol next to the numeric value.

Example:

\[
\text{Convert } \frac{3}{5} \text{ to a percent}
\]

\[
3 \div 5 = 0.60
\]

\[
0.60 \times 100 = 60\%
\]

To convert a percent to a fraction, remove the percent symbol, make a fraction with the percent as the numerator and 100 as the denominator, and reduce the fraction to its lowest possible terms.

Example:

\[
\text{Convert 60% to a fraction}
\]

\[
\frac{60}{100} = \frac{3}{5}
\]
To convert a decimal to a percent, multiply the decimal by 100 and add a percent symbol to the number.

Example:

Convert 0.75 to a percent

0.75 * 100 = 75%

To convert a percent to a decimal, drop the percent symbol and then divide the numerator by 100.

Example:

45% = 45/100 = 0.45

Another useful tool is being able to determine percentage. How much is X as a percent of Y? The formula is as follows:

(X ÷ Y) * 100 = Z%

Example:

How much is 56 of 82?

56 ÷ 82 = 0.6829

0.6829 * 100 = 68.29% (rounded)
Fractions and Decimal Equivalents

As a technician, you work in a very fast paced environment. It would be very helpful to have certain fraction and decimal equivalents memorized so that you can quickly make these conversions when necessary. Some common equivalent decimals and fractions are listed below:

- 0.1 and 1/10
- 0.2 and 1/5
- 0.25 and ¼
- 0.50 and ½
- 0.75 and ¾
- 1.0 and 1/1 or 2.2 or 1

To convert a fraction to a decimal, divide the numerator by the denominator, and round the answer to the desired precision if necessary.

Example:

Convert 3/9 to a decimal

\[ 3 \div 9 = 0.3333 \]
Section II
Applying Systems of Measurements

Many calculations have been simplified by the shift from apothecary to metric system of measurements. Unfortunately, there are still a significant amount of calculation errors. Most of these errors occur because of simple mistakes in arithmetic.

Metric System

The metric system appears in the official listing of drugs in the United States Pharmacopoeia (USP). The metric system of measurement was first developed by the French and is the most commonly used system for prescribing and administering medications. The basic units, multiplied or divided by 10, make up the metric system (the units are based on multiples of 10). The knowledge of decimals, reviewed in Section 1 will be useful in this section.

In the metric system, the three fundamental units are the meter for length, the liter for volume, and the gram for weight. In addition to these basic units, the metric system includes multiples of basic units with a prefix to indicate their relationship to the basic unit. The following tables are very important for the pharmacy technician to be familiar with:

Metric Weights

<table>
<thead>
<tr>
<th>One gram (g) is equal to</th>
<th>Unit Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001 kilogram</td>
<td>Kg</td>
</tr>
<tr>
<td>0.01 hectogram</td>
<td>Hg</td>
</tr>
<tr>
<td>0.1 dekagram</td>
<td>Dkg</td>
</tr>
<tr>
<td>10 decigrams</td>
<td>Dg</td>
</tr>
<tr>
<td>100 centigrams</td>
<td>Cg</td>
</tr>
<tr>
<td>1000 milligrams</td>
<td>Mg</td>
</tr>
<tr>
<td>1,000,000 micrograms</td>
<td>Mcg</td>
</tr>
<tr>
<td>1,000,000,000 nanograms</td>
<td>Ng</td>
</tr>
</tbody>
</table>

Metric Volume

<table>
<thead>
<tr>
<th>One liter (L) is equal to</th>
<th>Unit Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001 kiloliter</td>
<td>kL</td>
</tr>
<tr>
<td>0.01 hectoliter</td>
<td>hL</td>
</tr>
<tr>
<td>0.1 dekaliter</td>
<td>dkL</td>
</tr>
<tr>
<td>10 deciliters</td>
<td>dL</td>
</tr>
<tr>
<td>100 centiliters</td>
<td>cL</td>
</tr>
<tr>
<td>1000 milliliters</td>
<td>mL</td>
</tr>
<tr>
<td>1,000,000 microliters</td>
<td>µL</td>
</tr>
<tr>
<td>1,000,000,000 nanoliters</td>
<td>nL</td>
</tr>
</tbody>
</table>
Metric Length

<table>
<thead>
<tr>
<th>Unit</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>One meter (m) is equal to</td>
<td></td>
</tr>
<tr>
<td>0.001 kilometer</td>
<td>Km</td>
</tr>
<tr>
<td>0.01 hectometer</td>
<td>Hm</td>
</tr>
<tr>
<td>0.1 dekameter</td>
<td>Dkm</td>
</tr>
<tr>
<td>10 decimeters</td>
<td>Dm</td>
</tr>
<tr>
<td>100 centimeters</td>
<td>Cm</td>
</tr>
<tr>
<td>1000 millimeters</td>
<td>Mm</td>
</tr>
<tr>
<td>1,000,000 micrometers</td>
<td>μm</td>
</tr>
<tr>
<td>1,000,000,000 nanometers</td>
<td>Nm</td>
</tr>
</tbody>
</table>

Avoiding Errors in the Metric System

To prevent the problem of overlooking a decimal point, precede the decimal point with a zero if the value is less than one. If a prescription is written for an oral solution .5mg/.5mL, one possible mistake could be dispensing 0.5mg/5.0 mL solution. This under medication could be avoided by using preceding zeros.

To convert a larger unit to a smaller unit, multiply by 1,000 or move the decimal point 3 places to the right.

To convert a smaller unit to a larger unit, divide by 10,000 or simply move the decimal point 4 places to the left.

To add, subtract, multiply, or divide different metric units, first convert all the units to the same denomination. For example, to subtract 45 mg from 0.15 g, solve as 150 mg – 45 mg = 65 mg.

Milliliters are sometimes represented by cc, which is a cubic centimeter. This is very useful when converting from a volume unit to a unit of length.

Do not use unnecessary decimal points when taking prescriptions by phone. 25.0 mg could easily be interpreted as 250 mg.

Apothecaries’ System

Unlike the metric system, which has units for weight, volume, and the length, the apothecaries’ system has units for weight and volume only. This is an old system, and its use is rapidly declining. Some physicians still write prescriptions using this system, so the technician should at least be able to identify it when it appears.

The basic unit for weight is grain (gr), and the volume is minim. Be careful not to confuse grain (gr) with gram (g or G).
Apothecaries’ Liquid Measures

<table>
<thead>
<tr>
<th>60 minims</th>
<th>1 fluid dram</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 fluid drams</td>
<td>1 fluid ounce</td>
</tr>
<tr>
<td>16 fluid ounces</td>
<td>1 pint (pt or O)</td>
</tr>
<tr>
<td>2 pints (O)</td>
<td>1 quart (qt)</td>
</tr>
<tr>
<td>4 quarts (qt)</td>
<td>1 gallon (gal or C)</td>
</tr>
</tbody>
</table>

Apothecaries’ Weight Measures

| 20 grains (gr) | 1 scruple |
| 3 scruples | 1 dram |
| 8 drams | 1 ounce |
| 12 ounces | 1 pound (lb) |
| 1 pound (lb) | 5760 grains (gr) |

Household System of Measurement

This system has been on the rise due to the increase home health delivery. This system is inaccurate and should be discouraged. Even so, the technician should be familiar with some of the conversions in case it rears its ugly head. In this system, patients use household measuring devices such as the teaspoon, dessertspoon, tablespoon, wineglass, and coffee cup

One of the main reasons that this system is so inaccurate is that it relies heavily on the medicine dropper. This can be inaccurate because so many factors can affect the drop size, including: density of the medication, temperature, surface tension, diameter and opening of the dropper. The official medicinal dropper delivers 20 drops per mL of water at 25 degrees Celsius.¹ Some manufacturers provide specially calibrated droppers with their products. Several ear, nose, and eye medications are now available in calibrated containers, which provide drops by gently pressing the containers.

Keep in mind that the household system of measurement should not be used for calculations in compounding or conversions from one system to the other. The household system of measurement is designed for the convenience to the patient. It can be used for directions on the prescription labels.

¹ United States Pharmacopoeia-National Formulary (USP-NF)
**Common Household Measures**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Abbreviation</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 teaspoonful</td>
<td>Tsp, t</td>
<td>5 mL</td>
</tr>
<tr>
<td>1 dessertspoonful</td>
<td>Dssp</td>
<td>8 mL</td>
</tr>
<tr>
<td>1 tablespoonful</td>
<td>Tsp, T</td>
<td>15 mL</td>
</tr>
<tr>
<td>1 ounce</td>
<td>Oz</td>
<td>2 tbsp, 30 mL</td>
</tr>
<tr>
<td>1 wine-glass</td>
<td>---</td>
<td>30 mL</td>
</tr>
<tr>
<td>1 coffee cup</td>
<td>---</td>
<td>6 fluid ounces; 180 mL</td>
</tr>
<tr>
<td>1 glass</td>
<td>---</td>
<td>8 fluid ounces; 240 mL</td>
</tr>
<tr>
<td>1 quart</td>
<td>Qt</td>
<td>1000 mL</td>
</tr>
<tr>
<td>1 gallon</td>
<td>Gal, C</td>
<td>4000 mL</td>
</tr>
</tbody>
</table>
SECTION III
Liquid Dosage Forms

In section I we discussed proportions. We will now use the proportion method with liquid dosage calculations. The proportion method can be used to prepare a bulk formula when we know the strength per unit dose. These types of calculations are referred to as “enlargement” calculations. Conversely, we can perform a “reduction” calculation when the bulk preparation is given and the strength per unit dose (e.g., per teaspoon) is calculated. Here is an example of each.

**Enlargement Example**

An elixir of acetaminophen contains 160mg per 5 mL. How many mg would be used in preparing 1 ounce (30 mL) of the elixir?

\[
\frac{160 \text{ mg}}{5 \text{ mL}} = \frac{X \text{ mg}}{30 \text{ mL}}
\]

\[X = 960 \text{ mg}\]

**Reduction Example**

Phenobarbital elixir contains 2 g per liter (1000 mL). How many milligrams of Phenobarbital are contained in 1 teaspoonful (5 mL) dose of the elixir?

\[2 \text{ g} = 2000 \text{ mg}\]

\[
\frac{2000 \text{ mg}}{1000 \text{ mL}} = \frac{X \text{ mg}}{5 \text{ mL}}
\]

\[X = 10 \text{ mg}\]

**Dilutions and Concentrations**

As a pharmacy technician, you will occasionally encounter a situation when you need to calculated strength of a given solution. When a solvent from a liquid medication is evaporated, its concentration is increased. Also, when a liquid medication of a given strength is diluted, its strength will be reduced. For example, 10 mL of a solution containing 1 g of a substance has strength of 1:10 or 10% w/v. If this solution is diluted to 20 mL, i.e., the volume of the solution is doubled by adding 10 mL of solvent, the original strength will be reduced by one half to 1:20 or 5% w/v.
To calculate the strength of a solution prepared by diluting a solution of known quantity and strength, an equation may be set up as follows:

\[ C_1 \times V_1 = C_2 \times V_2 \]

Where,

\[ C_1 = \text{Initial concentration} \]
\[ V_1 = \text{Initial volume} \]
\[ C_2 = \text{Final concentration after dilution} \]
\[ V_2 = \text{Final volume after dilution} \]

From this expression, strength (or final concentration of the solution can be determined. To calculate the volume of solution of desired strength that can be made by diluting a known quantity of a solution.

Dilution Example

If 5 mL of a 10% w/v aqueous solution of genistein is diluted to 10 mL, what will be the final strength of genistein?

\[
10(\%) (C1) \times 5(\text{mL}) (V1) = X(\%) (C2) \times 10(\text{mL}) (V2)
\]

\[ X = 5 \times 10/10 \]

\[ X = 5\% \text{ w/v, answer} \]

Evaporation Example

If a solution (Tylenol) containing 1.6% w/v APAP is evaporated to 90% of its volume, what is the strength of APAP in the remaining solution?

\[
1.6(\%) (C1) \times 100(\text{mL}) (V1) = X(\%) (C2) \times 90(\text{mL}) (V2)
\]

\[ X = 160/90 = 1.78\% \text{ w/v, answer} \]

Alligation Medial

Alligation medial is a technique to determine what the concentration of a solution is when two or more liquids of known concentration are mixed. For example, when 5 mL of 2% alcohol is mixed with 10 mL of 4% alcohol, we will know by the alligation medial method that we will obtain 15 mL of 3.33% alcohol. The resulting strength can be considered a “weighted average” of the percentage strengths of all the individual components used. Thus, the alligation medial is a method where the percentage strength
of the mixture may be calculated by dividing the sum of the products of percentage strength of each constituent of the mixture multiplied by its corresponding quantity by the sum of the quantities mixed. This sounds complicated but is actually simple when broken down into steps.

What is the percentage of alcohol in the following mixture?

| Alcohol 2% | 5 mL |
| Alcohol 4% | 10 mL |

Step 1: Add the quantity of each components

\[
5 + 10 = 15 \text{ mL}
\]

Step 2: Multiply the quantity of each component used in the mixture by its corresponding percentage strength, and add up the products.

\[
\begin{align*}
5 \times 2\% &= 10 \\
10 \times 4\% &= 40 \\
\text{Total} &= 50
\end{align*}
\]

Step 3: Divide the value obtained in Step 2 by the value obtained in Step 1.

\[
\frac{50}{15} = 3.33\%, \text{ answer}
\]
Because capsules and tablets make up a large portion of the technicians duties, we will briefly highlight some techniques used in working with them. These dosage forms are usually available in several strengths. If a capsule of higher strength is prescribed but unavailable, two capsules of one-half the strength may be dispensed. Thus a pharmacy technician may need to administer one-half or some other portion of the tablet. In such a case, twice the total number of capsules required should be dispensed with the clear instructions to take two capsules to the patient.

Conversely, if a lower strength is prescribed and higher strength is available, the higher strength tablet may be split to provide the desired amount of the drug. It is important to remember that substitution of strengths should only be done with scored tablets. Another precaution to remember is when enteric-coated dosage forms are prescribed. Enteric-coated tablets are designed to resist the acidic environment in the stomach and release the medication in the small intestine. If such tablets are broken, they may lose their enteric properties. As a general rule, sustained release/controlled release medications should not be broken as they may lose their controlled release properties. There are exceptions to this rule, but unless it is specifically recommended by the manufacture, do not break or crush these medications.

Example 1

If a prescription is received with the instructions of providing 650 mg of acetaminophen to a patient, and the pharmacy technician has 325 mg tablets, how many tablets should the patient be instructed to take?

\[ 325 \text{ mg} \times X = 650 \text{ mg} \]

\[ X = 2 \]

The patient should take two tablets.

Example 2

You receive a prescription for Zantac 150mg b.i.d. (twice daily). If you only have 300 mg strength available, how many tablets should be dispensed?

One 300 mg tablet should be given for 1 day. For 21 days, 21 300 mg tablets should be dispensed.
1. Calculations involving proportions and ratios are rarely used in dispensing and compounding medications.
   a. True
   b. False

2. A ________ is a comparison of two numbers or like quantities.
   a. ratio
   b. quotient
   c. fraction
   d. decimal

3. A __________ is another way of expressing a fractional amount that is always a multiple of 10.
   a. ratio
   b. quotient
   c. fraction
   d. decimal

4. A _____________ indicates a portion of a whole number.
   a. ratio
   b. quotient
   c. fraction
   d. decimal

5. A __________ is the number obtained by dividing one quantity by another.
   a. ratio
   b. quotient
   c. fraction
   d. decimal

6. How many milligrams of a drug is present in 5 mL when there are 30 mg of that drug in 1 mL? (Hint: set as a proportion)
   a. 100 mg
   b. 125 mg
   c. 130 mg
   d. 150 mg
Final Exam

7. Convert 3/8 to a percent
   a. 37.5%
   b. 33.33%
   c. 40%
   d. 22.6%

8. Convert 80% to a fraction.
   a. 3/8
   b. 1/5
   c. 4/5
   d. 7/10

9. How much is 49 of 84? Express in a percentage, rounded.
   a. 50%
   b. 58.33%
   c. 42.66%
   d. 63.32%

10. What is the fractional equivalent of 0.2?
    a. 1/5
    b. ¼
    c. ¾
    d. 1/10

11. Which is not a fundamental unit of the metric system?
    a. gram
    b. liter
    c. grain
    d. meter

12. In the Apothecaries System of measurement, 8 drams = _________.
    a. 1 scruple
    b. 1 ounce
    c. 1 pound
    d. 1 gallon
Final Exam

13. When performing calculations in compounding, the household system is acceptable because of its accuracy.
   a. True
   b. False

14. One dessertspoonful is the approximate equivalent of:
   a. 5 mL
   b. 30 mL
   c. 180 mL
   d. 8 mL

15. A solution contains 250 mg per 5 mL. How many mg would be used in preparing 1 ounce (30 mL) of the solutions? (Hint: enlargement example)
   a. 1500 mg
   b. 125 mg
   c. 25 mg
   d. 100 mg

16. An elixir contains 4 g of a drug per liter (1000 mL). How many milligrams of the drug are contained in 1 teaspoonful (5 mL) dose of the elixir?
   a. 10 mg
   b. 20 mg
   c. 30 mg
   d. 40 mg

17. 10 mL of a solution containing 2 g of a substance has strength of:
   a. 1:10
   b. 1:5
   c. 5:10
   d. 5:20
18. What is the percentage of alcohol in the following mixture?

<table>
<thead>
<tr>
<th>Alcohol 4%</th>
<th>5 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol 2%</td>
<td>10 mL</td>
</tr>
</tbody>
</table>

a. 3.33%
b. 6.77%
c. 4.33%
d. 2.66%

19. If a capsule of higher strength is prescribed but unavailable, two capsules of one-half strength may be dispensed.

a. True
b. False

20. As a general rule, it is acceptable to split enteric coated tablets.

a. True
b. False