NUMERACY AND CLINICAL CALCULATIONS FOR NURSES

NEIL DAVISON

2ND EDITION

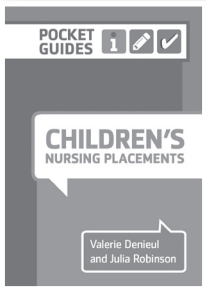
NUMERACY AND CLINICAL CALCULATIONS FOR NURSES

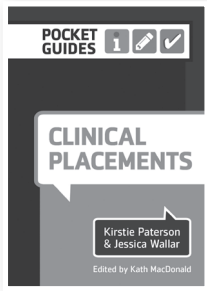
SECOND EDITION

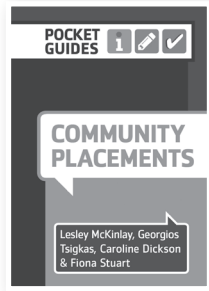
Key titles for new nurses

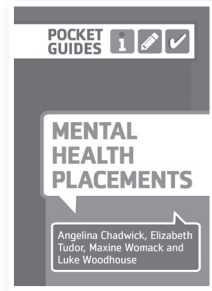
Pocket Guides series

Each of these unique books provides a wealth of practical detail, tips and advice to help you get to grips with, and make the most of, your placements.



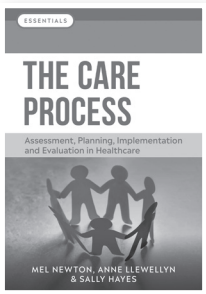


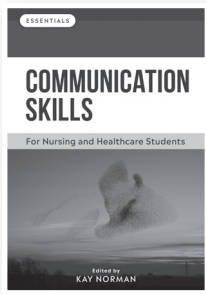


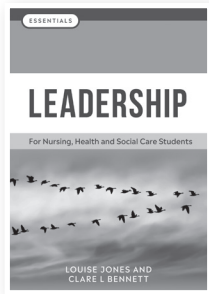


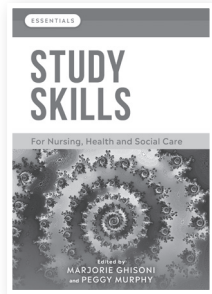
Essentials series

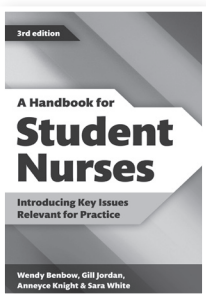
Practical introductory textbooks featuring clear explanations, scenarios, activities and case studies. They will help you learn the subject quickly and easily.











A Handbook for Student Nurses provides an introduction to the essential background knowledge that you need as a foundation for your pre-registration training, including:

- Practice supervision and assessment
- Communication
- Legal and professional issues
- Values, ethics and cultural awareness
- Reflection and personal development
- Quality care and evidence-based practice
- Study skills
- Public health and promoting health and wellbeing

NUMERACY AND CLINICAL CALCULATIONS FOR NURSES

SECOND EDITION

Neil Davison

Teaching Fellow, Bangor University

Lantern

ISBN: 9781908625793
Second edition published 2020
First edition published 2015 by Lantern Publishing Limited (ISBN 9781908625243); reprinted 2015, 2016, 2017, 2018
Lantern Publishing Limited, The Old Hayloft, Vantage Business Park, Bloxham Rd, Banbury, OX16 9UX, UK
www.lanternpublishing.com

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Typeset by Medlar Publishing Solutions Pvt Ltd, India
Cover design by Andrew Magee Design Ltd
Printed in the UK
Last digit is the print number: 10 9 8 7 6 5 4

CONTENTS

About the author *vi*

Preface to the second edition *vii*

Acknowledgements *viii*

How to use this book *ix*

Chapter 1 Numeracy and calculation skills in the clinical environment 1

Chapter 2 Back to basics *9*

Chapter 3 The SI system 55

Chapter 4 Calculating drug doses *67*

Chapter 5 Other clinical calculations 101

Chapter 6 Self-assessment tests 127

Appendices

1 *Administering medicines safely* *151*

2 *Routes of administration* *153*

3 *Medication administration records* *155*

4 *Drug glossary* *157*

5 *Multiplication grid* *161*

6 *Conversion tables* *163*

Answers to self-assessment tests *167*

References *189*

ABOUT THE AUTHOR

Neil Davison worked in trauma and orthopaedics after the completion of his state registration and orthopaedic nursing qualifications in the 1970s and early 1980s. He lectured at Bangor University for two decades and has extensive experience of teaching drug calculations and numeracy to both pre- and post-registration students. He was made a Teaching Fellow at the university in 1999 and retired in 2012. Since then Neil has continued to teach on healthcare courses in the further education sector and in the hospitals of North Wales.

PREFACE TO THE SECOND EDITION

Drug and clinical calculations are a significant part of modern nursing practice but performing them can cause unnecessary anxiety in many nurses.

This drug calculation book is written for student nurses at the start of their career and registered nurses who need a refresher. It is influenced by many years of teaching numeracy and drug calculation skills to undergraduate nurses in the classroom and practice setting, preparing them for online and traditional examinations and ultimately registration with the NMC.

The book aims to increase the reader's skills and confidence in calculating drug doses, whether in preparation for clinical practice, drug calculation exams or as part of professional updating. This is achieved by an initial self-assessment of numeracy skills, followed by practical examples that explore the key principles, techniques and formulae needed to accurately calculate drug dosages. This second edition provides more opportunities to assess your progress throughout the book and additional comprehensive summary tests in the final chapter.

Neil Davison

ACKNOWLEDGEMENTS

The publishers would like to thank the following lecturers and a selection of their students for reviewing the Back to Basics chapter of this book and providing useful comments that have informed the final version:

Maureen Crowley, University of the West of Scotland
David Maynard, Birmingham City University
Caroline Ridley, Manchester Metropolitan University
Maggie Roberts, University of Nottingham

Thanks also to Judy Waterlow for permission to reproduce the Waterlow chart (www.judy-waterlow.co.uk).

The 'Malnutrition Universal Screening Tool' ('MUST') is reproduced with the kind permission of BAPEN (British Association for Parenteral and Enteral Nutrition). For further information on 'MUST' see www.bapen.org.uk.

The National Early Warning Score (NEWS) is reproduced with permission from the Royal College of Physicians. *National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*. Updated report of a working party. London: RCP, 2017.

HOW TO USE THIS BOOK

There are various ways to use this book:

If you are a student nurse or have returned to nursing after a career break and want a comprehensive understanding of drug and clinical calculations used in nursing, then read the book cover to cover.

If you are confident in your basic numeracy skills but want to learn how to apply these to the clinical setting, concentrate on *Chapters 3* to *6*. These will equip you with information about the SI system used in healthcare, how to calculate drug doses and the use of numbers and calculations in other areas of clinical practice like nutrition and fluid balance. *Chapter 6* contains several tests so you can check your knowledge and understanding.

If you are an experienced nurse and have changed career directions and are unsure whether your current knowledge of drug and clinical calculations is up to scratch, then focus your study on *Chapters 3*, *4* and *6*. This will allow you to revise the SI system and practise calculating drug doses and other clinical calculations.

If you are confident in your basic numeracy skills but want to gain more practice of drug calculations then concentrate your efforts on *Chapters 3*, *4* and *6*. These focus mainly on drugs, the units of measurement and calculating correct doses.

If you are revising for a drug calculation exam, focus on *Chapters 3*, *4* and *6*. These chapters explain the SI system and the fundamentals of calculating drug doses as well as providing many clinically related practice calculations.

03

THE SI SYSTEM

THIS CHAPTER:

- outlines the SI units of measurement commonly used by nurses in clinical practice
- describes the units used for volume, weight and pressure and identifies the conventions of the SI system
- explains the procedure for converting within an SI unit of measurement.

3.1 Introduction

The SI system is an adaptation of the metric system and is almost universally employed in business, science and healthcare. The name SI is an abbreviation of the 'International System of Units', which was derived from the French 'Système International d'Unités'.

In healthcare, there is often a need to measure things, usually weights and volumes. In the SI system, volume is measured in litres and weight is measured in kilograms.

SI prefixes

SI units are used to quantify measurements, some extremely large and some extremely small. Standard prefixes are used to describe and name the quantities involved, irrespective of what is being measured.

The most commonly used prefixes that apply to clinical practice are:

- **Mega** – this prefix indicates millions. Benzylpenicillin, a penicillin antibiotic that is administered by injection, is available in vials containing one mega unit.

- **Milli** – this prefix indicates a thousandth of a unit. One milligram is one thousandth of a gram. Aciclovir dispersible tablets, used to treat shingles, contain 800 milligrams.
- **Micro** – this prefix indicates a millionth of a unit. One microgram is one millionth of a gram. (There are one thousand micrograms in one milligram and one thousand milligrams in one gram. One thousand multiplied by one thousand equals one million.) Glyceryl trinitrate, taken to relieve angina, is available in tablets containing 500 micrograms.
- **Nano** – this prefix indicates a thousand-millionth of a unit. This is extremely small and rarely used in clinical practice.

3.2 Volume

Volume is measured in litres or subunits of a litre, millilitres. 1000 millilitres is equal to one litre. The standard abbreviation for litre is L and the abbreviation for millilitre is ml.

Measuring volume

Drawing up medication in a syringe to accurately reflect a prescription is a common task in clinical practice. Syringes are available in several sizes. Reading the volume contained in the syringe is a prerequisite to accuracy.

SYRINGE SIZE	NUMBER OF GRADUATIONS	VOLUME OF EACH GRADUATION
1 ml	20	0.05 ml
2 ml	20	0.1 ml
5 ml	25	0.2 ml

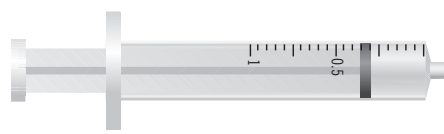


Figure 3.1. *A 1 ml syringe containing 0.3 ml.*

Figure 3.2. *A 2 ml syringe containing 1.6 ml.*

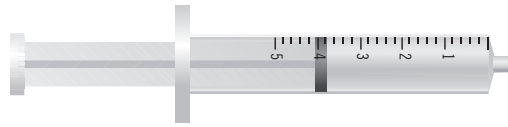


Figure 3.3. *A 5 ml syringe containing 3.8 ml.*

Some medicines such as heparin and insulin are measured in 'units'. Heparin is available in pre-loaded syringes or as a solution for injection at 5000 international units/ml or 25 000 international units/ml.

Insulin can be injected via a battery-operated pump, a pen device that uses a pre-loaded cartridge or by using a unique syringe that can measure up to 100 units. In the UK, insulin is available as U100 which means there are 100 units of insulin/ml. A prescription will state the number of units of insulin (and the type of insulin) that need to be given, for example 20 units.

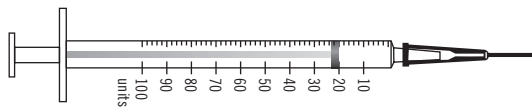


Figure 3.4. *An insulin syringe containing 20 units of insulin.*

Medicine pots are commonly used for the administration of oral solutions. When measuring liquids in a pot, read the lower meniscus line as the liquid may rise slightly against the medicine pot wall.

Figure 3.5. *A 25 ml medicine pot containing 20 ml.*

ERROR ALERT

Within the SI system it is standard practice that unit abbreviations are written in lower case, but because litre abbreviated to 'l' could be confused with the number '1', it is abbreviated to a capital letter 'L'. It is also important to remember that when expressing plurals, there is no 's' on the end of the abbreviated form. We may talk of a patient drinking 250 millilitres of tea, but when written this becomes 250 ml. It is also standard practice that the abbreviated form of the SI unit does not have a full stop after it, unless it is at the end of a sentence.

3.3 Weight

Kilograms

The SI unit of weight is the kilogram, which can be subdivided into smaller units several times. Kilograms are useful when measuring large items like body weight, but when measuring small amounts of drugs, alternative units of measurement are needed. The unit smaller than one kilogram is a gram, and 1000 grams equal one kilogram.

The abbreviation for gram is 'g'.

Converting from a larger unit to a smaller unit

RULE OF THUMB

Converting from a larger unit to a smaller unit means that you multiply by 1000.

Converting from a smaller unit to a larger unit means that you divide by 1000.

To convert 0.125 kilograms to grams:

$0.125 \times 1000 = 125$ grams

It's useful to remember that when multiplying by 1000, the decimal point moves three places to the right, i.e. one place for each zero.

0.125 becomes 125 (arrows show the decimal point move)

Converting from a smaller unit to a larger unit

To convert 125 grams to kilograms:

$125 \div 1000 = 0.125$ kg

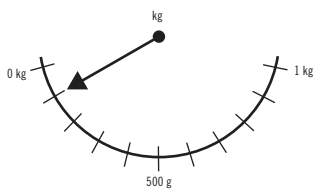
Remember that when dividing by 1000, the decimal point moves three places to the left.

125 becomes 0.125 (arrows show the decimal point move)

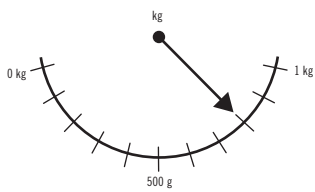
Self-assessment test 3.1: converting kilograms and grams

The recap questions below will help to consolidate your learning about conversions between these two units of measurement. Answers can be found at the end of the book.

1 How many grams are in 1.3 kg?
2 How many grams are in 1.25 kg?
3 How many grams are in 0.8 kg?
4 How many grams are in 0.125 kg?
5 How many grams are in 1.204 kg?
6 How many grams are in 0.5 kg?
7 How many grams are in 2.03 kg?
8 How many grams are in 0.032 kg?
9 How many grams are in 1.005 kg?
10 How many grams are in 0.002 kg?
11 How many kg are in 2500 grams?
12 How many kg are in 4025 grams?
13 How many kg are in 750 grams?
14 Identify the amount shown on the scale:



15 Identify the amount shown on the scale:



Grams and milligrams

Grams are widely used within clinical practice in drug administration. Grams can be divided into smaller units called milligrams; there are 1000 milligrams in one gram. Two 500 milligram paracetamol tablets are the equivalent of one gram. The correct abbreviation of milligram is 'mg'. Morphine is an opioid analgesic frequently used to control severe pain; it can be injected (intramuscularly, intravenously, and subcutaneously) and administered orally. As an oral solution, it is available in several different strengths. One of these contains 2 mg in 1 ml, therefore in 5 ml there are 10 mg.

Self-assessment test 3.2: converting grams and milligrams

The recap questions below will help to consolidate your learning about conversions between these two units of measurement. Answers can be found at the end of the book.

1. How many milligrams are in 1.04 g?
2. How many milligrams are in 1.005 g?
3. How many milligrams are in 0.001 g?
4. How many milligrams are in 2.202 g?
5. How many milligrams are in 1.016 g?
6. How many milligrams are in 0.33 g?
7. How many milligrams are in 0.75 g?
8. How many milligrams are in 0.06 g?
9. How many milligrams are in 1.018 g?
10. How many milligrams are in 0.106 g?
11. How many grams are in 1500 mg?
12. How many grams are in 2200 mg?
13. How many grams are in 900 mg?
14. Metformin is a drug used in diabetes. It is available in 850 mg tablets. Express this in grams.
15. Augmentin, an antibiotic, is available in 625 mg tablets. Express this in grams.

Micrograms

Milligrams can also be divided into smaller units called micrograms. There are 1000 micrograms in one milligram. Converting milligrams to micrograms follows the same rule as when converting kilograms to grams and grams to milligrams.

To convert 0.25 mg to micrograms:

$0.25 \times 1000 = 250$ micrograms

Remember that when multiplying by 1000, the decimal point moves three places to the right, i.e. one place for each zero.

0.25 becomes 250 (arrows show the decimal point move)

Self-assessment test 3.3: converting milligrams and micrograms

The recap questions below will help to consolidate your learning about conversions between these two units of measurement. Answers can be found at the end of the book.

1. How many micrograms are in 1.25 mg?
2. How many micrograms are in 1.062 mg?
3. How many micrograms are in 0.075 mg?
4. How many micrograms are in 0.220 mg?
5. How many micrograms are in 1.028 mg?
6. How many micrograms are in 0.009 mg?
7. How many micrograms are in 0.7 mg?
8. How many micrograms are in 0.125 mg?
9. How many micrograms are in 1.5 mg?
10. How many micrograms are in 0.75 mg?
11. How many milligrams are in 1200 micrograms?
12. How many milligrams are in 800 micrograms?
13. How many milligrams are in 250 micrograms?
14. Salbutamol is a drug used in asthma by inhaler. Each inhalation is 100 micrograms. Express this in milligrams.
15. Glyceryl trinitrate is a drug used in angina. It is available in several strengths, but if a tablet (placed under the tongue) contains 0.6 mg, what is this amount expressed in micrograms?

ERROR ALERT

There are two abbreviated forms of microgram 'mcg' and 'µg' but the use of these in clinical practice is controversial. For patient safety reasons, many hospitals demand that microgram is written in full to avoid confusion with 'mg'. If you see microgram abbreviated on a prescription, contact the prescriber to get the unit written in full, which could avoid a catastrophic drug overdose.

PRACTICE TIP

Conventions for prescriptions state that drugs should be prescribed in whole amounts, not decimal fractions. A prescription for digoxin should read 125 micrograms, not 0.125 mg, so you must be able to convert between units.

KEY POINT SUMMARY

- 1000 micrograms = 1 milligram (mg)
- 1000 milligrams (mg) = 1 gram (g)
- 1000 grams (g) = 1 kilogram (kg)

3.4 Pressure

The commonly used unit for the measurement of blood pressure in clinical practice in the UK is millimetres of mercury, which has the abbreviation 'mmHg'. Capital letters aren't routinely used as abbreviations for units of measurement, but Hg is the international symbol for the element mercury. You will see this displayed on sphygmomanometers used to measure and record a patient's blood pressure.

There is also an SI unit for pressure called the pascal (abbreviation Pa), which is named after the French physicist and mathematician Blaise Pascal (1623–1662). The pascal is a small unit so you are more likely to see it referred to using the prefix kilo, as kilopascal (kPa). The prefix kilo means 1000, so one kPa is equal to 1000 pascals. One kPa is equal to approximately 7.5 mmHg.

NON-SI UNIT FOR PRESSURE MEASUREMENT	SI UNIT FOR PRESSURE MEASUREMENT	COMPARISON
millimetres of mercury mmHg	pascal Pa	1 kPa = 7.5 mmHg (approximately)

ERROR ALERT

Where drug doses depend on body weight, as when using low molecular weight heparin, accurately weigh the patient. Guessing or asking patients to estimate their body weight is a known source of drug error and a potentially dangerous practice (NPSA, 2010; Charani *et al*., 2015; ISMP Canada, 2016).

The kPa is recognised as the standard unit for measuring blood gases in the UK, so you are likely to come across arterial blood gas analysis reports using kPa in intensive care and high dependency units, and on respiratory wards.

Blood for gas analysis is taken from an artery and is tested to find out the amount of oxygen and carbon dioxide contained within it. A unit of pressure like the kPa or mmHg is used to measure this as the mixture of gases in the blood each have a pressure. In a mixture of gases, each gas exerts a partial pressure, indicated as PaO_2 for oxygen and $PaCO_2$ for carbon dioxide. The pH of blood is also measured in arterial blood gas analysis.

Arterial blood gas normal values are summarised in the following table.

NAME	NORMAL VALUE
PaO_2	75–100 mmHg
$PaCO_2$	34–45 mmHg
pH	7.35–7.45

Self-assessment test 3.4: summary test

The recap questions below will help to consolidate your learning about the contents of this chapter. Answers can be found at the end of the book.

1. How many milligrams are in 1.3 g?
2. How many milligrams are in 0.8 g?
3. How many milligrams are in 1.125 g?
4. How many milligrams are in 0.6 g?
5. How many milligrams are in 0.505 g?
6. How many micrograms are in 0.75 mg?
7. How many micrograms are in 1.001 mg?
8. How many micrograms are in 0.07 mg?
9. How many micrograms are in 0.902 mg?

Self-assessment test 3.4: summary test (*continued*)

10 How many millilitres are in 1.5 L?

11 How many millilitres are in 2.25 L?

12 How many millilitres are in 0.1 L?

13 How many millilitres are in 0.075 L?

14 How many millilitres are in 0.005 L?

15 What volume of fluid is in the syringe shown?

16 What volume of fluid is in the medicine pot shown?

17 Complete the table by converting the SI units.

GRAMS (g)	MILLIGRAMS (mg)	MICROGRAMS
	6	
		120
0.01		
	9.5	
1		
		250
	1	
	2.75	
0.008		
		500

Write your answers to questions 18 to 22 in milligrams.

18 22.5 mg + 4600 micrograms =

19 1.6 mg + 500 micrograms =

20 4.005 mg + 6 micrograms =

21 123 mg – 900 micrograms =

22 6 mg – 25 micrograms =

Self-assessment test 3.4: summary test (*continued*)

23 Place the following weights into ascending order, starting with the smallest. 200 mg, 1100 micrograms, 1.5 g, 5 mg, 65 micrograms, 0.5 g, 0.25 mg, 25 micrograms, 1.5 mg, 0.005 mg, 3 micrograms, 2 g, 2100 mg, 1.6 mg, 1607 micrograms, 750 mg, 0.22 g, 0.034 mg, 0.065 g, 0.125 g, 400 micrograms

24 A patient is prescribed 300 mg of a drug to be taken at breakfast and lunchtime and a dose of 450 mg in the evening. How many grams per day does the patient take?

25 A liquid medicine contains 20 mg in 5 ml.

a **How many milligrams are in 7.5 ml?**

b **How many milligrams are in 12.5 ml?**

26 A patient takes lorazepam 1 mg as sedation before a minor surgical procedure. How many micrograms is this?

27 A patient takes tamsulosin hydrochloride 400 micrograms for benign prostatic hypertrophy. Express this quantity in milligrams.

28 A patient is given 1.5 g of the antibiotic cefuroxime. How many milligrams is this?

29 A patient takes a sodium valproate 300 mg modified release capsule. Express this amount in grams.

30 A patient wears a glyceryl trinitrate 5 mg patch for 24 hours. How many micrograms is this?

KEY POINTS TO TAKE AWAY FROM THIS CHAPTER

- The SI system means that volumes and weights can be written in whole numbers which increases patient safety.
- The strict conventions in the use of abbreviations, plurals and capital letters within the SI system are to ensure accuracy and safety.
- Some units, like mmHg, which is used to measure pressure in clinical practice, are not from the SI system but are acceptable and safe.