CHAPTER 4  CONVERSIONS AND CALCULATIONS USED BY PHARMACY TECHNICIANS

The foundational knowledge required for pharmacy technicians to assist the pharmacist in filling prescriptions and compounding medications lies in competency of measuring pharmaceutical ingredients, and the ability to manipulate pharmacy calculations with 100% accuracy. The best way to become familiar with common pharmacy measurements and pharmacy calculations is to begin with what you know and then slowly build upon your knowledge base.

In the U.S., the most common system of measurement is the household system. The U.S. Customary System is the official name for the system of household measurements; it is also a subset of the English/Imperial system. Household units such as teaspoons, cups, and gallons as well as length measures such as inches, feet, and miles are used most often in our daily activities. The main advantage of the household system is its familiarity, which is why patient instructions are prepared using them.

The metric system is preferred in pharmacy and other scientific fields because it is precise, accurate, and easy to use. The formal name for the metric system is SI, the abbreviation for “Le Système international d’Unités”. Federal agencies in the U.S. are now required to use the metric system. Private industries are now voluntarily converting to be more competitive internationally. The metric system is also the standard for use in laboratories and in scientific publications.

The metric system is now being used exclusively in the United States Pharmacopeia. Metric units include:

- Milliliters, cubic centimeters, and liters for volume
- Kilograms, grams, milligrams, and micrograms for weight
- Millimeters and meters for distance

In the metric system, the measurements for length, volume, and mass are tied together through a common reference point (1 cc water = 1 mL water = 1 g water). In addition, the metric system is based on multiples of 10, making conversions between larger and smaller units convenient. The main type of error associated with the metric system is the flip side of this convenience—errors involving multiples of 10 are the most common. These can be due to calculation errors as well as misreading where a decimal point has been placed.

The apothecary system of measurement originated in Europe, and is one of the oldest systems of measurement used when calculating medication dosages, though it has been replaced with the metric system. Many medical providers still use the Roman numeral symbols commonly used in the apothecary system. Using Roman numerals precludes medical providers and those reading the prescriptions from making mistakes in medication dosages. Therefore, in order to correctly read and fill prescriptions, and without error, pharmacy technicians must understand how to read and write Roman numerals. The most common letters used in medicine are between ¼ (⅛) and 10 (X). Roman numerals are formed by adding and subtracting numerals. When adding Roman numerals, remember to always use the largest numeral from the left to the right. For example, 15 = XV (X = 10 + V = 5 = 15). 10 (X) would proceed 5 (V) when adding Roman numerals. When determining smaller numbers in Roman numerals, always subtract. For example, 4 is written as IV in Roman numerals (I = 1 and V = 5; therefore, subtract 5 - 1 = 4 or IV in Roman numerals).

Click here for more information regarding Roman Numerals. This website also includes a Roman numeral converter.

The Avoirdupois system originated in England and is actually the name of one type of weights in the English (or British Imperial) system of weights and measures. The avoirdupois system is a system of weight measurement only. The basic unit of the avoirdupois system, the grain, is the same as in the apothecary system. The avoirdupois ounce and pound differ in weight and symbols from those in the apothecary system. The avoirdupois pound is the household pound to which we are all accustomed in our daily lives. It is also the weight measure in which bulk chemicals and over-the-counter pharmaceuticals are bought and sold. It is important to make this distinction from weights in the
Apothecary system, which is used only in the prescription or medication order. Although the avoirdupois, apothecary systems, and metric pharmacy measurements can sometimes seem like a foreign language, you will soon become comfortable with them, and thinking in these units will become second nature.

A pharmacy technician must learn the major conversions, as well as be able to identify a reliable source of the information for the less common conversions. You should also practice using conversions in dosage equations so that the procedures become familiar to you. In some cases, more than one method exists to perform a given calculation or conversion. You should practice with both methods to decide which method you are more comfortable with.

There are two main temperature scales—the Fahrenheit (°F) scale used in the U.S., and the Celsius (°C) Scale, part of the Metric System and used in most other countries. The Fahrenheit scale has 180 degrees between freezing and boiling while the Celsius scale has just 100 degrees. There are various methods for converting Celsius (Centigrade) to Fahrenheit and Fahrenheit to Celsius (Centigrade):

- Fahrenheit to Celsius Conversion (Method A)
  \[ C° = \frac{F° - 32}{1.8} \]
  Convert 96.5°F to C°
  \[ C° = \frac{96.5 - 32}{1.8} = 35.8° \]

- Fahrenheit to Celsius Conversion (Method B)
  \[ C° = \frac{5}{9} \times (F° - 32) \]
  Convert 96.5°F to C°
  \[ C° = \frac{5}{9} \times (96.5 - 32) = 35.8° \]

Celsius to Fahrenheit Conversion (Method A)
\[ F° = \frac{9}{5} \times C° + 32 \]
Convert 65°C to F°:
\[ F° = \frac{9}{5} \times 65 + 32 = 149° \]

Celsius to Fahrenheit Conversion (Method B)
\[ F° = \frac{9}{5} \times C° + 32 \]
Convert 65°C to F°:
\[ F° = \frac{9}{5} \times 65 + 32 = 149° \]
Click [here](http://www.pharmacytimes.com/publications/issue/2004/2004-12/2004-12-4830) to view videos explaining how to convert between Fahrenheit to Celsius.

**NOTE**: You will learn more specifics about converting between the temperature scales in the Pharmacy Calculations course.

A fraction indicates division and expresses the number of equal parts into which a whole is divided. If a whole is divided into equal parts, then one or more of this number of equal parts is called a fraction. The fraction $\frac{3}{8}$ means 3 of 8 equal parts. This could also be written as $3 \div 8$ because it indicates division into 8 equal parts. The numbers 3 and 8 are called the “terms of the fraction.” The lower number of the fraction is called the denominator or the divisor and indicates how many parts the unit is divided into. The upper number is called the numerator or the dividend and tells how many parts of the unit are taken.

Click [here](http://www.pharmacytimes.com/publications/issue/2004/2004-12/2004-12-4830) to view a brief video explaining the process of solving fractions, including equivalent fractions, adding and subtracting fractions, multiplying and dividing fractions, and improper fractions.

A decimal number is used in pharmacy math by using a numerical system which uses a base of 10. Medications are often prescribed using the decimal system, and many times dosage calculations are determined by using decimals. A decimal is a fraction whose denominator is 10 or any multiple of 10. However, it differs from a common fraction in that the denominator is not written, but instead is expressed by the proper placement of the decimal point. Usually decimal fractions and mixed decimals are called “decimals.” In prescription writing and when reading prescriptions, the decimal point can often be missed. Therefore, numbers containing decimal points are almost always a source of error; for example, the decimal point may be misplaced, or overlooked. As an example, without a leading zero, a prescription for “Haldol .5 mg” may be misinterpreted as “Haldol 5 mg”, the patient taking this misinterpreted prescription is likely to overdose. Therefore, a decimal point should always be preceded by a zero if there is no other true whole number appropriate. For example, the prescription for “Haldol .5 mg.” should be correctly written as “Haldol 0.5 mg.” In order to avoid misinterpretations due to decimal point placement, the Institute for Safe Medication Practices (ISMP) recommends the following:

- Always include a leading zero for dosage strengths or concentrations less than 1
- Never follow a whole number with a decimal point and a zero (trailing zero)
- Educate the staff about the dangers involved with expressing doses using naked decimal points and trailing zeros
- Eliminate dangerous decimal dose expressions from pharmacy and prescriber electronic order-entry screens, computer-generated labels, preprinted prescriptions, and the like
- Avoid using decimals whenever a satisfactory alternative exists (e.g., use 500 mg in place of 0.5 gram, 125 mcg instead of 0.125 mg, or 2 ½ mg instead of 2.5 mg)
- Identify drugs with known 10-fold differences in dosage strength (e.g., Cytomel 5 mcg and 50 mcg, Coumadin 1 mg and 10 mg, levothyroxine 25 mcg and 250 mcg), and place reminders in electronic order-entry systems and on pharmacy shelves to alert practitioners to double check the dosage strength
- When sending and receiving prescriptions via fax, keep in mind that the decimal point can be easily missed due to “fax noise;” whenever possible, prescribers should give the original prescription to the patient to take to the pharmacy for verification, and pharmacists should carefully review faxed prescriptions and clarify prescriptions that contain fax noise
- Eliminate the lines on the back copy of NCR forms so that a person can clearly see decimal points or other marks that were made on the top copy

**Source**

**NOTE**: There are also specific rules for “rounding” up or down in medical math, especially when calculating medication dosages. As a general rule, carry mg. to hundredths and round to tenths; drop
unnecessary zeros. In certain populations (pediatrics) and certain medications, there are a few exceptions.

Click here to view videos explaining the procedure for reading and writing decimals.

The term percentage and its symbol “%” mean hundredths. A percentage is a fraction whose numerator is expressed and whose denominator is understood to be 100. It can be changed to a decimal by moving the decimal point two places to the left to signify hundredths, or to a fraction by expressing the denominator.

Ratios and proportions are used every day in the pharmacy to calculate medication dosages. A proportion is a way of expressing one group’s ratio over the sum of all groups, and a ratio is how the sum of the groups is proportioned into individual groups. To learn how to solve any problem, you must first understand all of the details within the problem. A ratio is a comparison of two similar quantities obtained by dividing one quantity by the other. A ratio compares similar quantities (ratios are related or compared to another thing). Ratios can also be written as fractions and are written with the : symbol. A proportion is a comparison between the two ratios. In any ratio and proportion problem, you must always be given two ratios; you will also have one object in the equation which is unknown (x = unknown).

Click here to view videos explaining ratios, proportions, units and rates.

Dosage errors can be harmful or even fatal, yet they occur despite the presence of trained personnel at each point in the chain. From the perspective of the pharmacy technician, there are at least three potential sources of error—those present in the prescription as written, those introduced by the pharmacy technician, and those introduced by the patient or other person administering the dose. The pharmacy technician has the most control over any errors he or she introduces by making an incorrect calculation or choosing the wrong drug to dispense. These errors can be detected by appropriate cross checking and asking for help in any instance where a prescription is illegible or unclear. A technician also might notice an error in the prescription itself, picking up on something that does not seem right. The third source of error (on the part of the patient) is not under direct control of the pharmacy technician, but he or she can minimize such errors by ensuring that the patient instructions are written as clearly as possible. A key point is that the pharmacy technician should never assume the pharmacist will catch every error. If the pharmacy technician has rechecked his or her own calculations and something about the prescription still does not make sense (whether the dosage or the medication itself), the pharmacy technician should flag that concern for the pharmacist to review.

It is critical for the pharmacy technician to double-check mathematical calculations and formulas, but it is equally important to give the results a “gut check.” The pharmacy technician should picture themselves taking the medicine or giving it to a child. If the label instructions do not seem to make sense, the information should always be rechecked by the pharmacist. The pharmacist (not the pharmacy technician) should always instruct the parent how to measure the correct medication dosage for the child.

In most medical guidelines, the dose of a particular drug is given in terms of “milligram (mg) of drug per kilogram (kg) of body weight.” This allows for flexibility of individual dose calculation based on the patient’s weight. All official compendia, drug references, and drug manufacturers provide dosing regimens based on kilograms (kg). Therefore, prior to calculating a pediatric medication dosage, the pharmacy technician must convert the patient’s weight from pounds (lb) to kilograms (kg).

NOTE: 2.2 lb = 1 kg

There are several formulas that can be used to determine the drug dosage for a child.

Clark’s Rule specifies the following: \[ \text{Weight of child (lbs)} \times \text{Adult dose} = \text{Child’s dose} \]

Clark’s Rule does not take into account other factors such as height, age, etc. Young’s Rule uses the patient’s weight as the basis for calculating the child’s dose.

Young’s Rule: \[ \frac{\text{Child’s age in years} \times \text{Adult dose}}{\text{Child’s age} + 12} = \text{Child’s dose} \]

The most accurate equation for determining a child’s dosage is the Body Surface Area (BSA) formula.
BSA: \( \text{Child's BSA} \times \text{adult dose} = \text{Child's dose} \)

1.73

International/military time is used exclusively in hospital settings. International time is a 24-hour method of keeping time in which hours are not distinguished between AM and PM, but are counted continuously throughout the day. Medication orders arrive in the hospital pharmacy 24-hours a day, 365 days per year, so using international time prevents confusion and time misinterpretation. For example, 8:00 could be confused as 8:00 AM or 8:00 PM. However, when using the 24-hour clock, military time begins at 12:00 AM or 2400-hours and continues until 1:00 AM or 0100-hours. Therefore 8:00 AM would be 0800-hours, and 8:00 PM would be 2000-hours international time.

Military/International Clock

It might seem redundant and confusing, but a slight distinction can be made between 2400 and 0000. The end of a day is 2400, and the beginning of the next day is considered 0000. By using this system, the pharmacy technician will never question when an order was written or which order supersedes another.