

THIRD EDITION

Clinical Nursing. Calculations



The Pedagogy

Clinical Nursing Calculations drives comprehension through various strategies that meet the learning needs of students while also generating enthusiasm about the topic. This interactive approach addresses different learning styles, making this the ideal text to ensure mastery of key concepts. The pedagogical aids that appear include the following:

Case Consideration

As you begin each chapter, read and analyze real-life situations in clinical calculations. Then use your critical thinking skills to answer questions.

The CASE Approach

This step-by-step method of performing dosage calculations is applied to every dosage calculation. CASE is an acronym for Convert, Approximate, Solve, Evaluate.

CHAPTER 7 Dosage Calculations

Case Consideration ... Calculation Choices

After learning about each medication, the nursing student was ready to prepare the medications for administration. The patient needed an intravenous (IV) antibiotic, a liquid cough medicine, and several other medications that were dispensed as tablets and capsules. The student reviewed the medication administration record (MAR) and realized dosage calculations were indicated.

1. How is a dosage calculation performed?
2. Is there one method that can be used for all dosage calculations?

INTRODUCTION

When administering medications, each *case* should be considered separately. Because medications may be supplied in varying dosage strengths, varying amounts may be required to administer the same dosage of medication. For example, Paxil CR is supplied as 12.5 mg tablets and 25 mg tablets. Administration of a 25 mg dose would require two 12.5 mg tablets or only one 25 mg tablet. Even though the dose is the same, the amount to administer is different.

The patient's needs may also change. For example, a patient who was able to take an oral dose of medication may be ordered to take nothing by mouth (NPO) and will then require a different form and route of medication. Medications should be ordered on a case-by-case basis; safe dosages vary depending on the patient's age, weight, kidney function, liver function, and individual response. The authorized prescriber will order the dosage and route, but the nurse will have to consider the individual patient and supplied medication prior to administration.

To ensure safety and accuracy with dosage calculations, use the **CASE approach**. CASE is an acronym for the four steps of safe dosage calculation:

- **C: Convert**—convert to like units of measurement
- **A: Approximate**—estimate the amount to administer
- **S: Solve**—perform the dosage calculation
- **E: Evaluate**—check the dosage calculation and compare it to the approximated amount

The word CASE also reminds the nurse to consider the appropriateness of the medication and dose ordered in each individual case.

7-1 Comparing the Supply to the Ordered Dose

The first two steps of the CASE approach, **C: Convert** and **A: Approximate**, require the comparison of the dosage strength (referred to as the "supply") to the ordered dose (referred to as the "order"). For example, the ordered dose may be in grams (g), while the supply is in milligrams (mg). Step **C: Convert** requires comparing the supply to the ordered dose and converting to the same unit of measurement, if they are different. If the supplied dosage strength and the ordered dose are in the same unit of measurement, the conversion step is not applicable (N/A).

Chapter 3
Medication Administration Equipment

CHAPTER OUTLINE

- 3-1 Enteral Medication Administration Equipment
 - A. Oral Devices
 - B. Enteral Tube Equipment
- 3-2 Parenteral Medication Administration Equipment
 - A. Equipment Used for Injections
 1. Syringes
 2. Needles
 3. Parenteral Medication Containers
 - B. Administration of Other Non-enteral Medications

LEARNING OUTCOMES

Upon completion of the chapter, the student will be able to:

- 3-1 Differentiate enteral medication equipment.
- 3-2 Differentiate medication administration devices used for injections.

KEY TERMS

ampule p. 76	filter needle p. 76	parenteral p. 70
calibrated spoon p. 65	gauge p. 71	route p. 62
calibration p. 62	insulin pen p. 78	soufflé cup p. 63
cartridge p. 78	intradermal p. 70	subcutaneous p. 70
controlled substances p. 76	intramuscular p. 70	trailing ring p. 74
diluent p. 76	intravenous p. 70	U-100 p. 73
dropper p. 64	leading ring p. 74	vial p. 76
eccentric p. 65	medicine cup p. 63	viscosity p. 71
enteral p. 62	meniscus p. 63	zero calibration p. 74
	oral syringe p. 65	

Chapter Outline

Each chapter begins with a brief but clear outline to give students and instructors a preview of the content that will be covered.

Learning Outcomes

Learning Outcomes provide instructors and students with a snapshot of the key information they will encounter in each chapter and serve as a checklist to help guide and focus study. Learning outcomes are applied to all test questions, homework exercises, and presentation slides.

Key Terms

Found in a list at the beginning of each chapter, these terms will create an expanded vocabulary. To facilitate location of key terms within each chapter, page numbers are included next to each term.

Three Methods of Calculation

Ratio-Proportion, Formula Method, and Dimensional Analysis are all introduced, demonstrating the distinct advantage of each approach. The three methods are presented side-by-side in a tabled format for every dosage calculation.

Learning Activity

Practice what you learn as you read through the text.

Chapter Summary 341

Intravenous Incident ... Case Closure

Because the majority of patients have electronically regulated intravenous infusions, nurses (and nursing students) sometimes forget how to calculate manually regulated flow rates. Had the nursing student remembered the formula for determining manual flow in gt/min, $\frac{\text{mL}}{\text{min}} \times \frac{\text{drop factor (gt)}}{\text{mL}} = \frac{\text{gt}}{\text{min}}$, or remembered the concepts of dimensional analysis for determining rate, this error could have been avoided. Many factors affect manually regulated flow rates, including the placement and position of the intravenous catheter in relation to the patient's heart and to the IV bag. As the patient moves, the IV rate can change. Thus, it is important to check the IV rate regularly to ensure that it is infusing on time.

Chapter Summary					
Learning Outcomes	Points to Remember				
10-1 Differentiate solutions used for infusion therapy.	<ul style="list-style-type: none"> Isotonic: same osmolality as plasma/expands volume (NS, LR) Hypotonic: fewer particles than plasma/moves fluid into cells (½ NS, ¼ NS, D₅W [after glucose metabolizes]) Hypertonic: more particles than plasma/moves fluid into bloodstream (D₅NS, D₅ ½ NS, D₁₀LR) 				
10-2 Identify equipment used for infusion therapy.	<ul style="list-style-type: none"> Containers: 1,000 mL, 500 mL, 250 mL, and mini-bags (100 mL, 50 mL) Tubing: primary (long) for continuous infusion and secondary (short) for intermittent (medication) infusion Monitoring equipment: infusion pumps, syringe pumps, smart (computerized) pumps, controllers, volume-control sets Access devices: <ul style="list-style-type: none"> Peripheral devices: inserted into a vein in the periphery (hand or arm) for short-term therapy (e.g., saline lock, heparin lock) Central devices: inserted into a central vein (subclavian or jugular) for long-term therapy (e.g., triple-lumen lines, ports, PICC lines) 				
10-3 Calculate infusion therapy flow rates.	<ul style="list-style-type: none"> Electronic flow rates (mL/h): Example (time in hours): 3 L over 1 day Convert 3 L to 3,000 mL and 1 day to 24 h, or use conversion factors $\frac{1,000 \text{ mL}}{1 \text{ L}}$ and $\frac{1 \text{ day}}{24 \text{ h}}$ <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr style="background-color: #d9e1f2;"> <th>Ratio-Proportion</th> <th>Formula Method</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">$\frac{3,000 \text{ mL}}{24 \text{ h}} = \frac{x \text{ mL}}{1 \text{ h}}$ $x = 125 \text{ mL/h}$</td> <td style="text-align: center;">$\frac{3,000 \text{ mL}}{24 \text{ h}} = 125 \text{ mL/h}$</td> </tr> </tbody> </table>	Ratio-Proportion	Formula Method	$\frac{3,000 \text{ mL}}{24 \text{ h}} = \frac{x \text{ mL}}{1 \text{ h}}$ $x = 125 \text{ mL/h}$	$\frac{3,000 \text{ mL}}{24 \text{ h}} = 125 \text{ mL/h}$
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Case Closure

As you finish the chapter, the Case Closure uses information learned in the chapter to wrap up the case from the beginning of the chapter.

Clinical CLUE

These notes provide relevant information pertaining to clinical practice.



FIGURE 9-20 There is no dosage strength indicated with the reconstitution information provided on this label. Therefore, the nurse determines the dosage strength to be 1,000 mg/20 mL, from the amount of drug in the vial (1,000 mg) and the amount of diluent added (20 mL).

1. Determine the type and amount of diluent to instill and the resulting dosage strength. Instill 20 mL of sterile water. The dosage strength is 1000 mg/20 mL, which can be reduced to 50 mg/mL.
2. Calculate the amount of reconstituted medication needed to administer the prescribed dose.
- C. Convert—Because the order is in grams and the supply is reconstituted to milligrams, use the equivalent 1 gram = 1,000 mg to convert 0.35 g to 350 mg. For dimensional analysis, use the conversion factor 1,000 mg/1 g.
- A. Approximate—The ordered dose, 350 mg, is seven times the amount supplied in 1 mL. Therefore, seven times the volume, or 7 mL, will be needed to administer the ordered dose.

S. Solve

Ratio-Proportion	Formula Method
$\frac{50 \text{ mg}}{1 \text{ mL}} = \frac{350 \text{ mg}}{x \text{ mL}}$ or $50 \text{ mg} \cdot 1 \text{ mL} = 350 \text{ mg} \cdot x \text{ mL}$ $50x = 350$ $\frac{50x}{50} = \frac{350}{50}$ $x = 7 \text{ mL}$	$\frac{350 \text{ mg}}{50 \text{ mg}} \times 1 \text{ mL} = x \text{ (mL)}$ $\frac{350 \text{ mL}}{50} = x$ $7 \text{ mL} = x$
Dimensional Analysis	
$x \text{ (mL)} = \frac{1 \text{ mL}}{50 \text{ mg}} \times \frac{1,000 \text{ mg}}{1 \text{ g}} \times \frac{0.35 \text{ g}}{1}$ $x = \frac{350 \text{ mL}}{50}$ $x = 7 \text{ mL}$	

Because the calculated volume accurately completes the equation and is consistent with the approximated volume, 0.75 mL, the answer is confirmed. NOTE: Because of the ease of withdrawing 1 mL, and because no calculation is required, preparing the dosage strength of 750,000 units/mL is also appropriate for mixing this IV dose.

LEARNING ACTIVITY 9-4 For the following order and supply:

- A. Identify the diluent(s) that should be used to reconstitute the medication.
- B. Determine the volume of diluent to use.
- C. Determine the resulting dosage strength.
 1. Order: acyclovir 400 mg IV q8h for 7 days
Supply: See Figure 9-26.
 2. Order: Aztreonam 500 mg IM q12h
Supply: See Figure 9-27.
 3. Order: ceftriaxone 500 mg IV q8h
Supply: See Figure 9-28.

- The minimum daily dose of ampicillin for a 10 kg child is 500 mg per day.
- The maximum daily dose of ampicillin for a 10 kg child is 1,000 mg per day.
- The safe daily dose range of ampicillin for a 10 kg child is 500 to 1,000 mg per day.
- The minimum single dose of ampicillin for a 10 kg child is 125 mg per dose.
- The maximum single dose of ampicillin for a 10 kg child is 250 mg per dose.
- The safe single dose range of ampicillin for a 10 kg child is 125 to 250 mg per dose.

Clinical CLUE 12-2

The safe dose and safe dose range of medications that are typically ordered on a scheduled basis are usually determined per day rather than per dose. For example, because antibiotics and cardiac medications are scheduled around the clock, drug references usually provide information regarding the safe daily dose/dose range of these drugs. From this information, the nurse will calculate the safe daily dose/dose range and:

- Compare it to the ordered daily dose or
- Determine the single dose/dose range and compare the ordered (single) dose

LEARNING ACTIVITY 12-3 The recommended dose of amoxicillin is 20 to 40 mg/kg/day in divided doses q12h. Convert the weight of a 12 lb 4 oz infant to kg, then calculate the:

1. Minimum daily dose
2. Maximum daily dose
3. Minimum single dose
4. Maximum single dose

Clinical CLUE 12-3

Weight-based medications require accurate weights to be recorded in charts. In the interest of time, a prescriber may order medications based on a reported weight instead of an actual weight. This may cause a discrepancy in the safe dose calculation obtained by the nurse and the prescriber. Consider the following scenario:

- A parent reports a child's weight as 23 pounds to the physician. The physician converts this weight to 10.5 kg ($23 \text{ lb} \times 1 \text{ kg}/2.2 \text{ lb} = 10.45$ or 10.5 kg).
- Because the recommended dose of acetaminophen is 15 mg/kg/dose, the prescriber orders 158 mg to be given, based on this recommended (safe) dose calculation:

$$\frac{15 \text{ mg}}{1 \text{ kg}} \times \frac{10.5 \text{ kg}}{1} \times \frac{1}{1 \text{ dose}} = 157.5 \text{ or } 158 \text{ mg/dose.}$$
- The nurse obtains the child's actual weight of 22 pounds and converts it to 10 kg:

$$22 \text{ lb} \times \frac{1 \text{ kg}}{2.2 \text{ lb}} = 10 \text{ kg}$$

THIRD EDITION

Clinical Nursing Calculations

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Contents

Acknowledgments	xv
Preface	xvii
Introduction	xviii
Chapter 1 Basic Math	1
1-1 Calculating with Fractions	3
Types of Fractions	3
Creating Equivalent Fractions	4
Comparing Fractions by Size	4
Calculations Using Fractions	7
1-2 Calculating with Decimals	11
Adding Decimals	12
Subtracting Decimals	13
Multiplying Decimals	13
Dividing Decimals	14
Rounding Decimals	15
1-3 Converting Quantities	15
Converting Fractions	15
Converting Decimals	16
Converting Ratios	16
Converting Percentages	17
1-4 Calculating Unknown Quantities Using Ratio-Proportion	17
Cross-Multiplication to Determine If Fractions Are Equivalent	17
Multiplying Extremes and Means to Determine If Ratios Are Equivalent	17
Finding the Value of x in a Proportion	18
Finding x When a Fraction Is Multiplied by a Whole Number	18
1-5 Calculating with Percentages	19
Chapter Summary	21
Homework	25
Illuminations: Clinical Judgment Queries	25
References	26
Answer Key	27
Homework	27

Chapter 2	Systems of Measurement	29
2-1	Systems of Measurement Used to Calculate Dosages	30
	Apothecary System	39
	Household System	39
2-2	Converting Between Systems	44
	Household-to-Metric Approximate Equivalencies	44
	Other Units of Measurement	47
2-3	Centigrade and Fahrenheit Temperature Scales	49
2-4	International and Traditional Time	51
	Converting Traditional Time to International Time	52
	Converting International Time to Traditional Time	53
	Chapter Summary	54
	Homework	58
	Illuminations: Clinical Judgment Queries	58
	References	59
	Answer Key	60
	Homework	60
Chapter 3	Medication Administration Equipment	61
3-1	Enteral Medication Administration Equipment	62
	Oral Devices	63
	Enteral Tube Equipment	67
3-2	Parenteral Medication Administration Equipment	70
	Equipment Used for Injections	71
	Administration of Other Non-Enteral Medications	79
	Chapter Summary	84
	Homework	86
	Illuminations: Clinical Judgment Queries	89
	References	91
	Answer Key	91
	Homework	91
Chapter 4	Medication Orders	95
4-1	Medical Abbreviations	96
	Frequency Abbreviations	97
	Route Abbreviations	98
	Form Abbreviations	99
	General Abbreviations	99
4-2	Error-Prone Documentation	100
	Error-Prone Abbreviations	101
	Error-Prone Drug Name Abbreviations	104
4-3	Components of a Medication Order	105
4-4	Verbal Orders	107
4-5	Medication Administration Records	108
	Chapter Summary	110
	Homework	112
	Illuminations: Clinical Judgment Queries	114
	References	115
	Answer Key	116
	Homework	117

Chapter 5 Interpretation of Medication Labels and Package Inserts	119
5-1 Information on a Medication Label.....	120
Trade Name	121
Form	121
Dosage Strength	121
Combination Medication.....	122
Total Number, Volume, or Net Weight.....	122
Multiple-Dose and Single-Dose Packaging.....	124
Route of Administration	124
Reconstitution Instructions.....	125
Warnings.....	126
Controlled Substance Schedule	127
Storage Information.....	128
Manufacturing Information.....	128
5-2 Information on a Medication Package Insert.....	130
Chapter Summary.....	133
Homework.....	134
Illuminations: Clinical Judgment Queries.....	136
References	138
Answer Key	138
Homework.....	138
Chapter 6 Elements of Safe Medication Administration.....	141
6-1 Three Medication Label Checks.....	142
Before Medication Preparation.....	142
During Medication Preparation.....	143
After Medication Preparation	144
6-2 Rights of Medication Administration.....	145
Right Patient	145
Right Drug	146
Right Dose	146
Right Route	147
Right Time	147
Right Reason	148
Right Documentation	148
Right to Know.....	149
Right to Refuse.....	149
6-3 Assessment	150
6-4 Patient Teaching.....	151
Chapter Summary.....	153
Homework.....	155
Illuminations: Clinical Judgment Queries.....	156
References	158
Answer Key	159
Homework.....	159

Chapter 7 Dosage Calculations	161
7-1 Comparing the Supply to the Ordered Dose	162
7-2 Methods of Dosage Calculation	166
Ratio-Proportion	167
Formula Method	175
Dimensional Analysis	177
Homework	182
Illuminations: Clinical Judgment Queries	184
References	186
Answer Key	186
Homework	189
Chapter 8 Enteral Medication Dosage Calculations	197
8-1 Solid Enteral Medications	198
Capsules	201
Dosage Calculations with Tablets and Capsules	202
8-2 Liquid Enteral Medications	207
Types of Liquid Medications	207
Dosage Calculations with Liquid Medications	209
Chapter Summary	215
Homework	218
Illuminations: Clinical Judgment Queries	224
References	226
Answer Key	226
Homework	227
Chapter 9 Parenteral Medication Dosage Calculations	229
9-1 Injectable Solution Calculations	230
9-2 Rounding According to Appropriate Syringe Calibration	235
Syringe Selection	235
9-3 Reconstitution Calculations	243
Single Reconstitution Options	247
Multiple Reconstitution Options	252
9-4 Calculations with Dosage Strength as a Ratio or Percentage	260
Calculating Dosage of Percentage and Ratio Strength Medications	261
9-5 Determining the Amount of Medication in a Given Volume When the Dosage Strength Is a Percentage or Ratio	263
Chapter Summary	265
Homework	267
Illuminations: Clinical Judgment Queries	281
References	284
Answer Key	284
Homework	286

Chapter 10	Infusion Therapy and Calculations	289
10-1	Solutions	291
	Components	291
	Tonicity	295
	Solution Additives	296
10-2	Equipment for Infusion Therapy	298
	Solution Containers	298
	Tubing	298
	Monitoring Equipment	301
	Vascular Access Devices	305
10-3	Infusion Flow Rate Calculations	309
	Continuous Flow Rate Calculations	310
	Intermittent Flow Rate Calculations	318
10-4	Additional Intravenous Calculations	326
	Time Calculations	326
	Volume Calculations	332
10-5	Monitoring IV Infusion Therapy	338
	Initial and Ongoing IV Checks	338
	Complications of IV Therapy	340
	Chapter Summary	341
	Homework	343
	Illuminations: Clinical Judgment Queries	346
	References	348
	Answer Key	348
	Homework	349
Chapter 11	Solution Calculations	351
11-1	Solution Concentration Calculations	352
11-2	Additional Solute and Solvent Calculations	359
	Enteral Feeding Solutions	359
	Topical Solutions	368
	Chapter Summary	371
	Homework	373
	Illuminations: Clinical Judgment Queries	375
	References	376
	Answer Key	377
	Homework	377
Chapter 12	Dosage Calculations for Special Patient Populations	379
12-1	Factors That Impact Drug Dosing in Special Patient Populations	380
	Pharmacokinetics	381
	Pediatric Patients	381
	Geriatric Patients	381
12-2	Weight-Based Calculations	382
	Calculating a Safe Single Dose (SSD)	383
	Calculating a Safe Single Dose Range	384
	Calculating a Safe Daily Dose (SDD)	387
	Calculating a Safe Daily Dose Range	388
	Comparing a Safe Dose to an Ordered Dose	391

12-3 Body Surface Area (BSA) Calculations	398
Calculation of BSA	398
Using a Nomogram to Determine Body Surface Area	400
Calculation of BSA-Based Doses	402
12-4 Minimum Drug Dilution Calculations	406
Calculations for Medications Administered via Volume-Control Sets	410
Calculations for Medications Administered via Syringe Pump	414
Chapter Summary	418
Homework	420
Illuminations: Clinical Judgment Queries	423
References	425
Answer Key	425
Homework	426
Chapter 13 Hydration and Nutrition Calculations	429
13-1 Pediatric Daily Fluid Requirement (DFR) Calculations	430
Assessing Intake	433
Assessing Output	435
13-2 Pediatric Daily Caloric Requirement Calculations	436
13-3 Nutrient Calculations	439
Caloric Content of Energy Nutrients	439
Calculating Percentage of Major Nutrients	440
Nutrient-Restricted Diets	442
13-4 Fluid Resuscitation	445
Chapter Summary	447
Homework	448
Illuminations: Clinical Judgment Queries	449
References	451
Answer Key	451
Homework	452
Chapter 14 High-Alert Medications	455
14-1 Insulin	458
Insulin Labels and Types	459
Insulin Administration by Syringe	466
Insulin Pens	475
Insulin Pumps	477
14-2 Heparin	480
Determining the Concentration for Subcutaneous Heparin	480
Intravenous Heparin Calculations	483
Weight-Based Heparin Protocol	488
Chapter Summary	505
Homework	508
Illuminations: Clinical Judgment Queries	514
References	516
Answer Key	516
Homework	518

Chapter 15 Critical Care Calculations	521
15-1 Intravenous Infusion Flow Rate Calculations for Dosage per Time	522
Medications Infused per Hour	524
Medications Infused per Minute	529
15-2 Intravenous Infusion Flow Rate Calculations for Dosage per Body Weight and Time	533
15-3 Intravenous Infusion Dosage Calculations Based on a Specified Volume per Time	541
15-4 Titrated Intravenous Dosage Calculation	543
Chapter Summary	556
Homework	557
Illuminations: Clinical Judgment Queries	558
Reference	559
Answer Key	559
Homework	560
Appendix A: Calculating with Complex Fractions	561
Appendix B: Apothecary System	563
Appendix C: The Joint Commission's Do Not Use List	565
Appendix D: ISMP's List of Error-Prone Abbreviations, Symbols, and Dose Designations	567
Appendix E: ISMP's List of Confused Drug Names	575
Appendix F: Adult Nomogram	587
Appendix G: Sample Weight-Based Heparin Protocol Adjusted According to Anti-Factor Xa Assay	589
Glossary	591
Illuminations: Calculations Quick Guide	603
Index	613



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To future and practicing nurses, we hope this text makes safe practice a little easier.

We wish you success.

“A good book is a lighthouse; a wise person is a lighthouse; conscience is a lighthouse; compassion is a lighthouse; science is a lighthouse! They all show us the true path! Keep them in your life to remain safe in the rocky and dark waters of life!”

~ Mehmet Murat ildan



Preface

While teaching nursing in both associate and baccalaureate nursing programs, we discovered that while some students are very comfortable and competent with math, others are not. Even when a dosage calculation course or math proficiency is a requirement for admission to a nursing program, testing at the start of each semester in a nursing program reveals that some students need continued support and remediation to perform dosage calculations.

Students weak in long division and basic math rely on calculators to problem solve. They appear to have lost the understanding of numerical values and thus are not able to discern whether or not a solution is realistic. An example of a common error: If the dose is 5 mg, and the patient is supplied 10 mg tablets, the student might suggest administering two tablets (20 mg) instead of half a tablet (5 mg). This answer is yielded when the problem is set up incorrectly and the student fails to estimate a reasonable amount to administer.

Students observe staff nurses' reliance on technology to establish infusion rates and determine amounts to administer without performing calculations. "Smart pumps" generate infusion rates after the nurse inputs the volume and time, and electronic medication administration records (eMAR) include (computer-generated) amounts to administer. While these devices assist the nurse and reduce medication error potential, they may provide a false sense of security, prompting the nurse to eliminate double-checking via calculation. Thus, we set out to write a text that would strengthen students' and nurses' comfort with performing calculations in the clinical setting.

This text offers a step-by-step approach to basic math and dosage calculation. We have included approximation as a critical thinking step to evaluate the calculated answer. Believing students have different learning styles, we have color-coded steps to appeal to visual learners, provided narrated PowerPoint slides to appeal to auditory learners, and provided suggested activities for clinical instructors to support kinesthetic learners. Student engagement is supported through questions inserted in each chapter in PowerPoint. Adult learners may recognize the relevance of the material presented, as each chapter begins with a case study. In addition to demonstrating three different dosage calculation techniques side-by-side, we provide tips for performing dosage calculation efficiently in the clinical setting. Learning activities and practice problems are designed in response to actual clinical errors or common student errors, in addition to reinforcing the content presented. Faculty will appreciate this practical text, which students can use throughout the nursing program and into professional practice.



Introduction

Clinical Nursing Calculations, Third Edition can be used as a primary text for a dosage calculations course or as a supplemental text for a nursing course/program or pharmacology course. It also can be used by practicing nurses. This text is intended to appeal to faculty who teach online or in the classroom, have a strong clinical background, and want to apply math concepts to clinical practice. Content can be integrated into a medical-surgical curriculum, and clinical instructors can use content for remediation or assigned clinical exercises. Students will enjoy and benefit from the features that distinguish *Clinical Nursing Calculations* from other dosage calculation texts, such as:

- The *CASE* approach, a step-by-step process of performing dosage calculations
- A tabled side-by-side comparison of three methods of dosage calculation (ratio-proportion, formula method, dimensional analysis) for each calculation
- A case study that opens and closes each chapter
- Color coding of values and labels to appeal to visual learners
- Advantages of each approach presented:
 - Ratio-proportion promotes critical thinking.
 - Formula method is a shortcut tactic useful for individuals who easily grasp math.
 - Dimensional analysis is most useful when multiple conversions are required.

CASE is an acronym for a four-step calculation process, developed by the authors, that will prompt the student to methodically proceed with calculations:

- Convert
- Approximate
- Solve
- Evaluate

First, the student must determine if it is necessary to convert the ordered dose and the supplied dose to like units of measurement. After converting, the student can approximate the amount to administer. The approximation step promotes confidence in the answer if the approximated value is close to the solved value. To solve the dosage calculation, the student uses one of three methods of dosage calculations: ratio-proportion, formula method, or dimensional analysis. In the evaluate step, the student compares the solved value to the approximated value and checks the answer by repeating the calculation, replacing the unknown (x) with the solved value. The Approximate and Evaluate steps promote critical thinking that is vital to safe medication administration.



Numerous pedagogical features are included in every chapter. An outline, followed by Learning Outcomes and Key Terms (with page numbers for locating them within the chapter), begins every chapter. When defined in the text, the key terms are in bold. Expanding on the *CASE* acronym, each chapter includes a case study: opening with a Case Consideration in which a clinical issue is presented that includes a dosage error or potential error (relevant to the chapter material) and then concluding with a Case Closure in which the clinical issue is explained and resolved.

Learning Activities are inserted after each new concept is taught. Many of these activities are designed to be used with an audience response system in the classroom or to facilitate student engagement during independent learning. Because many students have difficulty remembering when and how far to round, Rounding Rules are emphasized as a key feature. Warnings and Clinical Clues provide helpful tips that apply to clinical practice. Chapter Summaries provide a quick reference to chapter material and are organized by learning outcomes. Each chapter concludes with 50 questions that can be assigned as homework or that students can use for practice. Homework is followed by a feature called *Illuminations: Clinical Judgment Queries*. These are critical thinking questions written in a format similar to items on the National Council Licensing Exam (NCLEX). All questions are referenced to learning outcomes, allowing students and faculty to select questions by outcome for practice or homework.

General features throughout the text include:

- Expanded clinical content, including nutrition and insulin pen calculations
- Legal implications of medication administration
- Exercises targeting safe practice with high-alert medications
- Examples given in eMAR and electronic health record format
- Information from The Joint Commission and the Institute for Safe Medication Practices regarding safe medication administration

Faculty and students will appreciate the use of current medications presented with large readable labels in this text. Realistic dosages, practical clinical application, and case studies should assist students and nurses to perform clinical calculations with competence.

What's new in the *Third Edition*?

- The lighthouse on the text cover is a symbol of strength, safety, and illumination. Strength is a quality that enables students to overcome obstacles. We hope that our students refer to this text as *The Lighthouse Text* and that it will empower them to overcome challenges associated with clinical calculations.



- Four new features to illuminate the pathway to safety, that is, safe medication administration, have been added:
 - *Illuminations: Clinical Judgment Queries*—Added to these NCLEX-style questions that promote critical thinking are NGN (NCLEX Next Generation) items. These rigorous items make a perfect assignment for small group work in a classroom or clinical setting!
 - *Illuminations: Calculations Quick Guide*—This a concise reference of key math skills covered throughout the text to include metric conversions, basic dosage calculations, computations requiring reconstitution, basic and critical care IV calculations, safe dosage determination, and implementation of a weight-based heparin protocol. This reference is located in the back of the text, before the back cover, to provide convenient access.
 - *Illuminations: Video Calculation Clips*—These short video clips, accessible via the Navigate platform, demonstrate the aforementioned clinical calculation skills.
 - *Illuminations: Mastery Assessments*—Added to the Navigate platform are a set of 14 questions per chapter, 4 of which are NCLEX-style items. These brief assessments will aid the student in determining and, ultimately, achieving mastery of the most important information in each chapter!
- The key terms listed on the first page of each chapter now have page numbers next to them to facilitate their location within the chapter.
- Key features, i.e., Rounding Rules and Clinical Clues, are numbered within each chapter to facilitate reference and location within the text.
- New assessments, containing six to seven questions per chapter, are accessible. Questions are tagged with Learning Outcomes. Answers are available for faculty only.
 - 50-question midterm exam (on Chapters 1–8)
 - 100-question comprehensive final exam (on Chapters 1–15)
- Information on safe medication administration has been updated in accordance with the guidelines promulgated by the Institute for Safe Medication Practices.