Contents

PART I – DRUG CALCULATIONS IN CONTEXT

Part I

Drug calculations in context

1 Back to Basics!

Calculating and understanding simple medicine dosages

“Setting the scene and laying the foundations”

This chapter explores:

- How medication strengths are expressed using different units of measurements
- Converting between medication doses expressed in different units of measurements
- Calculating medication dose using prescription charts and stock medicine
- Calculating medication dose from daily dose prescriptions
- Calculating medication dose from prescriptions based on patient body weights

Units of Measurement

I am going to go right back to very basics to help you understand units of measurement. The amount of drug that is prescribed for a patient is specific according to their clinical condition, their weight and the therapeutic effect of that drug. In order to ensure that this amount is administered, we need to be able to measure the drug. This is similar to when you are baking a cake; you need to have specific amounts of each ingredient, for example flour or eggs. Most drugs are measured according to their weight or their volume, or their weight and volume together.

The main units of measurement for weight used in clinical practice are kilograms, grams, milligrams, micrograms and nanograms (see Box 1). The main units of measurement for volume are litres and millilitres (see Box 1).

Box 1 Common measurements used in drug dosages, with abbreviations

Measurement	Abbreviation	Size order	Measurement	Abbreviation
Grams	g	Decreasing in size ↓	Litres	L
Milligrams	mg		Millilitres	ml
Micrograms	mcg			
Nanograms	Nanograms Should not be abbreviated			

There are other ways of expressing measurements for drugs and these will be discussed in more detail in relation to calculations as we move through the book (see Box 2).

Box 2 Measurement types and explanations

Measurement	Explanation
Grams, milligrams, micrograms and nanograms	Measures of a drug's weight, for example 1 gram paracetamol
Weight/volume	Some drugs are expressed according to the amount of weight of drug that has been dissolved in a certain amount of volume. For example, an elixir may contain 100mg/5ml (see Chapter 2)
Standardised International Units	These refer to a measurement of activity or effect of the drug. Each one unit of the drug has a specific biological effect, which is agreed internationally and is thus standardised. This varies for each drug. Quantities of the drug are then expressed as multiples of this standard The quantity of the drug has been standardised into 'units' of measurements, known as international units (IU), for example 25 000 units heparin (see Chapter 2 on units)
Percentages	Percentage refers to an amount of the drug standardised out of a hundred. For example, 5% glucose infusion refers to 5g out of every 100ml
Moles and millimoles (mmol/L)	Chemicals used as drugs, such as potassium, are expressed according to the number of atoms (smallest part of the chemical) that a solution contains. As atoms are very tiny, a measurement is often given for a specific number of atoms known as a 'mole'. There are also smaller measurements of the 'mole'. The most commonly seen in practice is the millimole (1 mole = 1000 millimoles). For example, an infusion may contain 40 millimoles of potassium in 1 litre. This is written as 40mmol/L
Ratios	Measurements can be expressed as a relationship between two parts. In drugs this is usually the relationship between the weight of a drug and the volume it is dissolved in. The most common ratio used in practice is adrenaline, which is often used in strengths 1:1000 or 1:100. This means that there is 1g of adrenaline to 1000ml (1:1000) or 1g adrenaline to 100ml (1:100) (see later in Chapter 1)

Weight

Most of us are familiar with kilograms (kg) and grams (g) as we use these measurements in everyday life, for example using 100g butter in a cake or buying a 2kg bag of sugar. (Although some of us are still more familiar with the old imperial system of pounds (lbs) and ounces (oz), we are at least aware and use the metric system on a daily basis.)

Kilograms and grams are useful measures for food where you need a relatively large amount. However, for drugs, where only a small amount may be needed to have a therapeutic effect, different weight measurements are required. This is where the other measurements of milligrams, micrograms and nanograms are useful (see Box 1).

✱ Clinical Context

Only a tiny amount of digoxin is needed to have a therapeutic effect on a patient. If you only used the measurement of kilograms to express this weight of digoxin, you would have a prescription for 0.000000125kg! Obviously having such a number written on a medicine chart and on tablet bottles is cumbersome and likely to cause errors, with the risk of someone missing out one of the zeros. So in order to make it easier and safer to measure weight dosages for drugs, different, smaller units of measurements are required.

The order of size for the units of measurement and their common abbreviations can be seen in Box 1. In clinical practice, grams, milligrams and micrograms are the most common units used. When working in clinical areas where patients are clinically unstable, such as intensive care or theatres, or if working with young children and babies in paediatrics, much smaller amounts of drugs are required. In these areas the unit of measurement nanograms would also be used.

Drug dosages tend to be fairly stable in nursing, particularly in adult nursing, so that you begin to recognise the common dosages prescribed for certain drugs and the usual unit of measurement used. For example, I'm sure you have all seen paracetamol prescribed for adults as 1 gram, or amoxicillin for adults in milligrams.

Being able to recognise common drug dosages and their usual measurements will help you to form a picture in your head of what 1 gram looks like or 250 milligrams, for example. This will help when you are converting between different units of measurement (which I will explain shortly) and will also help you to check that any calculations you solve make sense for that particular drug.

Warning!
As nurses, we should always be familiar with the typical dosages for each drug before we administer these to ensure that there are no errors in either the prescription or our administration. Obviously it would be impossible to learn all the dosages for every single drug, which is why you should always have access to a drug formulary such as the *British National Formulary* (BNF) and use this to check before administering.

Formulations

Box 3 Common formulations for drugs

Formulation	Description
Tablets	Drug is mixed with a base to bind drug into a tablet form and then often coated with coloured material or sugar. Binding substance can be used to delay release of drug in stomach or intestine, for example slow release tablets
Capsules	Capsule containing the drug is made out of gelatine or a similar substance. Drug is released in the stomach or intestine as capsule is digested. Capsule substance can be used to delay the release of the drug
Elixir	Drug is dissolved in a liquid which usually contains alcohol and sweeteners
Mixtures	Liquids that contain several ingredients dissolved or diffused throughout water or another solvent
Emulsion	Two liquids where one is dispersed within the other
Linctus	A liquid that contains a syrupy substance to relieve coughs, for example codeine linctus
Ampoules or vials	A drug that has been dissolved in a liquid, usually water. If the drug is unstable in a liquid, it may be contained in the ampoule or vial as a powder form and require reconstituting prior to use, for example antibiotics

Drugs are manufactured in different formulations, for example tablets, elixirs and ampoules (see Box 3 for different formulations). For each formulation, the dose of drug contained is most commonly expressed in the weight that each amount of formulation contains of the drug. For example, for tablets and capsules the dosage in weight is given for each tablet, while for elixirs and ampoules it is the weight of drug that each set volume of the liquid contains, as illustrated below (Figure 1).

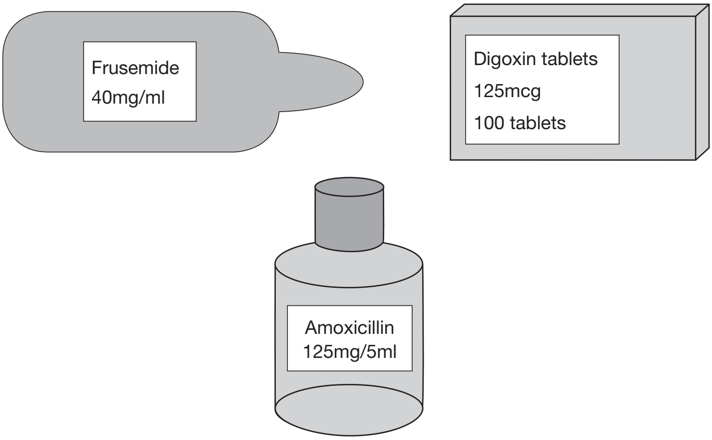


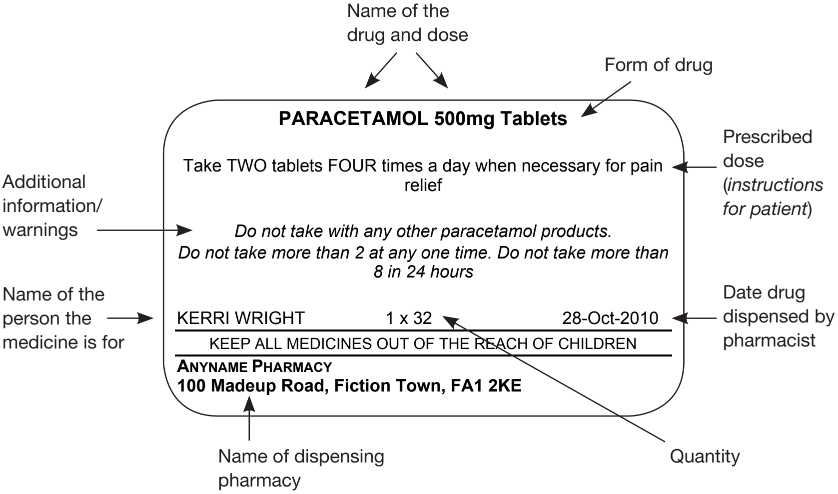
Figure 1 Medications and the dosages expressed as weight/volume or weight for elixir, ampoules and tablets

Warning!
It is important that you check the medicine dosage carefully and understand what this means before beginning to calculate or administer it.

Labelling of Medications

Medicine that is kept as stock in a hospital ward is labelled by the drug manufacturers and contains information about the name of medicine, the dosage, expiry date and the number of tablets in the container/volume in the container or ampoules in the box. This information needs to be checked before you administer any medication (see Figure 2).

Figure 2 Illustration of a medicine packet and labelling



PARACETAMOL 500mg Tablets

Take TWO tablets FOUR times a day when necessary for pain relief

Do not take with any other paracetamol products.
Do not take more than 2 at any one time. Do not take more than 8 in 24 hours

KERRI WRIGHT 1 x 32 28-Oct-2010

KEEP ALL MEDICINES OUT OF THE REACH OF CHILDREN

ANYNAME PHARMACY
100 Madeup Road, Fiction Town, FA1 2KE

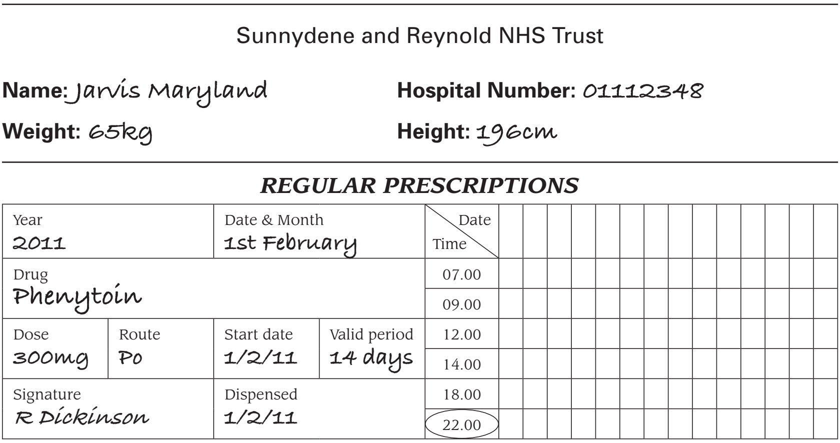
Figure 3 Medicine labelled for an individual person

When a medication has been dispensed for a specific person, it will have an additional administration label which has been added by the pharmacist. This can be a community pharmacist for people at home or a hospital pharmacist for people in a hospital or hospice (see Figure 3). This medicine must **only** be given to the person named on the label. The expiry date for this medicine will be on the side as before (see also Figure 4). A batch number refers to a group or batch of drugs that were produced at the same time by the manufacturers. This is useful if there is ever a problem with a drug as the manufacturers can track all drugs made at the same time (Figure 4).

Figure 4 A side view of a medicine box showing the expiry date and batch number

Warning!
It is vital that you concentrate when you are calculating drug dosages and administering medication. You need to ensure that you create an environment that is as free as possible from distractions and allows you to concentrate. Ideally, complex dosage calculations should be undertaken in a room away from distractions, for example in a quiet room in a patient's house or a treatment room.

When you have medicine that is for an individual person, the dose prescribed and the amount of this medicine to be administered will have already been worked out by the pharmacist and put on the label. When you are using stock medicine, however, you need to calculate the amount to administer using the prescribed dosage. Generally, the prescribed dosage is written on a medicine administration chart (see Figure 5).



Sunnydene and Reynold NHS Trust

Name: Jarvis Maryland
Hospital Number: 01112348
Weight: 65kg
Height: 196cm

REGULAR PRESCRIPTIONS

Year 2011		Date & Month 1st February		Date Time														
Drug Phenytoin				07.00														
				09.00														
Dose 300mg	Route Po	Start date 1/2/11	Valid period 14 days	12.00														
				14.00														
Signature R Dickinson		Dispensed 1/2/11		18.00														
				22.00														

Figure 5 An example of a medicine administration chart

Looking at the medicine chart above, what dose of phenytoin does Jarvis require? Hopefully you can all read the information from the medicine chart that states that Jarvis has been prescribed 300mg phenytoin to be administered orally. As the nurse caring for Jarvis, you need to ensure that he receives this dose of phenytoin at the time prescribed.

On a ward, drugs are generally stocked in a drug trolley or in a patient's locked cupboard by their bed. Nurses take the required medicine from this stock. If the phenytoin tablets in stock each contain 100 milligrams of phenytoin, you would need to calculate how many tablets to give to Jarvis so that he received the required dose. I know this sounds obvious and you may be thinking that of course you would give three 100 milligram tablets to Jarvis because three lots of 100 milligrams would give 300 milligrams. If you have leapt to this solution then well done. Don't skip on to another section though, thinking that you know this and it's too easy. It is really important that you start to understand how you worked out the answer. This will help you in three ways to:

1. Be safe and confident in the knowledge that your solution is correct
2. Develop secure problem-solving skills for when you are faced with really tricky calculations
3. Be able to explain to someone else why your answer is correct and support them with *their* calculations if necessary

It is important that you are secure in these fundamental steps of calculating so that you can build on these, knowing that your foundations are strong.

Warning!

It is important that you learn the different routes by which medications can be administered and also the abbreviations that are used on medicine administration charts. The route will give you information about the dose and whether it is likely to be correct and can also be useful in helping you to understand what it is you are trying to calculate, for example number of tablets to give for the patient to swallow or number of millilitres to inject (see Box 4).

With the example in Figure 5 you had to give a 300 milligram dose to Jarvis and you had tablets available which each contained 100 milligrams. Most people do one of two things when faced with a calculation like this:

1. Either they 'see' immediately that 300 divided by 100 would be 3 so Jarvis would require 3 tablets.
2. Or they 'see' that 100 milligrams add 100 milligrams add another 100 milligrams would give 300 milligrams, which is the required dosage so would be 3 tablets.

Box 4 Summary of the common routes, abbreviations and usual dose for this route

Route	Abbreviation	Forms	Usual dose
Orally	PO or O	Tablets, capsules, suspensions	1–5 tablets or between 1–50ml if suspension
Via PEG or NG tube PEG = percutaneous endoscopic gastrostomy tube NG = naso gastro tube	Via PEG or NG	Suspensions, elixirs	In liquid form so usually millilitres. Volume depends on dosage calculated for that medicine; usually more than 5ml. Medicine requires flushing with water to ensure it reaches the stomach and prevents tube blocking
Intramuscular injections	IM	Ampoules or vials* (may require reconstituting)	In liquid form so usually millilitres. Amount varies according to muscle site of injection and age of child but generally no more than 5ml
Intravenous	IV	Infusion bags, ampoules or vials* (may require reconstituting)	In liquid form and varies according to medication and how this needs to be administered, for example added to an infusion bag or as an injection
Subcutaneous	S/C or SC	Ampoules or vials* (may require reconstituting)	In liquid form so usually millilitres. Amount varies according to site for injection and age of child but generally no more than 2ml

* The terms ampoule or vial are often used interchangeably and refer to a small glass or plastic bottle that contains medicine in either a liquid or solid form (powder). I will be using both terms throughout this book.

The first method can be simplified and put into a formula that can be used each time this type of calculation is required. This formula is dividing the dosage of drug that the patient requires by the dosage contained in each tablet available. Most nurses shorten this formula to ‘what you want divided by what you have’.

The second method is a repeated addition method and is often supported by the actions of the nurse during the physical act of administering the drug. For the above example, I would put each 100 milligram tablet into the dispensing pot and add up the total dosage contained until the prescribed dosage is reached. This method also allows the solution to be checked by actively counting the number of tablets as they are put into the pot: 1 tablet (= 100 milligrams), 2 tablets (= 200 milligrams), 3 tablets (= 300 milligrams). To check you have followed this, I am going to work through another example.

Example

You pick up a medicine chart for Mrs Davis who requires 30 milligrams prednisolone. You look in the drug trolley and the stock tablets available are 5 milligram tablets.

Formula method

$$\frac{\text{what you want}}{\text{what you have}} = \text{number of tablets}$$

$$\frac{30 \text{ milligrams}}{5 \text{ milligrams}}$$

$$= 6 \text{ tablets}$$

Repeated addition method

5 milligrams	1 tablet
10 milligrams	2 tablets
15 milligrams	3 tablets
20 milligrams	4 tablets
25 milligrams	5 tablets
30 milligrams	6 tablets

Of course there is nothing stopping you from using a combination of the two methods. For example, you might prefer the formula method, but then check your solution by repeatedly adding up the dosage weight contained in each tablet to check that it totals the required prescribed amount.

Before we move on, I need to take a slight detour. I know you are probably desperate to get on with it, but it is a vital and necessary detour at this stage.

Checking

Often when students or nurses are solving drug calculations and especially when these are being practised from books or in a classroom setting, there is a tendency to rush to get to the answer and to check to see whether this is right. No problem here you may be thinking and yes, that is true, it is not a problem when you are in a classroom setting or sat at home. After all if you got the calculation wrong, all that happens is you have a look to see why, kick yourself for making such a silly mistake, correct it and move on. This is not the case in clinical practice. The answer that you reach is going to determine the dosage that you administer and if wrong … well, I don't need to tell you what the implications could be. So, even if you are doing drug calculations at home or in a classroom it is vital that you get into the habit of checking your answer **as if** you were in clinical practice. It is precisely because we know that the dosage could cause harm to a patient if wrong that we do check and re-check in clinical practice (or at least we should do).

We need to get into the habit, in the classroom and at home, of thinking as if we were in practice and carry over these skills to the clinical setting. This means that when you arrive at your solution this is not the end point of your calculation at all. You need to carefully check this solution and your working out to ensure that you don't just **think** it is the right answer, but you **know** that it is right. Box 5 gives several ways for you to check that your answer is definitely correct. Please take the time to read this and practise these checking techniques. You can even photocopy this and pin it to your wall!

Box 5 Checking your solution to drug calculations

Checking

There are different ways that you can check that you have calculated the correct dosage. Some of the methods you would do naturally in a clinical setting and some you will need to train yourself to do. Some of the natural checks that you would do are not possible in a classroom, so in order to activate some of these natural checks you will need to imagine that you are in your clinical area and visualise actually preparing that dosage to administer.

Making sense

- The first obvious check is to look at your solution in the context of your understanding of the question and ask whether it fits as a solution here. So, does it make sense to administer that number of tablets or that volume of elixir considering what you are trying to work out?

For example, if you needed to give 10mg of a drug, the ampoules available are 50mg/1ml and you have worked out that you need to administer 5ml. Does this make sense? If 1ml contains 50mg then you need less than 1ml for 10mg so 5ml cannot be correct. This should stimulate you to relook at the question and see where you have gone wrong or try a different method for solving it.

- Estimate the answer or a range that you are expecting your answer to be within. The ideal situation would be for you to work out estimates for your solutions first, before you even start to solve the problem. However, you can also do them as you go along to check that you are on the right lines and also at the end to double-check your solutions.

For example, if you needed to administer 80mg and the ampoules were 100mg/2ml you can work out a range for this solution of between 1–2ml by using the halving method. The diagram below illustrates how to estimate the amount of solution to administer (and see, Chapter 2 for explanation of halving methods).

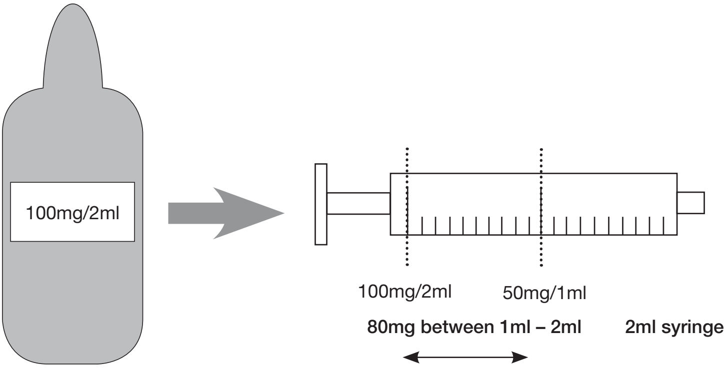


Diagram illustrating how to estimate the amount of solution to administer

✔ Tips for Learning

Use the halving or doubling method to give you a rough estimate of what your answer should be (see Chapter 2, pages 45 and 48).

Practice experience

- You also need to look at your answer and think whether it makes sense in relation to clinical practice and your clinical experience. So have you ever administered 40 tablets to a patient? Have you ever had to draw up 5.3ml of a drug from ampoules before? Have you ever given 0.1ml of a suspension before? If you haven't done these things, this is not to say that you are wrong as there is a first time for everything, but it should ring a warning bell.

  The unfamiliarity of a drug dosage should trigger alarm bells, and make you stop and think about your calculation and whether it can be right. If, once you have checked and are convinced your calculation is correct, but it is still an unusual amount of the drug to give, then you need to check with someone else as it could be an error in the prescription. Even when you are in a classroom setting you should not think that just because you are not in clinical practice then any solution could be right. You should still keep the alarm bells active and use them as a warning for you.

- Use your clinical knowledge about specific drugs. So is this approximately the right volume that we give for this particular drug in your experience? As nurses, we need to be familiar with the drug dosages for any drugs that we administer and develop from experience what the expected amounts should be when administering drugs expressed as a weight and volume.

  When solutions for particular drugs fall outside our expected ranges, then alarm bells should again be triggered and prompt you to examine your solution again more carefully. Once again, if in doubt, you shouldn't be administering the drug and should be asking for someone else to check your calculation and the prescription written.

  To give an example using tablets, if you calculated that you needed to administer 4 paracetamol tablets you would immediately have an alarm bell ringing because you know that for adults the usual dosage is 2 tablets, so the calculated dosage of 4 immediately activates your warning system that something isn't quite right. Sometimes we don't always know what it is that isn't quite right, just that it doesn't seem right. That feeling of unease should be enough to trigger careful examination of your calculation and the prescription.

- Check backwards to ensure that you have got the right dosage to administer. For example, if you have worked out that you need to administer 3 tablets, then count up this dosage to ensure it equals the prescribed dosage. This is a common check to do, but can be lost if you are in a classroom or at home. In these instances you will need to imagine that you are preparing the dosage in your head and visualise counting the tablets.

Checking calculations

- Always go back over any calculations to check for understanding and any errors. To do this we can just work through our calculations again and check that we have done these correctly or we can work backwards and do the calculations a slightly different way. For example, if I had calculated that 125 divided by 5 is 25, then I could check this by multiplying 25 by 5 and ensuring I reached the same answer of 125.

Doing the calculation another way

- Check your solution to a calculation using another method. I have heard some nurses say that they will use a calculator to double-check that their solution is correct. However, in contrast, I have seen other nurses use a doubling and halving method to check the solution they reached using a calculator. Sometimes when you find the question difficult to understand and cannot obviously see the answer, using a calculator and the formula method can help to actually make sense of the question.

  For example, if I had to administer 125mg of a drug and the elixir available was 50mg/5ml, I could use the formula method to give the solution to administer 12.5ml. Using this answer I could then work backwards to help me make sense of the answer and ensure it is correct. So here I may think 50mg/5ml, 100mg/10ml and 25mg/2.5ml so that would be 12.5ml.

There are quite a few different checks that you can and should be doing once your reach your solution. You must get into the habit of doing some of these each time you reach your solution or as you are working towards your solution. The most vital of these checks relies on your having a clear understanding of what that question is asking you to do. If you haven't got this understanding then you won't be able to look at your solution and see whether it actually makes sense. Many of these checking systems also rely on clinical experience so you must make sure that you practise these questions in a clinical situation as much as you can.

✔ Tips for Learning

It may not have escaped your notice that in order to solve problems such as this you need some mathematical knowledge. Thankfully, most drug dosages in clinical practice are nice easy numbers (particularly in adult nursing) so you can probably get away with working out 6 lots of 5 milligrams by adding up each 5 milligram and using your fingers to keep count of how many you have added. However, it would probably help you if you could recognise that 5 × 6 = 30 and therefore 6 tablets are required. The common dosages and multiples to learn are:

	×2	**×3**	**×4**	**×5**	**×6**	**×7**	**×8**	**×9**	**×10**	**×20**
5	10	15	20	25	30	35	40	45	50	100
10	20	30	40	50	60	70	80	90	100	200
15	30	45	60	75	90				150	300
20	40	60	80	100	120	140	160	180	200	400
25	50	75	100	125	150	175	200		250	500
50	100	150	200	250					500	1000
100	200	300	400	500	600	700	800	900	1000	2000
125	250	375	500	625			1000			
250	500	750	1000				2000			
500	1000	1500	2000							
1000	2000	3000	4000	5000	6000	7000	8000	9000	10 000	

For example, with the repeated addition method and an available tablet dose of 5mg then you would need to know your five times table!

For the formula method, if you have your calculator, then you need to understand that:

$$\frac{30 \text{ milligrams}}{5 \text{ milligrams}}$$

Mathematically, this actually means 30 milligrams divided by 5 milligrams or how many 5 milligrams there are in 30 milligrams. On your calculator you would therefore key in:

$\boxed{3}\ \boxed{0}\ \boxed{\div}\ \boxed{5}\ \boxed{=}$

If you did not have a calculator, then you would have to know that 30 ÷ 5 = 6 (or work it out using repeated addition).

To check that you are really secure in these two methods I will give you some more calculations from practice. The answers and the working for both methods are available in the answers section.

EXERCISE 1

1. The medicine administration chart states that Joy requires 1000 milligrams of amoxicillin. The stock tablets available each contain 250 milligrams of amoxicillin. How many tablets do you need to administer to Joy?
2. Sita requires 250 micrograms of digoxin. The tablets available each contain 62.5 micrograms. How many tablets would you administer to Sita?

(Answers: page 215)

✔ Tips for Learning

When buying a calculator for nursing, please consider the following guidance:

- You only need the four arithmetic functions of addition, subtraction, multiplication and division. Avoid using calculators that have more complex functions unless you are confident in using these
- Use an actual calculator rather than a calculator function on a mobile phone or computer
- Ensure that the calculator keys are the right size for your fingers. You need to be able to accurately key in the numbers and function

you want. Bigger keys are better and reduce the risk of pressing the wrong key by mistake
- Make sure that the screen is clear enough for you to read the numbers easily, bearing in mind that you may be using this when you are tired or the light is poor
- Try to use your own calculator consistently so you become used to how it works and the feel of the keys
- Always carry your calculator with you on duty if you are regularly calculating drug dosages and prefer to use a calculator for this

Converting

There are times in clinical practice when you need to express the unit of measurement used for a drug in another unit of measurement. For example, you may want to express 1 gram of paracetamol in milligrams or 0.1 milligram of aminophylline in micrograms. The most common time when you need to do this conversion is when the prescribed drug has been expressed in a different unit of measurement to the stock drug available. For example, the prescription may stipulate 0.25 milligrams of digoxin, but the stock tablets available on the ward or in someone's home are 62.5 microgram tablets. One dosage (in this case the prescription) is expressing the weight in milligrams and the other (tablets) is expressing the weight in micrograms. You cannot follow the same procedure as before to work out how many tablets you need to administer to give this dosage because the unit of measurement for each dosage is different. This is like trying to compare euros with dollars or kilograms with stones. The only way to compare the two dosages in order to calculate how many tablets to give is to convert both dosages into the *same* unit of measurement.

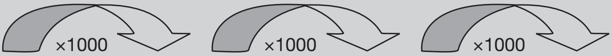
To convert between different units of measurement you need to know the relationship between them. This is the same as when you are on holiday and you want to understand how much money those classy jeans cost: you would convert the price given in dollars into sterling, that is, pounds. So you would work out that if $1 = £2 then the $25 jeans would cost £50 and are not quite the bargain you thought!

Thankfully, for converting between weights in clinical practice the 'conversion rate' stays stable (unlike currency rates) and is the same conversion amount between all the units of weight. So you only need to remember one number. That magic number is 1000.

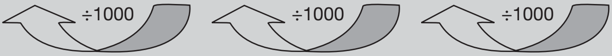
Using this relationship we know that:

1 kilogram = 1000 grams
1 gram = 1000 milligrams
1 milligram = 1000 micrograms
1 microgram = 1000 nanograms (see Box 6)

Box 6 Conversion



Grams	Milligrams	Micrograms	Nanograms
1	1000	1000 000	1000 000 000



Using this relationship, how many milligrams would be the same weight as 0.5 grams? Look back at Box 6 if you are not sure.

Just remember the 1000 relationship and you'll be halfway there. When converting between different weights, it will help you considerably if you can visualise in some way what it is you are doing. To be able to visualise this, it is helpful to be secure in your knowledge of the different units of weight and the size order of each of these. For example, if you can picture and understand that micrograms are 1000 times smaller than milligrams, you will be able to 'see' that you will need a thousand micrograms to make up the same weight as 1 milligram. This is the same as saying that you need 1000 mice to equal the same weight as 1 elephant! Have a look at Figure 6 below to help you imagine this.

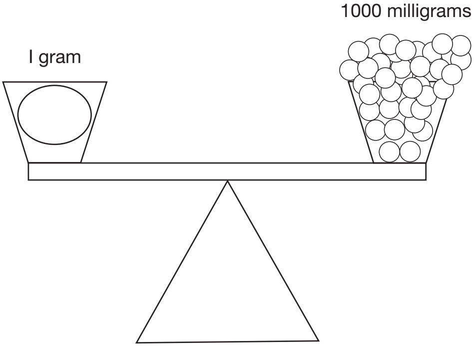


Figure 6 **Illustrating the relationship between grams and milligrams**

Remember that 1000 milligrams is the same weight as 1 gram so you need a thousand times more milligrams to equal the equivalent weight of grams. To work out how many milligrams is the same weight as 0.5 grams, therefore, you could do one of three things:

1. You could multiply 0.5 grams by 1000 (if you are unsure about multiplying and dividing by 1000 please go to Chapter 4 where this is explained in detail).
2. You could use the knowledge that 1 gram is the same weight as 1000 milligrams, so 0.5 is one half of 1 gram. Therefore the equivalent weight would be one half of 1000 milligrams.
3. Finally, you could use your practice knowledge of different drug dosages and know that one paracetamol tablet contains 500 milligrams, which is a half of 1 gram.

Hopefully you have worked out that the answer is 500 milligrams.

Many nurses in practice are able to 'see' the equivalent weights in different units of measurement through experience and through repetition of similar conversions. As you practise these conversions, they will become more familiar and easier to you. The best way of practising is always in clinical practice where you can make sense of the whole calculation required in relation to the clinical care for specific patients and actually have the tablets and medicine charts in front of you. Before we move on to more clinical examples it would be an idea to explain and practise conversions a bit more.

Warning!
We do not generally show the decimal point in a number unless the number is a part of a whole number, for example 1.2, although the decimal point is still there. So I could write the number 1 as 1.000 showing that it is 1 unit, no tenths, hundredths of thousandths and so on (this is explained more in Chapter 4). In healthcare, there have been a number or errors in drug administration through the written numbers being unclear and misread or misunderstood. The following rules have been devised to help prevent these errors:

- Never include a decimal point after a whole number, for example 2.0. This must always be written clearly as 2
- A zero or number should always come before a decimal point, for example 3.6 or 0.6, we should not be writing .7 as the decimal can easily be missed and the number read as 7
- When writing large numbers commas should not be used. These can be misread as decimal points. In some countries, commas are used as decimal points, which can lead to confusion. It is clearer to use a space, for example 5000 000
- If there is any doubt that the dose maybe misread, then the number can be written in both numerical figures and words in the same way as when writing on a cheque. This system is used when controlled drugs are being prescribed, for example 240mg morphine sulphate, two hundred and forty milligrams morphine sulphate

✔ Tips for Learning

Some written drug calculation tests may have questions that ask you to convert from grams to micrograms or micrograms to grams. If this is the case, then do your conversion in stages. First convert the grams to milligrams and then the milligrams to micrograms. This will help you to be more systematic and reduce errors.

In practice, most of the conversions required will be between grams and milligrams; milligrams and micrograms; or micrograms and nanograms. Very rarely, if ever, would you need to convert between grams and micrograms or grams and nanograms! In addition in clinical practice, you would not be required to convert dosage after dosage into different units of measurement, first going from grams to milligrams and then micrograms to milligrams as is often required in written drug calculation tests. This can become quite confusing. To try to avoid this, we will do each conversion in turn and practise these and then at the end of the chapter you can practise these all mixed up as you would find in a written test. If you are not feeling confident about these conversions, then use Box 6 to help you or think about common drug dosages you know in practice.

Warning!
You must clearly state the unit of measurement in your answer. The answer of 200 would not be correct as this does not state whether this is units, grams or sack loads of the drug!

EXERCISE 2

Grams to milligrams
Convert the following gram weights into the equivalent milligram weights:
1. 0.6 grams
2. 1.2 grams
3. 0.25 grams

Milligrams to grams
Convert the following milligram weights into equivalent gram weights:
1. 1800 milligrams
2. 800 milligrams
3. 2000 milligrams

Milligrams to micrograms
Convert the following milligram weights into equivalent microgram weights:
1. 0.3 milligrams
2. 0.125 milligrams
3. 0.01 milligrams

Micrograms to milligrams
Convert the following microgram weights into equivalent milligram weights:
1. 100 micrograms
2. 500 micrograms
3. 2500 micrograms

(Answers: page 215)

✔ Tips for Learning

When completing written tests read the questions carefully and do not assume that the questions will represent reality and accidentally ‘read’ milligrams instead of micrograms as this is what you are expecting.

Having become more confident with conversions, we will now consider a conversion within a calculation in clinical practice. For example, Ali has been prescribed 1.8 grams benzylpenicillin and the ampoules available each contain 600mg. There are several stages to this calculation:

1. You need to be clear that you understand what it is you are trying to work out. In this problem it is how many ampoules or part of the ampoules you need to administer in order for Ali to receive the required prescription dose of 1.8 grams.
2. You should recognise that the units of measurement being used for the dosages are different so you will need to convert one of the dosages. So you now need to work out how many milligrams would be the same weight as 1.8 grams.

Using your understanding of the different units of weight, you know that:

- Milligrams are lighter than grams
- 1000 milligrams are required to make up the equivalent weight of 1 gram
- To convert from grams to milligrams therefore, you need a thousand times more milligrams. So you would need to multiply 1.8 grams by 1000 (see Box 6 to help you if you are unsure)

Once you have done this multiplication, you should arrive at the answer that 1.8 grams in equivalent milligram weight is 1800 milligrams.

3. You now need to go back to the question that you were asked again. Your patient requires 1800 milligrams of benzylpenicillin and the ampoules available each contain 600 milligrams of benzylpenicillin. Remember, you are working out how many ampoules you need to administer to give the 1800 milligram prescribed dosage. Hopefully you can now recognise that the problem is the same as previous questions on working out how

> many tablets to give. So you should now be able to work out how many ampoules to give using one of the methods I showed you. If you can't remember or didn't recognise this problem, don't worry. It will come in time, providing that you continue practising!

To work out this problem you can use either of the two methods I have already shown you:

Formula

$$\frac{1800 \text{ milligrams}}{600 \text{ milligrams}}$$

= 3 ampoules

Repeated addition

600 milligrams	1 ampoule
1200 milligrams	2 ampoules
1800 milligrams	3 ampoules

We can summarise the steps that you followed to solve this problem (see Box 7).

As you become more experienced, you won't think through each step like this but will probably 'jump' straight to the answer of 3 ampoules. I am sure that you have seen nurses do this in practice and have been left in admiration wondering how they worked it out so quickly! As you are developing this expertise, though, it is useful to go keep going through these steps systematically to ensure you understand exactly what it is you are doing and why.

Being systematic is also really important when you start to solve more complex calculations and time spent developing this approach now will help you in the future. In addition, even when you become more of an expert and are able to 'jump' straight to the answers, it is still essential that you are able to think back to the steps that you have taken automatically and without consciously thinking about them so that you can explain your solution to other nurses and also support learners as they develop calculation skills. Using the steps in Box 5 to guide your thinking, have a go at solving the clinical problems in Exercise 3.

After you have completed this exercise I will assume that you are more confident with units of measurements for weight and will therefore revert to only using their abbreviations rather than their full names as I have been doing so far. You can always check in Box 1 if you are ever unsure.

✓ Tips for Learning

You can either convert the prescription dosage from grams to milligrams or the ampoule dosage from milligrams to grams. Which one do you think would be easier? Generally the **rule is to convert to the same unit of measurement that the available drug is expressed in**. So, in this example, you would convert the prescription of 1.8 grams into milligram weight. Why do you think this rule makes the calculation easier? What would happen if we converted the 600 milligram ampoules into grams?

Example

You require 1.8 grams and have ampoules of 600 milligrams. To demonstrate, we will convert 600 milligrams into grams, so 600 ÷ 1000 = 0.6g. You now need to find out how many of these will make 1.8 grams. You can do this by adding up 0.6 until you reach 1.8 or dividing 1.8 by 0.6. You will get the same answer as before, but the decimal point can cause confusion and possible errors.

✓ Tips for Learning

If the size of the numbers is putting you off, you could imagine that it is 18 and 6 you are dealing with (reducing down by dividing both by 100). You can do this with either method, so you are dividing 18 by 6 and repeatedly adding sixes.

Box 7 Step by step guide – calculating number of tablets or ampoules to administer

1. Think about what you are actually trying to work out, for example how many tablets to administer, how much of an ampoule to administer and so on.
2. Check the units of measurement in prescribed dosage and available drug dosage are the same.
3. If the units of measurement are different, then convert the prescribed dosage units into the available drug units.
4. Go back to the question and recheck what you are trying to work out using the new measurements.

5. Work out how many tablets or ampoules to administer using the formula method or repeated addition.
6. Check that your answer makes sense in relation to the question and clinical practice, for example is it usual in practice to give this number of tablets? Is this the usual number of tablets to give for this drug? If you gave this number of tablets, what dosage would you be giving (add up the dosage for each tablet and check it is the same as the prescribed dosage).

✔ Tips for Learning

The words ‘what you want’ do not always feature in written drug calculation questions. The ‘what you want’ is basically the dosage that you want to give to someone because it is the dosage prescribed. So you will see different expressions such as ‘you need to give’, ‘you are required to give’, ‘your patient has been prescribed’ or ‘the patient needs’, for example. These all have the same meaning, which is the dosage that you are going to give to the patient, that is, what you want to administer.

EXERCISE 3

1. Your patient has been prescribed 0.25 milligrams digoxin. The tablets available each contain 62.5 micrograms. How many tablets would you administer?
2. Your patient has been prescribed 1.2 grams benzylpenicillin. The ampoules available each contain 600 milligrams. How many ampoules would you administer?
3. John requires 1 gram amoxicillin. The tablets available each contain 250 milligrams. How many tablets do you need to administer?
4. Your patient requires 0.1 grams of flucloxacillin. The elixir contains 100 milligrams in every 5 millilitres. How many millilitres would you administer?
5. Ola has been prescribed 0.3 milligrams hyoscine. The hyoscine ampoules each contain 600 micrograms. How many or how much of the ampoule would you administer?

(Answers: page 216)

Units

There is another measurement used in clinical practice to express dosages which are known as Standardised International Units (SIU). In clinical practice you will see these dosages written as Units or abbreviated to 'U' or IU (International Units). For example, you may see a dose of 50U insulin or 25 000 units heparin. Units are weights of specific drugs which have been standardised according to their therapeutic activity level. This basically means that they are easier to use! The most common drugs you will probably come across that are expressed as standardised units are insulin and heparin.

Warning!
I must quickly give a word of warning about insulin. Insulin dosages, as I have mentioned, are standardised into units. The units are standardised so that 100 units are contained in 1ml. In the past nurses had to work out how many millilitres to draw up to administer a certain number of units of insulin using this principle. For example, if the dose was 23 units the nurse would have to calculate what proportion of 1ml to administer! (Who said the old ways are best!). Nowadays in clinical practice, we have insulin syringes that are calibrated to give the units along the side. So we only have to draw up the insulin to the required 23 units marked on the syringe.

There is a warning here, though, which is **ensure that you are using the right syringe when drawing up insulin**. Sadly, a community nurse gave a fatal dose of insulin to her patient by drawing up the units of insulin in a 1ml syringe and giving millilitres of insulin rather than the required unit dosage given on an insulin syringe (Stokes, 2009).

Ratios

Ratios are another way of specifying the dosage of a drug. Ratios express a relationship between two amounts (see Chapter 4 for more information on ratios). In drug dosages, this is usually the weight of the drug in relation to the volume. The most common drug that is expressed as a ratio is adrenaline. Adrenaline is manufactured in several different strengths – 1:100, 1:1000 and 1:10 000 strength. The adrenaline is expressed here as a weight in relation to the volume that it has been dissolved in. This ratio in practice means:

1:1000 = 1g adrenaline for very 1000ml
1:100 = 1g adrenaline for every 100ml

Generally, any ratio in practice also has the weight volume dosage written on the drug as well. For adrenaline the weight/volume dosage would be:

1:10 000	100mcg/1ml
1:1000	1mg/1ml
1:100	10mg/1ml

To understand why these two ways of expressing the dosage are the same see Box 8.

Box 8 Explanation of dosages used for adrenaline

1:1000 means 1g in 1000ml. This could be written as a weight/volume dose as 1g/1000ml. If we convert the adrenaline dosage to milligrams this would be 1000mg/1000ml. We can now divide both sides by 1000 to get 1mg/1ml (remembering the rule of doing the same to each side).

For the 1:100 dosage:

1g in 100ml	
1000mg in 100ml	convert grams to milligrams
10mg in 1 ml	divide both sides by 100

For the 1:10 000 dosage:

1g in 10 000ml	
1000mg in 10 000ml	convert grams to milligrams
0.1mg in 1ml	divide both sides by 1000
100mcg in 1ml	converting milligrams to micrograms

In practice, you would rarely need to calculate dosages using ratios alone and it is enough to appreciate the different strengths that ratios represent. However, ratio calculations can sometimes be used in written drug calculation assessments and so it is worth ensuring that you understand these. Try these three questions which could appear in a written test:

EXERCISE 4

1. How many milligrams of 1:1000 adrenaline are contained in 0.5ml?
2. You administer 2ml 1:100 adrenaline. How many milligrams of adrenaline have you administered?
3. You need to administer 200mcg adrenaline. How many millilitres of 1:10 000 adrenaline would you need to give?

(Answers: page 217)

Dosage per Weight

In order to have the precise therapeutic effect, some medication is prescribed according to the patient's individual body weight. The same dosage of medication would have a different effect on a larger person compared with a smaller person. This is especially important where someone's clinical condition is unstable and medication needs to be given more precisely and also in children where individual weights vary greatly.

When a medication has been prescribed according to body weight it is usually prescribed as a specific weight of medication for every kilogram weight of the individual. So, for example, the prescription could be 2mg/kg. This means that for every kilogram the person weighs they need 2mg. So if the individual weighed 2 kilograms you would give 2mg for the first kilogram and then 2mg for the second kilogram weight. The dosage required for this person would thus be 2 lots of 2mg, which would be 4mg.

✱ Clinical Context

Some drugs, such as chemotherapy, are prescribed according to the body surface area (BSA) of the patient, for example 2mg/m^2 (this is more common in children). Once you have calculated the surface area, then the calculation proceeds in the same way as a dosage per weight calculation. The calculation for the BSA relies on a formula and there are several available to use. It is recommended that you refer to your clinical area for the advised BSA formula to use.

If your patient weighed 10kg and you needed to give 2mg/kg how many milligrams would this person require?

Remember that for every kilogram weight of the patient you need to give 2mg, so here you would need to give ten lots of 2mg. This would be 20mg. Do you understand what you are doing mathematically to work out the dosage? How would you explain the way to work out weight dosages to someone who didn't know? Have a look at the following example to see if you are correct.

Example

You are required to administer a certain dosage for every kilogram weight of the individual. So for every kilogram that the person weighs you administer that dosage. If the prescription was 10mcg/kg and the person weighed 5kg, you would need to administer:

10mcg (1kg) and 10mcg (1kg) and 10mcg (1kg) and 10mcg (1kg) and
10mcg (1kg) = 50mcg/5kg

This is 5 lots of 10mcg, which is the same as saying 10mcg multiplied by 5 or mathematically 5 × 10.

The formula for working out the weight/dosage is: weight of person (kg) × dosage per kg

Using this formula what is the total dosage required for a patient who has been prescribed 5mg/kg and who weighs 25kg?

weight of person (kg) = 25
dosage per kg = 5mg
So, 25 × 5mg
= 125mg to administer

✔ Tips for Learning

Always keep the units of measurement if writing down the calculation as above. If using a calculator, make sure that you go back to the question to check what unit of measurement your answer is in.

? Maths Explained

You will find that knowledge of long multiplication could be helpful for you here. Have a look at Chapter 4 where this is explained.

Warning!

To ensure that your patient is receiving the correct dose of the medication with dose/weight prescriptions, it is important that the weight of the patient you are using in the calculation is accurate. This means that you will need to consider how and how often you ascertain the weight of your patient in order to use this figure in your calculations. For example, do you weigh your patient? When was your patient last weighed and is their weight likely to have changed since then? Also, consider the accuracy of relying on patients' or parents' recall of their own or their child's weight.

Once you have worked out the dosage of drug for that particular patient, you can then proceed with calculating how many tablets or ampoules to administer to the patient using the stock drug available. This means that for some problems in clinical practice there are actually several stages that you need to work out in order to solve the problem. These stages have been summarised in Box 9.

This is similar to the stages you work through in order to calculate the number of tablets or ampoules to administer when the units of measurement used for the two dosages are different, but with the additional stage of calculating the dosage the individual patient requires first. Again, once you become more familiar with these problems in clinical practice, you will be able to work through these stages in your head or jump some stages. However, as you are developing competence in calculation skills it is recommended that you follow each stage and become familiar with this sequencing and way of thinking first.

Box 9 Step by step guide – calculating number of tablets or ampoules to administer when prescribed as dose per weight

1. Make sure you understand the question and what exactly you are trying to work out. For example, the dosage for the individual patient and then how much of the available drug to give in order to administer this dosage.
2. Calculate the individual dose for the patient by multiplying their weight in kilograms by the dosage per kilogram.
3. Go back to the question and check that you are still clear about your understanding. For example, I know the actual dosage I now need to calculate how much of the available drug to administer.
4. Check that the prescribed dosage has the same unit of measurements as the available drug dosage.
5. If the units of measurement are different, then convert the prescribed dosage so it is expressed in the same unit of measurement as the available drug.
6. Go back to the question and check that you are still clear about your understanding. For example, I need to administer this dosage, I have this dosage available and they are both now in the same unit of measurement. I now need to work out how much of this drug would give the prescribed dosage.
7. Work out how much of the available drug to administer by using repeated addition or dividing the prescribed dosage by the available dosage.
8. Check your answer makes sense in relation to the questions and the dosages being prescribed and available, and your knowledge of clinical practice. For example, does it seem reasonable to administer this amount of a drug? Have I ever administered this amount before? Is this the usual amount of ampoules/tablets that I administer for this particular drug?

EXERCISE 5

1. Your patient has been prescribed 50mg/kg of amoxicillin. Your patient weighs 10kg. The amoxicillin ampoules available contain 250mg. How many of these ampoules do you need to administer to your patient in order to give the prescribed dosage?
2. Your patient has been prescribed 2mg/kg gentamicin. Your patient weighs 60kg. The available ampoules of gentamicin each contain 40mg/1ml. How many of these gentamicin ampoules would you administer to give the prescribed dosage?
3. Your patient has been prescribed 500mcg/kg of frusemide by slow intramuscular injection. Your patient weighs 10kg. The frusemide ampoules available are 10mg/ml. How many millilitres would you administer?

(Answers: page 218)

Divided Doses

Some prescriptions do not specify what dosage the patient requires throughout the day, but will specify a total dosage over the 24-hour period and the number of doses required. For example, instead of the usual prescription of 50mg diclofenac sodium required at 9am, 2pm and 10pm, it may be prescribed as 150mg in three divided dosages per day. So the patient needs three equal doses of the drug throughout the day. With this example, how many milligrams would you administer for each dose?

In order to gain three equal doses I need to 'share' 150mg between three dosages. This means that I need to divide 150mg by 3 to work out that I would administer 50mg of the drug, at three separate times spread throughout the day. The doses obviously need to be spaced out equally throughout the day.

Most regular dosages are given during the day, usually between 6am and 10pm on a standard ward. So the three dosages of 50mg may be administered at 9am, 2pm and 10pm, although any times that are roughly equally spaced out throughout the day would be acceptable.

To summarise, if the total dosage for the day has been prescribed with the number of divided dosages required for the day, then to calculate this you divide the total dosage by the number of dosages required:

$$\frac{\text{total daily dosage}}{\text{number of dosages required}} = \text{dosage each time}$$

Try the following questions:

EXERCISE 6

1. Your patient has been prescribed 500mg in four divided dosages throughout the day. What dosage would you administer each time?
2. Your patient has been prescribed 1800mg in three divided dosages throughout the day. What dosage would you administer each time?
3. Your patient has been prescribed 1g in two divided dosages throughout the day. What dosage would you administer each time?

(Answers: page 219)

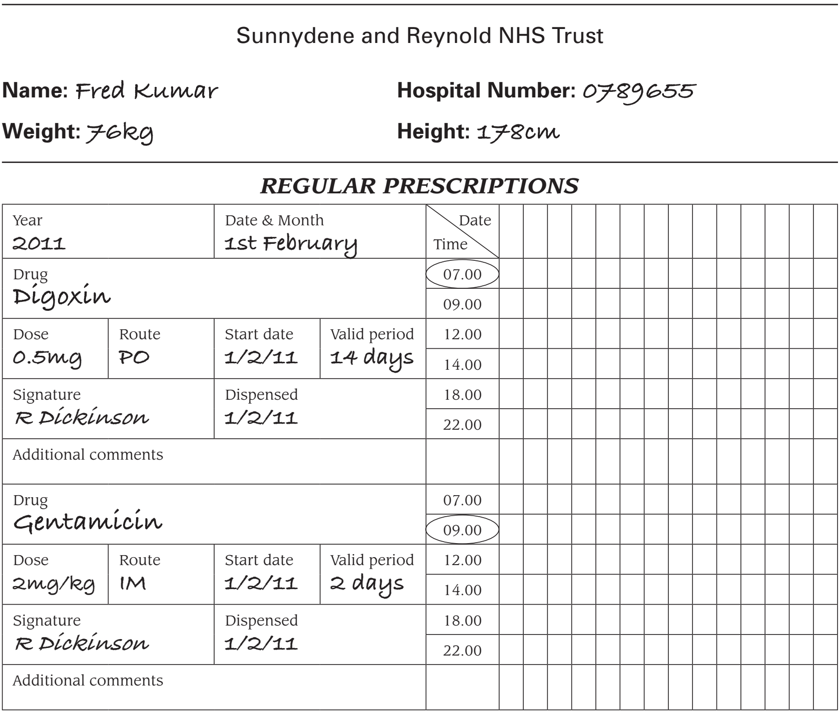
Chapter Summary

This chapter has explained the different types of measurements that are used to express the dosages of drugs and how we convert between them. I have also explained how to calculate the number of tablets to administer to a patient and how to calculate divided doses and the dose when expressed as a dose per patient weight.

Now have a go at the assessment for this chapter.

Assessment 1

1. Your patient has been prescribed 500mg amoxicillin orally. The tablets available are 250mg tablets. How many tablets do you need to administer to your patient?
2. The doctor has prescribed 60mg/kg cefuroxine in three divided doses for a child who weighs 18kg. What dose does the child require for each administration?
3. You need to administer 2g flucloxcillin to your patient. The tablets available are 500mg tablets. How many tablets do you need to administer?
4. Using the information on the medicine chart below and the available digoxin tablets, calculate how many tablets you would administer to Mr Kumar.

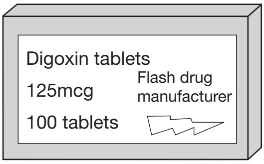


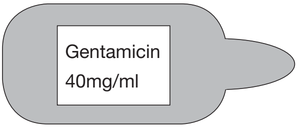
Sunnydene and Reynold NHS Trust

Name: Fred Kumar
Hospital Number: 0789655
Weight: 76kg
Height: 178cm

REGULAR PRESCRIPTIONS

Year 2011		Date & Month 1st February		Date Time														
Drug Digoxin				[✓ 07.00]														
				09.00														
Dose 0.5mg	Route PO	Start date 1/2/11	Valid period 14 days	12.00														
				14.00														
Signature R Dickinson		Dispensed 1/2/11		18.00														
				22.00														
Additional comments																		
Drug Gentamicin				07.00														
				[✓ 09.00]														
Dose 2mg/kg	Route IM	Start date 1/2/11	Valid period 2 days	12.00														
				14.00														
Signature R Dickinson		Dispensed 1/2/11		18.00														
				22.00														
Additional comments																		





5. Use the information from the medicine chart above to calculate the dose of gentamicin that Mr Kumar requires.

6. Your patient requires 30mg prednisolone. The tablets available are 5mg. How many tablets do you need to administer?

7. Your patient has been prescribed 1.2g benzylpenicillin. The vials contain 600mg. How many vials will you need to administer?

8. Your patient has been prescribed 3mg/kg daily of spironolactone in three divided doses. The patient weighs 50kg. The tablets available are 25mg. How many tablets does your patient require for each dose?

9. You need to give 300mg phenytoin to your patient orally. The tablets available are 100mg. How many do you need to administer?

10. You need to administer 50mg/kg daily chloramphenicol in four divided doses. Your patient weighs 40kg and the capsules available are 250mg. How many capsules would you need to administer for each dose?

(Answers: page 219)

References

Stokes, P. (2009) Pensioner ‘unlawfully killed’ by nurse’s insulin overdose, *The Daily Telegraph* online at http://www.telegraph.co.uk/news/uknews/5061193/Pensioner-unlawfully-killed-by-nurses-insulin-overdose.html (last accessed 1/7/10).

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