Drug Calculations

Unit: Basic Skills

Problem Area: Basic Mathematics Skills

Lesson: Drug Calculations

Student Learning Objectives.

Instruction in this lesson should result in students achieving the following objectives:

1. **Practice basic math skills, including the use of Roman numerals, decimals, fractions, addition, subtraction, multiplication, and division.**
2. **Demonstrate proficiency in the order of operations.**
3. **Solve ratio, proportion, concentration, and drip-rate problems.**

Resources.

The following resources may be useful in teaching this lesson:

Ansel, Howard C. *Pharmaceutical Calculations*, 13th ed. Lippincott Williams & Wilkins, 2009.

"Decimals, Fractions and Percentages," *MathIsFun.com*. Accessed March 25, 2010. <http://www.mathsisfun.com/decimal-fraction-percentage.html>.

Fred, Linda Y., ed. *Manual for Pharmacy Technicians*, 3rd ed. American Society of Health-System Pharmacists, 2004.

The Joint Commission. "Medication Errors Related to Potentially Dangerous Abbreviations," *Sentinel Event Alert*, Issue 23, September 1, 2001. Accessed March 25, 2010. <http://www.jointcommission.org/sentinelevents/sentineleventalert/sea_23.html>.



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Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

Key Terms.

The following terms are presented in this lesson (shown in bold italics):

- Arabic numerals
- concentration
- decimal
- drip rate
- fraction
- order of operations
- percent
- proportion
- ratio
- Roman numerals

Interest Approach.

Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

> *Many students feel that math learned in school is a waste of time and will never be used again. Ask students to think of the many ways we use math in everyday life: at Best Buy to figure out what is a better deal (the boxed Star Wars Trilogy for $42.99 or each movie separately for $14.99), in estimating and adding costs to see whether we have enough money to buy what we want ($15.00 for a movie ticket, popcorn, pop, and candy), or in figuring out how much tax will be on a purchase. Ask what kind of math might be used in a pharmacy and how it might be used.*

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CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Practice basic math skills, including the use of Roman numerals, decimals, fractions, addition, subtraction, multiplication, and division.

Anticipated Problem: What basic math skills may be required of a pharmacy technician?

I. A pharmacy technician is expected to perform various calculations using basic math skills that involve Roman numerals, decimals, fractions, addition, subtraction, multiplication, and division.

A. A numeral is an expression of a number and can take many forms: word, letter, symbol, figure, etc. The two main types of numerals used in pharmacy are Arabic and Roman.

1. ***Arabic numerals*** are the 10 digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.
2. ***Roman numerals*** are the letters (I, V, X, L, C, D, M) used to represent numbers in a system originating in ancient Rome. In pharmacy, Roman numerals are often used to show quantity on prescriptions.
3. Pharmacists regularly convert Arabic and Roman numerals. Therefore, knowledge of both systems is essential.

   Examples:

Roman	Arabic
ss	$^1/_2$
I or i	1
X or x	10
L or l	50
C or c	100
D or d	500
M or m	1000

a. When reading Roman numerals, several rules apply.

(1) A smaller numeral before a larger numeral means the smaller numeral should be subtracted from the larger numeral. The most frequent use of this is for the numbers 4 (IV) and 9 (IX).

(2) A smaller numeral after a larger numeral means the smaller numeral should be added to the larger numeral. Examples: XXII = 22; XVI = 16; DCL = 650.

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(3) Examples of quantities expressed on prescriptions:

iii drops
i tsp
IV oz
XX tabs
LX lozenges
XIV patches

B. Numbers are most often expressed as whole numbers, fractions, or mixed numbers.

1. A whole number is a counting number (0, 1, 2, 3, 4).
2. A ***fraction*** is a part of a whole number ($^1/_2$, $^3/_4$, $^2/_3$).
3. A mixed number is a combination of a whole number and a fraction ($2^1/_4$, $3^3/_4$, $5^1/_2$, $1^1/_2$).
4. A ***decimal*** is a fraction written a linear way ($^1/_4 = 0.25$; $1^3/_4 = 1.75$) and based on the power of 10 ($^1/_{10} = 0.1$).
   a. A decimal is distinct because of the decimal point.
   b. There are important safety points regarding decimals.
      (1) The Joint Commission (the main accrediting agency for hospitals and other institutions) has incorporated how to write using decimals into a safety goal. When writing decimals, there should be **no trailing zeros**. For example, one should never write 5.0. However, one should always include a zero before the decimal point for a quantity less than 1 (such as 0.5).
      (2) Serious and deadly errors can occur by misreading a number when the decimal point isn't legible. (Example: If the decimal point in 5.0 is unnoticed, the number might be read as 50, resulting in a tenfold overdose).
      (3) On the other hand, if a zero is placed before the decimal point but illegible, the zero would indicate that a decimal point should be there.

      Examples of correct and incorrect use of decimal points and zeros:

Correct	Incorrect
2. or 2	2.0
0.2	.2

C. Mathematical functions are often used in everyday pharmacy. The common ones are reviewed below.

1. Fractions: For fractions to be added or subtracted, they must have a common denominator. For fractions to be multiplied or divided, a common denominator is **not** needed.

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a. Addition example: How many teaspoonfuls of amoxicillin suspension would be needed per day if the dose is $^{3}/_{4}$ teaspoonful in the morning and $^{1}/_{2}$ teaspoonful in the evening?
   (1) Find the common denominator: $^{3}/_{4}$; $^{1}/_{2} = {}^{2}/_{4}$
   (2) Add the fractions: $^{3}/_{4} + {}^{2}/_{4} = {}^{5}/_{4} =$
   (3) Change to a mixed number: $^{5}/_{4} = 1^{1}/_{4}$ teaspoonfuls

b. Subtraction example: The pharmacy has $^{1}/_{2}$ bottle of Tylenol® and needs $^{1}/_{3}$ of the bottle to fill a prescription. How much will remain in the bottle after the prescription has been filled?
   (1) $^{1}/_{2} = {}^{3}/_{6}$; $^{1}/_{3} = {}^{2}/_{6}$
   (2) $^{3}/_{6} - {}^{2}/_{6} = {}^{1}/_{6}$ of the bottle left

c. Multiplication example: How many ounces of suspension would be required to fill a prescription with the following directions to the patient: "Take $^{1}/_{2}$ ounce orally six times daily for 1 day"? $^{1}/_{2} \times {}^{6}/_{1}$
   (1) Multiply the numerators: $1 \times 6 = 6$
   (2) Multiply the denominators: $2 \times 1 = 2$
   (3) Write as a fraction: $^{6}/_{2}$
   (4) Reduce if possible: 3 ounces

d. Division example: How many days' worth of antibiotic can be gotten from a 6-ounce bottle if the patient needs $^{3}/_{4}$ ounce per day? $^{6}/_{1} \div {}^{3}/_{4} =$
   (1) Multiply the first fraction times the inverse, or reciprocal, of the second: $^{6}/_{1} \times {}^{4}/_{3} =$
   (2) Multiply numerators: $6 \times 4 = 24$
   (3) Multiply denominators: $1 \times 3 = 3$
   (4) Write as fraction: $^{24}/_{3}$
   (5) Reduce: $^{24}/_{3} = 8$ days

2. The ability to convert various numbers back and forth is also important.
   a. Fraction to decimal: Divide the numerator by the denominator: $^{1}/_{2} = 0.5$; $^{3}/_{4} = 0.75$; $^{7}/_{8} = 0.875$
   b. Mixed number to decimal: $2^{1}/_{3} =$
      (1) Think of the mixed number as two separate numbers: 2 and $^{1}/_{3}$
      (2) Convert $^{1}/_{3}$ to a decimal: 0.33
      (3) Add the decimal to the whole number: $2 + 0.33 = 2.33$
   c. Decimal to mixed number or fraction: 0.75
      (1) The decimal point shows the place value and therefore the denominator. The number indicates the numerator. $0.75 = {}^{75}/_{100}$
      (2) Reduce if possible: $^{75}/_{100} = {}^{3}/_{4}$
   d. Percentage to fraction: ***Percent*** means "per 100," so the denominator is always 100.
      (1) $36\% = {}^{36}/_{100}$; reduced $= {}^{9}/_{25}$
      (2) $2.5\% = {}^{2.5}/_{100}$ or $^{25}/_{1000}$ or $^{1}/_{40}$

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e. Fraction to percentage: Divide the numerator by the denominator to get a decimal. Then multiply by 100.
   (1) $^4/_5 = 4 \div 5 = 0.8$
   (2) $0.8 \times 100 = 80\%$

D. Pharmacists must be able to convert measures of volume, weight, and temperature between the English system of measurement and the International System of Units (SI). The International System of Units is a modern standardized form of the metric system. The metric system, first adopted in 1791, is a decimal system of measurement in which all units are based on multiples of 10. Because the system is based on the powers of 10, its units can be easily converted between measurements.

1. Common measurements in the English system include cups, teaspoonfuls, ounces, pounds, and degrees Fahrenheit.
2. Common measurements in the metric system include milliliters, liters, grams, kilograms, and degrees Celsius.

Teaching Strategy: *Use VM–A, VM–B, and LS–A to practice concepts learned. Invite a pharmacy technician to speak to the class about his or her responsibilities. Be sure to have the speaker discuss required math skills. Lead a class discussion on math skills required of a pharmacy technician. During the discussion, have the students provide real-life examples of conversions between systems of measure.*

Objective 2: Demonstrate proficiency in the order of operations.

Anticipated Problem: Why is the order of operations important in performing pharmacy calculations?

II. The ***order of operations*** is a set of rules used to solve math problems that requires functions to be done in the following order: (1) parentheses, (2) exponents, (3) multiplication, (4) division, (5) addition, (6) subtraction. Well-known mnemonics that can be used to help remember this order are **P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally and PEMDAS.

A. To calculate quantities and duration of medications, the order of operations is sometimes required.

1. Example of quantity: How many tablets would be required to fill the following prescription with the directions “Take 1 tablet by mouth on Monday, Wednesday, and Friday and 2 tablets by mouth on Tuesday, Thursday, Saturday, and Sunday”? Give 1 month’s supply.
   a. $[(1 \times 3) + (2 \times 4)] \times 4$ weeks $= 11 \times 4 = 44$ tablets

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2. Example of duration: A prescription reads, "Give 15 ml by mouth two times daily." If this prescription were filled with a 300 ml bottle of cough medicine, how many days of cough medicine would the patient have?
   a. $300 \div [(15 \times 2)]$
   b. $300 \div 30 = 10$ days

Teaching Strategy: *Lead a class discussion on the order of operations. Discuss why the order of operations is important in doing pharmacy calculations. Use examples with which students might be familiar, either from their experiences in home medication or from what they may have seen in a medical facility. Assign LS–B as homework or to be completed during supervised study. Upon completion of LS–B, review the answers with the class.*

Objective 3: Solve ratio, proportion, concentration, and drip-rate problems.

Anticipated Problem: How does one go about solving problems involving ratio, proportion, concentration, and drip rate?

III. Knowledge and use of ratio, proportion, concentration, and drip rate are vital in all the different areas of pharmacy but especially in the hospital and home care environments.

A. ***Ratio*** is the mathematical relationship between one quantity and another. Example: 0.9 g of sodium in 100 ml of water (often referred to as "normal saline")

B. ***Proportion*** is the equality between two ratios. Example:

$$\frac{0.9 \text{ g sodium}}{100 \text{ ml water}} = \frac{9 \text{ g}}{1000 \text{ ml}}$$

C. ***Concentration*** is the amount of drug per volume or weight of the product and may be written as a percentage or a ratio strength.

1. Percent weight-in-weight (w/w) is the grams of a drug in 100 g of a product, usually a cream or an ointment. Example: Hydrocortisone 1% cream = 1 g hydrocortisone/ 100 g cream
2. Percent weight-in-volume (w/v) is the grams of a drug in 100 ml of a product. Example: Dextrose 5% in water = dextrose 5 g/ 100 ml water
3. Percent volume-in-volume (v/v) is the ml of a drug in 100 ml of a product. This is not a common way of expressing concentration in the practical world of pharmacy.
4. The most common way concentration is expressed is in mg/ml or as a percentage.

D. In hospitals, many patients are unable to take medications orally, so they are given directly into a vein (intravenously) and called intravenous (IV) medications. The pharmacy technician is responsible for making many of these medications.

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One form of this type of medication is called an IV drip because it must infuse slowly (drip) into the patient, often for safety reasons.

1. The calculated rate at which a medication infuses into a patient (how fast it goes in) is called the ***drip rate***. The concentration of the drug and the period of infusion are used to calculate the rate. Some different ways to express the rate include ml/hr, ml/min, mg/kg/min.

> **Teaching Strategy:** *Lead the class through the calculations related to ratio, proportion, concentration, and drip rate problems. Prepare or obtain practice problems, and assign them to the students. Ask the mathematics teachers for cross-curricular assistance in teaching how to solve problems confronted by pharmacy technicians.*

Review/Summary.

Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the text book may also be used in the Review/Summary.

Application.

Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

Evaluation.

Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

Answers to Sample Test:

Part One: Matching

1. c
2. b
3. a
4. f
5. e
6. d

Part Two: Multiple Choice

1. d
2. d
3. b
4. d
5. a
6. b

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Part Three: True/False

1. T
2. F
3. F
4. T
5. T
6. T

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Sample Test

Name _____

Drug Calculations

Part One: Matching

Instructions: **Match the term with the correct definition.**

a. order of operations
b. ratio
c. proportion
d. fraction
e. decimal
f. drip rate

_____1. The equality between two ratios
_____2. The mathematical relationship between one quantity and another
_____3. A set of rules for to solve math problems
_____4. The calculated rate at which a medication infuses into a patient
_____5. A fraction written in a linear way
_____6. A part of a whole number

Part Two: Multiple Choice

Instructions: **Circle the letter of the correct answer.**

_____1. 45 in Roman numerals is _____.

a. XXXXiiiii
b. IV
c. XIV
d. VL

_____2. You need a common denominator in the _____ of fractions.

a. multiplication
b. subtraction
c. addition
d. both b and c



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_____3. 35% is equal to all of the following except _____.

a. 0.35
b. 0.035
c. $^{35}/_{100}$
d. $^{7}/_{20}$

_____4. The order of operations is as follows: _____

a. Parentheses, multiplication, division, exponents, addition, subtraction
b. Addition, subtraction, multiplication, division, exponents, parentheses
c. Subtraction, addition, exponents, multiplication, division, parentheses
d. Parentheses, exponents, multiplication, division, addition, subtraction

_____5. To dispense the following prescription for amoxicillin suspension, you will need _____. "Take ii tsp by mouth three times daily for 7 days."

a. 7 ounces
b. 4 ounces
c. 1 ounce
d. 5½ ounces

_____6. The patient will have _____ days of Robitussin with Codeine® if you dispense 10 ounces and the directions read: "Take 10 ml by mouth three times daily for cough."

a. 30
b. 10
c. 7
d. 5

Part Three: True/False

Instructions: **Write *T* for true or *F* for false.**

_____1. 1000 ml = 1 L

_____2. 2.4 g = 240 mg

_____3. 1 lb = 1 kg

_____4. In the order of operations, you multiply before you add.

_____5. Benadryl® 1% cream is a weight-in-volume concentration.

_____6. Dextrose 15% = 15 g dextrose/ 100 ml water

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COMMON PHARMACY ABBREVIATIONS

microgram	mcg
gram	g
milligram	mg
kilogram	kg
milliliter	ml
liter	L
pound	lb
ounce	oz
teaspoonful	tsp
tablespoonful	TBS
intravenous	IV



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PHARMACY CONVERSIONS

Measurement	Equivalent
1 L	1000 ml
1 kg	1000 mg
1 mg	1000 mcg
1 lb	16 oz
1 cup	8 oz
1 oz	30 g
1 fl oz	30 ml
1 tsp	0.167 fl oz = 5 ml
1 TBS	0.5 fl oz = 15 ml
1 pt	16 oz
2 pt	1 qt
4 qt	1 gal
1 cup	8 fl oz = 240 ml
1 kg	2.2 lb
1 drop	Not a standard measurement. Volume depends on type of liquid and size of dropper used.

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LS–A

Name _____

Pharmacy-Related Conversion Problems

Purpose

The purpose of this activity is to become proficient with pharmacy conversion problems.

Objectives

1. Practice Arabic and Roman numeral conversions.
2. Practice other pharmacy-related conversions.

Materials

- lab sheet
- writing utensil

Procedure

1. Complete the following conversions.

Roman Numeral	Equivalent Arabic Numeral
ii	
IX	
XIV	
XXXVIII	
ss	
CC	
MCD	



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2. Practice other pharmacy-related conversions.

4 tsp	_____ ml
9 tsp	_____ TBS
3 gal	_____ qt
480 ml	_____ oz
1.2 L	_____ ml
$^1/_2$ cup	_____ ml
0.13 g	_____ mg
12.5 mg	_____ g
1 tsp	_____ ml
45 ml	_____ TBS
0.35	_____ %
$1^3/_4$ tsp	_____ ml
88 mcg	_____ mg
0.5 L	_____ fl oz

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Pharmacy-Related Conversion Problems

1.

Roman Numeral	Equivalent Arabic Numeral
ii	2
IX	9
XIV	14
XXXVIII	38
ss	½
CC	200
MCD	1400

2.

4 tsp	20 ml
9 tsp	3 TBS
3 gal	12 qt
480 ml	8 oz
1.2 L	1200 ml
$^1/_2$ cup	120 ml
0.13 g	130 mg
12.5 mg	0.0125 g
1 tsp	5 ml
45 ml	3 TBS
0.35	35%
$1^3/_4$ tsp	8.75 ml
88 mcg	0.088 mg
0.5 L	16.7 fl oz

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LS–B

Name _____

Other Pharmacy-Related Mathematical Calculations

Purpose

The purpose of this activity is to become proficient with other pharmacy-related mathematical calculations.

Objective

Perform commonly encountered pharmacy-related mathematical calculations.

Materials

- lab sheet
- writing utensil

Procedure

Solve the following problems.

1. A common IV fluid given patients in the hospital is dextrose 5% in 0.45% sodium chloride (written as D5W/0.45).

   a. How many grams of sodium are contained in 500 ml?

   b. How many grams of dextrose are contained in 500 ml?



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2. How many grams of sodium are in 1000 ml of 0.9% sodium chloride?

3. A patient who is dehydrated may often get 3 bags of 1000 ml 0.9% sodium chloride per day.

   a. How many grams per day of sodium would this be?

   b. Does that seem like a lot?

4. The pharmacy has a shortage of Bactroban® ointment. To make the supply last, the 30 g tubes that come from the manufacturer will be repackaged into 0.5 g single-use cups.

   a. How many doses of 0.5 g cup can you make from a 30 g tube?

   b. If a patient uses 0.5 g three times daily, how many days' worth of Bactroban® ointment could be obtained from a 30 g tube?

5. If a patient takes 1 tablet by mouth of 2 mg strength Coumadin® on Monday, Wednesday, and Friday and 2 tablets on Tuesday, Thursday, Saturday, and Sunday, how many 2 mg tablets would you need to fill a 3 months' (12 weeks') supply?

6. How many ml of Bactrim® suspension would you need to fill a prescription with the following directions: "Take $^{3}/_{4}$ tsp by mouth three times daily for 10 days"?

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Other Pharmacy-Related Mathematical Calculations

1. a. 0.45% sodium chloride = 0.45 g/ 100 ml
   0.45 g × 5 = 2.25 g in 500 ml
   b. Dextrose 5% = 5 g dextrose/ 100 ml
   5 g × 5 = 25 g in 500 ml

2. 0.9% sodium chloride = 0.9 g/ 100 ml

   0.9 g × 10 = 9 g sodium chloride in 1000 ml

3. a. 9 g × 3 = 27 g of sodium per day
   b. The American Dietetic Association (ADA) recommends only 2 g of sodium per day, so yes, that is a lot. However, patients usually get that much only until they are no longer dehydrated, which is usually one or two days.

4. a. 30 g ÷ 0.5 = 60 doses
   b. 0.5 g × 3 = 1.5 g
   30 g ÷ 1.5 = 20 days

5. 1 tablet × 3 (Mon., Wed., Fri.); 2 tablets × 4 (Tues., Thurs., Sat., Sun.); for 12 weeks

   [(1 × 3) + (2 × 4)] × 12 = 11 × 12 = 132 tablets for 12 weeks' supply

6. $^3/_4 \times {}^3/_1 = {}^9/_4$ tsp per day

   Change to decimal: $^9/_4$ = 2.25 tsp

   Change to ml: 2.25 tsp × 5 ml = 11.25 ml per day

   11.25 ml × 10 days = 112.5 ml needed to fill prescription

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