

Chapter 3

Basic Mathematics for Limited Operators

Learning Objectives

- Demonstrate calculations involving the use of fractions, decimals, percentages, exponents, ratios and proportions, and simple algebraic equations
- Identify and use standard measurement units, state equivalent values for measurements in both English and metric systems, and convert measurements from one unit to another

Learning Objectives (Cont' d)

- When given two of the milliamperere-second (mAs) values (milliamperere [mA], time, mAs), calculate the third
- Calculate changes in radiation intensity and required mAs for changes in source–image receptor distance (SID)

Learning Objectives (Continued)

- Given a set of exposure factors, calculate the changes needed to change contrast levels using the 15% rule
- Given a set of exposure factors, make appropriate adjustments for difference in patient part thickness using both kilovolt peak (kVp) and mAs

Learning Objectives (Continued)

- Given a set of exposure factors, make appropriate adjustments for grid changes using mAs
- Given a set of exposure factors, make appropriate adjustments in mAs for changes in the relative speed of the image receptor system
- Perform routine medication dose calculations accurately

Why Learn About Math?

- Math skills are important for:
 - Adjusting radiographic exposure factors to:
 - Patient size and body type
 - Image receptor speed
 - Grid ratio
 - SID
 - Accurately calculating medication dose

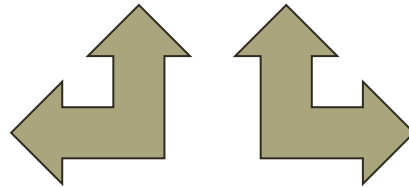
Important Mathematical Terms

- Sum
- Difference
- Product
- Dividend
- Divisor
- Quotient
- Remainder

Fractions

Numerator
indicates
the number of
pieces
or parts

3/4



Denominator
indicates
the number of
equal parts
in the whole

- Fraction calculations include:
 - Reducing to lowest terms
 - Finding the value of a portion of the whole by multiplying the fraction by the whole number
 - Converting a fraction to a decimal

Decimals

- Like fractions, decimals indicate a portion of the whole
- Value is indicated by the position of a decimal point

Example:

10.05 = ten and five one-hundredths

100.5 = one hundred and five tenths

Decimals (Cont' d)

- Decimal calculations include:
 - Adding and subtracting
 - Dividing and multiplying
 - Converting to a percentage

Percentages

43%



Denominator always equals 100 and is unwritten

Symbol used to indicate percentage

- Percentage calculations include:
 - Adding and subtracting
 - Multiplying and dividing
 - Converting to decimals

Equations

- Consist of two mathematical statements that are equal to each other

Example

$$7 + y = 16$$

Equations (Cont' d)

- When solving equations:
 - The unknown quantity is indicated by a letter and may be either left or right of the equal sign
 - A letter and number adjacent to each other ($5x$) indicates multiplication
 - A horizontal line ($4x/2$) indicates division
 - Both sides are balanced by performing the same operation on both sides of the equation

Ratios and Proportions

- Ratio
 - Expresses an operation in which one number is divided by another and is indicated by the colon
- Proportion
 - Statement that two ratios are equal to each other
 - Proportions may be directly or inversely related

Ratio Example
2:6

Proportion Example
2:6::4:12

Exponents

- Indicate a number that has been multiplied by itself
- A superscript number indicates how many times the number has been multiplied

Example

$$4^3 = 4 \times 4 \times 4$$

Square Roots

- Square root indicates a value that, when multiplied by itself, equals the original number
- A radical symbol $\sqrt{\quad}$ indicates square root

Example

$$\sqrt{64} = 8$$

Measurement Units

- Metric Units

- Gram
- Liter
- Meter

- Metric Prefixes

- Kilo
- Milli
- Micro
- Deci
- Centi

- English Units

- Inch
- Foot
- Yard
- Mile
- Ounce
- Pint
- Quart
- Gallon
- Pound
- Ton

Common English Metric Equivalents

- 1 inch = 2.54 centimeters
- 1 yard = 1.0926 meters
- 1 ounce = 30 milliliters
- 1 quart = 0.946 liters
- 1 pound = 2.2 kilograms

Radiographic Applications

Milliamperere-seconds (mAs)

- mAs indicates the quantity of radiation in a radiographic exposure
- Affects radiographic density and patient dose

Radiographic Applications

Milliamperere-seconds (mAs) (Cont' d)

- Calculating mAs

$$\text{mA} \times \text{seconds} = \text{mAs}$$

- Calculating seconds

$$\text{mAs} \div \text{mA} = \text{seconds}$$

- Calculating mA

$$\text{mAs} \div \text{seconds} = \text{mA}$$

Radiographic Applications

Source–Image Receptor Distance (SID)

- SID is the distance between the source of radiation and the IR
- Affects radiographic density and patient dose

Radiographic Applications

Source–Image Receptor Distance (SID) (Cont' d)

- Radiation intensity is inversely proportional to the square of the distance

$$\frac{I_1}{I_2} = \frac{(SID_2)^2}{(SID_1)^2}$$

I_1 = Original Intensity

I_2 = New Intensity

SID_1 = Original Distance

SID_2 = New Distance

Radiographic Applications

Kilovoltage (kVp)

- Affects radiographic contrast, density, and patient dose
- An increase in kVp decreases contrast and increases density
- A decrease in kVp increases contrast and decreases density

Radiographic Applications

Kilovoltage (kVp) (Cont' d)

- To use the 15% rule to change contrast and maintain density:
 - Divide the mAs by 2 when increasing the kVp 15%
 - Multiply the mAs by 2 when decreasing the kVp 15%

Radiographic Applications

Patient Size Adjustments

- Kilovoltage
 - Affects radiographic density and contrast
 - 2 kVp/cm compensates for patient size changes when kVp is less than 85
 - 3 kVp/cm compensates for patient size changes when kVp is greater than 85

Radiographic Applications

Patient Size Adjustments (Cont' d)

- Milliampere-Seconds
 - 30% increase compensates for a 2-cm increase in patient size
 - 20% decrease compensates for a 2-cm decrease in patient size

Radiographic Applications

Image Receptor System

- The faster the speed of the IR the less mAs needed to produce adequate radiographic density
- Calculating mAs for a change in IR speed

$$\frac{mAs_1}{mAs_2} = \frac{\text{Relative Speed}_2}{\text{Relative Speed}_1}$$

mAs_1 = Original mAs

mAs_2 = New mAs

RS_1 = Original IR Speed

RS_2 = New IR Speed

Radiographic Applications

Grids

- Placed between the patient and the IR to absorb scatter radiation
- Absorption decreases density, requiring an increase in mAs
- mAs increase depends on grid ratio or how much radiation the grid absorbs

Radiographic Applications Grids (Cont' d)

- Calculating mAs change when a grid is used

$$\frac{mAs_1}{mAs_2} = \frac{GCF_1}{GCF_2}$$

mAs_1 = Original mAs

mAs_2 = New mAs

GFC_1 = Original Grid Ratio

GFC_2 = New Grid Ratio

Summary

- Fractions, decimals, and percentages indicate a portion of the whole
- Equations consist of two mathematical statements that are equal to each other
- Ratio expresses an operation in which one number is divided by another and is indicated by the colon

Summary (Cont' d)

- Proportion is a statement that two ratios are equal to each other
- Proportions may be direct or may be inversely related
- Exponent is represented by a superscript number that indicates the number of times the number has been multiplied by itself

Summary (Cont' d)

- Square root indicates a value that, when multiplied by itself, equals the original number and is represented by the radical symbol $\sqrt{\quad}$
- English and metric units may be used to indicate distance, weight, and liquid measures

Summary (Cont' d)

- mAs indicates the quantity of radiation in a radiographic exposure and affects radiographic density and patient dose
- SID is the distance between the source of radiation and the IR and affects radiographic density and patient dose
- Radiation intensity is inversely proportional to the square of the distance (SID)

Summary (Cont' d)

- Kilovoltage affects radiographic contrast, density, and patient dose
- The faster the speed of the IR, the less mAs needed to produce adequate radiographic density
- Grids are placed between the patient and the IR to absorb scatter radiation
- Medication calculations are used to determine dosage accurately