Medical Calculations and Conversions

Most of the material courtesy of Elizabeth Warren, RVT (modified from VSPN)

Terms:

Kilo = (k) = 1000 = 10^3
Basic Unit = 1 = 10^0
Deci = (d) = 0.1 = 10^{-1}
Centi = (c) = 0.01 = 10^{-2}
Milli (m) = 0.001 = 10^{-3}
Micro (m) = 0.000001 = 10^{-6}
Pico (p) = 0.000000000001 = 10^{-12}

More commonly used units:

1000 milliliters (ml) = 1.0 liter (L)
1000 microliters (ul) = 1.0ml
1,000,000ul = 1.0L
30ml = 1.0 ounce (oz)
5ml = 1.0 teaspoon (tsp)
8oz = 1 cup
% solution = grams/100ml

1000 grams (g) = 1.0 kilograms (kg)
1000 milligrams (mg) = 1.0 gram
1000 micrograms (ug) = 1.0mg
2.2 pounds (#, lb) = 1.0kg
1.0 grain (gr) = 64.8mg ***This is really only relevant these days for Phenobarbital. This drug is one of the few still described in grains rather than milligrams*

Weight (gram, pound, ounce)

1 grain (gr) = 0.0648 grams (g)
1 grain (gr) = 64.8 milligrams (mg), sometimes 60mg is used
1 gram (g) = 0.001 kilograms (g)
1 gram (g) = 1,000,000 micrograms (ug)
1 gram (g) = 1,000,000,000,000 picograms (pg)
1 gram (g) = 1000 milligrams (mg)
1 gram (g) = 15 grain (gr)
1 kilogram (kg) = 1000 grams (g)
1 kilogram (kg) = 2.2 pounds (lb or #)
1 micrograms/gram (ug/g) = 1 parts per million (ppm)
1 milligram (mg) = 1000 micrograms (ug)
1 milligram/kilogram (mg/kg) = 1 parts per million (ppm)
1 ounce (oz) = 28.4 grams (g)
1 pound (lb or #) = 0.45 kilograms (kg)
1 pound (lb or #) = 16 ounces (oz)
1 ton = 1016 kilograms (kg)
1 ton = 2000 pounds (lb or #)

Length (meter, inch, foot)

1 centimeter (cm) = 0.39 inches (in)
1 foot (ft) = 12 inches (in)
1 foot (ft) = 30.5 centimeters (cm)
1 inch (in) = 2.54 centimeters (cm)
1 mile = 1.6 kilometers (km)
1 mile = 1760 yards (yd)
1 mile = 5280 feet (ft)
1 yard (yd) = 0.9 meters (m)
1 yard (yd) = 3 feet (ft)

Dilutions

1:X	mg/mL	%
1:10	100 mg/mL	10 %
1:100	10 mg/mL	1 %
1:1000	1 mg/mL	0.1 %
1:10,000	0.1 mg/mL	0.01 %
1:100,000	0.01 mg/mL	0.001 %

Body surface area:

kg	m2		kg	m2		kg	m2		kg	m2		kg	m2
0.5	0.06												
1.0	0.10		11.0	0.49		21.0	0.76		31.0	0.99		41.0	1.19
2.0	0.15		12.0	0.52		22.0	0.79		32.0	1.01		42.0	1.21
3.0	0.20		13.0	0.55		23.0	0.81		33.0	1.03		43.0	1.23
4.0	0.25		14.0	0.58		24.0	0.83		34.0	1.05		44.0	1.25
5.0	0.29		15.0	0.60		25.0	0.85		35.0	1.07		45.0	1.26
6.0	0.33		16.0	0.63		26.0	0.88		36.0	1.09		46.0	1.28
7.0	0.36		17.0	0.66		27.0	0.90		37.0	1.11		47.0	1.30
8.0	0.40		18.0	0.69		28.0	0.92		38.0	1.13		48.0	1.32
9.0	0.43		19.0	0.71		29.0	0.94		39.0	1.15		49.0	1.34
10.0	0.46		20.0	0.74		30.0	0.96		40.0	1.17		50.0	1.36

Volume (fluid ounce, liter)

1 cup (c) = 240 milliliters (mL)		1 milliliter (mL) = 1000 microliters (mL)
1 cup (c) = 8 ounces (fl oz)		1 ounce (fl oz) = 30 milliliters (mL)
15 drops (ggt) = 1 milliliter (mL)		1 pint (pt) = 0.47 liters (L)
1 gallon (gal) = 3.79 liters (L)		1 pint (pt) = 2 cups (c)
1 gallon (gal) = 4 quarts (qt)		1 quart (qt) = 0.95 liters (L)
1 liter (L) = 1000 milliliters (mL)		1 quart (qt) = 2 pints (pt)
1 milliliter (mL) = 0.34 ounces (fl oz)		1 tablespoon (tbs) = 15 milliliters (mL)
1 milliliter (mL) = 1 cc (centimeter cubic)		1 teaspoon (tsp) = 5 milliliters (mL)

Temperature

°F = (°C x 9/5) + 32

°C = (°F –32) x 5/9

[9/5 = 1.8]

[5/9 = 0.555 etc.]

Approximate Daily Energy (kcal) and fluid (mL) requirements of dogs (in kg):

kg	mL/kcal	kg	mL/kcal	kg	mL/kcal	kg	mL/kcal
1	132	10	742	19	1201	28	1607
2	222	11	797	20	1248	29	1650
3	301	12	851	21	1295	30	1692
4	373	13	904	22	1341	35	1899
5	441	14	955	23	1386	40	2100
6	506	15	1006	24	1431	45	2293
7	568	16	1056	25	1476	50	2482
8	628	17	1105	26	1520		
9	686	18	1154	27	1564		

Approximate Daily Energy (kcal) and fluid (mL) requirements of cats:

kg	mL/kcal	kg	mL/kcal	kg	mL/kcal
1.0	80.0	2.5	159.1	4.0	226.3
1.5	108.4	3.0	182.4	4.5	247.2
2.0	134.5	3.5	204.7	5.0	267.5

Other Equations and Calculations

- **Molarity (M**) = # of moles of solute / liters (L) of solution
- Milliliters (mL) x M (molarity) = **# of millimoles**
- **Normality (N)** = # of gram equivalents solute / L
- **Milliequivalent (mEq)** = mmoles x valence = (mg x valence) / mw (molecular weight)
- 1 gram (g) = 1,000,000,000,000 picograms (pg)
- **Serum osmolality** = $2(Na + K) + \frac{BUN}{2.8} + \frac{Glu}{18}$
- **Anion gap** = (Na + K) - (Cl + HCO3)
- **Globulin** = Total Protein - Albumin
- **A/G ratio** = Albumin/Globulin
- **Corrected Calcium** = Calcium - Albumin + 3.5
- **Sodium/Potassium ratio** = Na/K
- **French to English measurement of tubular instruments:** 1 Fr = 0.33 mm
- **Subcutaneous fluid dose** » 60 mL/kg
- **RER (Resting Energy Requirement)** = 70 x weight (kg) to the 0.75 power
- **MER (Maintenance Energy Requirement**) = activity or illness factor x RER
- **Food dosage** = kcal required/caloric density of food
- **whole blood transfusion mL needed**

  DOG = $\frac{\text{desired PCV - current PCV}}{\text{PCV of donor blood}} \times (kg) \times 80$

  CAT = $\frac{\text{desired PCV - current PCV}}{\text{PCV of donor blood}} \times (kg) \times 70$

Problem Sets - common mathematical calculations

Courtesy of Rose Peters, DVM, DACVIM (Neurology/ Neurosurgery)

Note: This primer assumes you have a basic understanding of mathematical principles (addition, subtraction, multiplication, division, decimal system, and fractions). Please go to www.math.com for a reminder of basic mathematical principles if needed. For most of my medical calculations, I like to use the method of "unit cancellation". I will demonstrate this with each problem presented below as it applies. This method will keep you on the right track in terms of making sure you are making the right choice to multiply versus divide to make your calculations. It keeps you from having to memorize lots of equations and "short-cuts" and is a good way to double check yourself.

Here is an example with explanation of how this might work for us. We can convert 10mg/lb to g/kg in the following way:

We know that there are 2.2lb in each kilogram, so 10x2.2 = 22mg/kg

How do we know that it is 10x2.2 and not 10/2.2?? If we use unit cancellation, you will be correct every time!

They key is to follow a system that requires putting each number into a "fraction" format:

Step 1 - Put each number into a fraction and make sure each fraction is in the correct orientation

Step 2 - Multiply across the fractions (this depends on you knowing how to multiply fractions)

Step 3 - Cancel any units that are found both on top (in the numerator) and bottom (denominator) of the final answer

Step 4 - Do your units match the desired result? Does your answer make sense?

Using the problem above, we will set up our fractions as follows:

$\frac{10mg}{lb} \times \frac{2.2lb}{kg} = \frac{10mg}{\cancel{lb}} \times \frac{2.2\cancel{lb}}{kg} = 10x2.2 = \frac{22mg}{kg}$ This has given us part of our answer. Now we must convert to g/kg

***Notice how the conversion of 2.2lb/1kg equals "1.0" --> meaning 2.2 pounds is the exact same weight as 1.0 kilogram (think of 2.2 pounds on one side of a scale and 1.0kg on the other side -- they should be perfectly balanced). This is the key to converting units this way - whenever we multiply by a ratio of 1.0, the final answer is not affected, only the units which is what we want to change.*

To say this in another way, the actual number might change (like from 10 to 22 in the example above), but the actual value of how much drug you are giving per body weight does not. We are only expressing it in a different way - in this case mg/kg instead of mg/lb.

Here is the next step to convert to g/kg:

$\frac{22mg}{kg} \times \frac{1g}{1000mg} = \frac{22\cancel{mg}}{kg} \times \frac{1g}{1000\cancel{mg}} = 22/1000 = 0.022g/kg$ This has given us the rest of the answer.

We can also do this in one long set up:

$\frac{10mg}{lb} \times \frac{2.2lb}{kg} \times \frac{1g}{1000mg} = \frac{10\cancel{mg}}{\cancel{lb}} \times \frac{2.2\cancel{lb}}{kg} \times \frac{1g}{1000\cancel{mg}} =$ 0.022g/kg We have the same answer after cancelling lb and mg.

You can set up a long series of conversions this way - just remember to follow your units carefully!

What happens if you set it up wrong?

$\frac{10mg}{lb} \times \frac{kg}{2.2lb} \times \frac{1g}{1000mg} = \frac{10mg}{lb} \times \frac{kg}{2.2lb} \times \frac{1g}{1000mg} = \frac{0.0045\ mgxkgxg}{lbxlbxmg} = \frac{0.0045\ \cancel{mg}xkgxg}{lbxlbx\cancel{mg}} = \frac{0.0045\ kg\ g}{lb\ lb}$

This answer is clearly wrong because the units do not make sense. You want g/kg but you got g*kg/lb*lb. This means you need to look back at your setup to see what went wrong.

$\frac{10mg}{lb} \times \frac{kg}{2.2lb} \times \frac{1g}{1000mg}$ *Here you can see that you should have inversed the circled fraction. This fixes it all!*

For each calculation, you should also consider if there is another way to make the same calculation. If there is, I encourage you to calculate using the alternative method. If your numbers match, then you are on the right track!

Finally, think critically about whether or not your answer makes sense. For example if you usually give a dachshund 0.2ml of morphine, this is a very small dose for a mastiff. More dangerous is the dose of ketamine that is appropriate for a mastiff but given to a dachshund! If the answer doesn't make sense, you should double-check it. If you are ever unsure, you should not be afraid to ask a buddy to double-check you. One characteristic of a good, conscientious technician is to not be afraid to ask for assistance when needed.

1. **Weight conversions**

   a. **Buster weighs 17.5kg. How many pounds does he weigh?**

   $\frac{17.5kg}{1} \times \frac{2.2lb}{kg} = \frac{17.5\cancel{kg}}{1} \times \frac{2.2lb}{\cancel{kg}} = 17.5 \times 2.2 =$ 38.5lb

   b. **Sasha weighs 14.6 pounds. How many kilograms does she weigh?**

   $\frac{14.6lb}{1} \times \frac{1}{2.2lb} = \frac{14.6\cancel{lb}}{1} \times \frac{1}{2.2\cancel{lb}} = 14.6/2.2 =$ 6.6kg

   c. **Huxley weighs 10 pounds and 4 ounces. How many kilograms does he weigh?**

   Sometimes you will use a scale that measures in pounds and ounces instead of a decimal value (like 2.5 pounds). In those cases, you will need to convert the total weight to pounds before you convert to other values like kilograms. There are 16 ounces in a pound, so we will need to convert ounces to a fraction (decimal value) of a pound for easier conversion.

   Step 1: Convert ounces to a fraction of a pound = $\frac{4oz}{1} \times \frac{1lb}{16oz} = \frac{4\cancel{oz}}{1} \times \frac{1lb}{16\cancel{oz}} = 4/16 = 0.25lb$

   Step 2: Add the total pounds values together = 10lb + 0.25lb = 10.25lb

   Step 3: Convert to kilograms = $\frac{10.25lb}{1} \times \frac{1kg}{2.2lb} = \frac{10.25\cancel{lb}}{1} \times \frac{1kg}{2.2\cancel{lb}} = 10.25/2.2 =$ 4.7kg

**We know these answers make sense if we think about it. A pound is the same as 2.2kg. To say it another way, there are a little more than 2 kilograms per pound. Thinking about it this way, there is a little over twice the value of pounds compared to kilograms. We can also say there are a little less than half of the number of pounds compared to the kilogram value. Now look back at the previous problems and notice this relationship.

   d. **Your tiny patient, Bruno, weighs 166 grams. Your doctor is giving you drug doses in mg/kg for this patient. How many kilograms does Bruno weigh?**

   $\frac{166g}{1} \times \frac{1kg}{1000g} = \frac{166\cancel{g}}{1} \times \frac{1kg}{1000\cancel{g}} = 166/1000 =$ 0.166kg

**You might notice here that we are dealing with factors of ten (0.001, 0.01, 0.1, 1, 10, 100, 1000). Whenever we are dealing with multiplying or dividing by a factor of ten, we can also move the decimal place to get the same answer. For each "ten" that you are multiplying, you will move the decimal place to the right by one position. Likewise, for each "ten" you are dividing, you will move the decimal place to the left by one position. In this case, there are 1000g in each kilogram. 10x10x10 = 1000. This is essentially three "tens" (notice the 3 zeros?). If you look at 166g and want to convert to kilograms, we know we will get a much lower number because kilograms are a much bigger unit (so a few grams is just a small fraction of one kilogram).

First ten: 166.0/10 moves the decimal one place to the left to get 16.60
Second ten: 16.60/10 moves the decimal one place to the left to get 1.660
Third ten: 1.660/10 moves the decimal one place to the left to get 0.1660

2. Volume and concentration calculations

a. Your doctor asks you to add 5ml of sterile water to a 500mg vial of ampicillin powder for injection. What is the final concentration of the injectable solution?

***In this case, we are assuming the volume of the powder is negligible*

When we are asking for concentration, this generally mean we are wanting to know how much mass is in a certain volume. So in this case, we want to know how many milligrams are in each milliliter:

$\frac{500\text{mg}}{5\text{ml}} = 500/5 = 100\text{mg/ml}$

b. Your doctor asks you to use 5ml from a bag of 250ml normal (0.9%) saline to reconstitute a 500mg vial of ampicillin. Then to draw up the entire volume (all 500mg) of ampicillin from the bottle and add it back to the 250ml bag of saline. What is your final concentration of ampicillin in the saline bag?

We know that all of the 500mg are ending up in the 250ml of saline:

$\frac{500\text{mg}}{250\text{ml}} = 500/250 = 2.0\text{mg/ml}$

c. The doctor asks you to fill 60ml of lactulose liquid medication for Claudia. You have 1oz, 2oz, 3oz, and 4oz bottles for dispensing medication. Which one should you choose for Claudia's medication?

In this problem, we must convert milliliters to ounces. *We know there are 30ml per ounce*:

$\frac{60\text{ml}}{1} \times \frac{\text{oz}}{30\text{ml}} = \frac{60\cancel{\text{ml}}}{1} \times \frac{\text{oz}}{30\cancel{\text{ml}}} = 2.0\text{oz}$ We can use a 2oz bottle for dispensing this medication.

d. Daisy had an allergic reaction to a bee-sting at home. Her owners don't have a syringe but they do have measuring spoons. You would like Daisy to get 2.5ml of Children's Elixir Benadryl. How many teaspoons should the owner give Daisy?

***Many human medications are dispensed in terms of milligrams per 5ml. Children's Elixir is 12.5mg/5ml. This 5ml unit is used because it is equivalent to 1 teaspoon which is an easy measuring device that most people have at home.*

$\frac{2.5\text{ml}}{1} \times \frac{1\text{tsp}}{5\text{ml}} = \frac{2.5\cancel{\text{ml}}}{1} \times \frac{1\text{tsp}}{5\cancel{\text{ml}}} =$ 0.5tsp or 1/2 teaspoon

e. You have calculated the daily hydration requirement for Bernard to be about 600ml of fluid. How many cups of water should you tell the owners is a minimum amount the dog should be drinking?

We know from the conversion tables at the beginning of this document that there are 240ml per cup.

$\frac{600\text{ml}}{1} \times \frac{1\text{ cup}}{240\text{ml}} = \frac{600\cancel{\text{ml}}}{1} \times \frac{1\text{ cup}}{240\cancel{\text{ml}}} = 600/240 = 2.5\text{ cups}$

f. Your doctor asked you to draw up a 5ug/kg dose of dexmedetomidine for Scrappy. Scrappy is 10kg and dexmedetomidine is 0.10mg/ml. How do you convert the concentration to ug/ml for easier conversion?

$\frac{0.10\text{mg}}{\text{ml}} \times \frac{1000\text{ug}}{\text{mg}} = \frac{0.10\cancel{\text{mg}}}{\text{ml}} \times \frac{1000\text{ug}}{\cancel{\text{mg}}} = 0.1 \times 1000 = 100\text{ug/ml}$

If you want to complete the first portion of this problem, you would then use the ug/ml value to calculate a dose for Scrappy:

$\frac{5\text{ug}}{\text{kg}} \times \frac{1\text{ml}}{100\text{ug}} \times \frac{10\text{kg}}{1} = \frac{5\cancel{\text{ug}}}{\cancel{\text{kg}}} \times \frac{1\text{ml}}{100\cancel{\text{ug}}} \times \frac{10\cancel{\text{kg}}}{1} = 0.5\text{ml}$

See how we oriented the fractions so that ultimately we get the units we want in the end?

g. Mannitol is 20% solution. How many mg/ml is this equivalent to?

We know from our conversion charts that % solution is equal to the number of grams for every 100ml of solution. In this case it is 20g for every 100ml

$\frac{20\text{ g}}{100\text{ml}} \times \frac{1000\text{mg}}{\text{g}} = \frac{20\cancel{\text{g}}}{100\text{ml}} \times \frac{1000\text{mg}}{\cancel{\text{g}}} = (20\text{x}1000)/100 =$ 200mg/ml

*****Here's a quick trick:** If you multiply % solution by 10, you will get the value in mg/ml. Now look at the problem above and see that this is true. Now you know why this works.*

h. Your Lidocaine solution is 20mg/ml. What percent solution is this?

We need to convert this using grams per 100ml as our unit of "%" (see pervious problem)

$\frac{20\text{mg}}{\text{ml}} \times \frac{\text{g}}{1000\text{mg}} = \frac{20\cancel{\text{mg}}}{\text{ml}} \times \frac{\text{g}}{1000\cancel{\text{mg}}} = 20/1000 = 0.02\text{g/ml}$

This gives us how many grams are in 1ml. Now we need to know how many grams are in 100ml - there is 100 times as much in 100ml compared to just 1.0ml. When we use the conversion factor of 1g/100ml, then we end up with no units left and will defer to the % value in this case:

$\frac{20\text{mg}}{\text{ml}} \times \frac{\text{g}}{1000\text{mg}} \times \frac{100\text{ml}}{\text{g}} = \frac{20\cancel{\text{mg}}}{\cancel{\text{ml}}} \times \frac{\cancel{\text{g}}}{1000\cancel{\text{mg}}} \times \frac{100\cancel{\text{ml}}}{\cancel{\text{g}}} = 0.02 \times 100 =$ 2%

*****Here's a quick trick:** If you divide mg/ml by 10, you will get the value in % solution Now look at the problem above and see that this is true. Now you know why this works.*

i. Your doctor has asked you to add 20mEq/L of KCl (potassium) to a new 1L bag of Normosol-R. KCL is 2mEq/ml. How many milliliters do you add to the bag of Norm-R?

***We will assume the volume we are adding to the bag is negligible. See the comments with dextrose calculations for more detail.*

If we want 20mEq/L, then this problem is easy because we just have to figure out how many ml of KCl it takes to get 20mEq. This is because we are adding to 1L.

$\frac{20\text{mEq}}{1} \times \frac{1\text{ml}}{2\text{mEq}} = \frac{20\cancel{\text{mEq}}}{1} \times \frac{1\text{ml}}{2\cancel{\text{mEq}}} = 20/2 =$ 10ml

j. Your doctor has asked you to add 20mEq of KCl (potassium) to a 1L bag of Normosol-R that right now only has 600ml left after running 400ml into the patient already. KCL is 2mEq/ml. How many milliliters do you add to the 600ml bag of Norm-R?

***This problem is a little trickier. I like to think in terms of ratios. So if there is 600/1000ml, this means there is 60% (600/1000x100% = 60%) of the fluid left in the bag. This means we only need 60% of whatever you would have calculated for 1.0L. I find it's easier to calculate how much you would need for one liter, then determine what 60% of that value would be:*

We use the previous calculation for determining how many milliliters we need of KCl for 1.0L of Norm-R:

$\frac{20\text{mEq}}{1} \times \frac{1\text{ml}}{2\text{mEq}} = \frac{20\text{mEq}}{1} \times \frac{1\text{ml}}{2\text{mEq}} = 20/2 = 10\text{ml}$

10ml x 60% = 10ml x 0.6 = 6ml

***If you are ever not confident about your answer, you can always find a way to double check yourself. In this case you will take your 6ml of KCl, determine how many mEq are in that 6ml, then calculate your total mEq/600ml, then finally convert milliliters to liters (each of these steps is sequentially reflected below in the series of multiplied fractions):*

$\frac{6\text{ml}}{1} \times \frac{2\text{mEq}}{\text{ml}} \times \frac{1}{600\text{ml}} \times \frac{1000\text{ml}}{1\text{L}} = \frac{6\cancel{\text{ml}}}{1} \times \frac{2\text{mEq}}{\cancel{\text{ml}}} \times \frac{1}{600\cancel{\text{ml}}} \times \frac{1000\cancel{\text{ml}}}{1\text{L}} = 20\text{mEq/L}$

k. **Your doctor has asked you make up a 1L bag of LRS with 5% dextrose. The dextrose is 50% concentration. How do you prepare the fluid bag?**
This is a situation in which you can use the following equation:
C1V1 = C2V2
C1=concentration of the Fluid A
C2=concentration of Fluid B
V1=volume of Fluid A
V2=final volume of Fluid B

Anytime you have one fluid of a particular concentration that you are adding to another fluid, you can use this formula.

In this situation:
Fluid A = dextrose 50% solution
Fluid B = 5% LRS fluid solution
C1=concentration of the Fluid A = 50%
C2=concentration of Fluid B = 5%
V1=volume of Fluid A = unknown - this is what we are trying to determine so we will call it V1
V2=final volume of Fluid B = 1000ml

(50%)(V1) = (5%)(1000ml) --> (50%)V1 = 5000%*ml --> $\frac{5000\cancel{\%}*ml}{50\cancel{\%}}$ =V1 -->V1 = 100ml of 50% dextrose

***In this case, 100ml seems like a significantly large volume compared to the 1000ml in the bag. This math problem assumes your final volume is 1000ml, however if you simply add 100ml of 50% dextrose to the LRS, you end up with the volume of LRS plus the dextrose which is 1000+100 = 1100. To be more accurate, you should:*
First remove 100ml of plain LRS from the bag - discard
Next add 100ml of 50% dextrose to the 900ml of LRS
Now you have 1000ml of 5% dextrose in your final mixture

***To be precise, this should be done anytime you are adding fluid volumes (like our injectable metoclopramide), however those volumes are usually very small and considered negligible compared to the larger volumes needed to make a dextrose CRI. Even for this problem, the difference when not taking this step is not large. 100ml of 50% dextrose to end up with 1100ml gets you about 4.5% dextrose. Likewise, 50ml of 50% dextrose to end up with 1050ml is about 2.4% which is not far from the intended 2.5%. I bring this up here, because as you get to larger proportions of fluid volumes that you are adding, the volume will become more significant and you must understand how this relationship is supposed to work and then decide if you must remove volume (as described above) in your preparation to keep it more accurate. If you are ever unsure, ask your doctor what he/she prefers.*

l. **Your doctor has asked you add dextrose to a patient's LRS fluid bag to make a 2.5% dextrose solution. The dextrose is 50% concentration and the LRS fluid bag only has 600ml left out of the original 1000ml. How do you prepare the fluid bag?**
This is similar to the previous problem --> in this case:
Fluid A = dextrose 50% solution
Fluid B = 2.5% LRS fluid solution

C1=concentration of the Fluid A = 50%
C2=concentration of Fluid B =2. 5%
V1=volume of Fluid A = unknown - this is what we are trying to determine so we will call it V1
V2=final volume of Fluid B = 600ml

(50%)(V1) = (2.5%)(600ml) --> (50%)V1 = 1500%*ml --> $\frac{1500\cancel{\%}*ml}{50\cancel{\%}}$ =V1 -->V1 = 30ml of 50% dextrose

***In this case, you can remove 30ml of the original LRS solution and discard*
Then you will add 30ml of 50% dextrose to give you the final 600ml of 2.5% dextrose solution.
Alternatively if you leave it as 30ml plus 600ml for a final concentration of 2.4%.

For the following problems, I am not going to elaborate each step as I did for the previous problems. By now you should be getting the hang of it, so I will focus on elaborating more unusual or tricky steps

3. Filling prescriptions

a. Your doctor has asked you to fill 4 week's worth of 1/4 grain (16.2mg) Phenobarbital tablets for Sassy. She gets 1/2 of a 1/4 grain tablet every 12 hours. How many tablets should you fill for Sassy?

First we need to figure out how many tablets Sassy gets every day. If Sassy gets 1/2 of a tablet twice a day, then she gets 1 tablet per day.

$$\frac{0.5\ tablet}{\cancel{dose}} \times \frac{2\ \cancel{doses}}{day} = 1\ tablet/day$$

We then multiply the number of tablets she gets per day by the number of days she needs the medication to get the total number needed. In this case it is 1 tablet multiplied by 28 days (because there are 7 days a week and 4 weeks total).

$$\frac{1\ tablet}{\cancel{day}} \times \frac{4\ \cancel{weeks}}{1} \times \frac{7\ \cancel{days}}{\cancel{week}} = 1x4x7 = 28\ tablets$$

b. Your doctor has asked you to fill 3 weeks of gabapentin for Elsworth. She should get about 10mg/kg of gabapentin every 8 hours. She weighs 9.2 kg. Your clinic carries 50mg, 100mg, and 300mg capsule sizes. Which size do you choose and how many do you fill for Elsworth?

First we need to figure out what size capsule she needs to take:

$$\frac{9.2\cancel{kg}}{1} \times \frac{10mg}{\cancel{kg}} = 92mg$$

This is very close to the 100mg capsule size, so this is what we will choose. Next we need to decide how many capsules she needs in total. We will do what we did in the previous problem by figuring out how many capsules she needs per day, then how many total for the 3 weeks. We will put this together in one long problem below:

$$\frac{1.0\ capsules}{\cancel{dose}} \times \frac{3\ \cancel{doses}}{\cancel{day}} \times \frac{3\ \cancel{weeks}}{1} \times \frac{7\ \cancel{days}}{\cancel{week}} = 1x3x3x7 = 63\ capsules$$

c. Your doctor has prescribed 0.8ml of 50mg/ml oral suspension gabapentin every 8 hours for 2 weeks for Sparky. How many milliliters of the gabapentin suspension do you need to fill for Sparky?

We treat this the same way we do for pills and capsules. We first figure out how much he needs per day, then we multiply by the number of days he needs the medication:

$$\frac{0.8ml}{\cancel{dose}} \times \frac{3\ \cancel{doses}}{\cancel{day}} \times \frac{2\ \cancel{weeks}}{1} \times \frac{7\ \cancel{days}}{\cancel{week}} = 0.8x3x2x7 = 33.6ml$$

***In cases of liquids, I will often fill a little bit more to account for losses in the syringe hub or if the owner might need to redose. You might ask your doctor if they want to round up to 35ml for these reasons.*

d. **Your doctor has asked you to make 10 syringes of 0.3ml of buprenorphine for Fluffernutter. How many milliliters will you charge for in total?**

We need to multiply the volume by the number of syringes to get the total volume you are drawing up:

$\frac{0.3ml}{\cancel{syringe}} \times 10\ \cancel{syringes} = 3.0ml$

***Remember how we can move the decimal point over to the right one space for each ten we use to multiply? See how all we need to do is to just move the decimal point here because we are multiplying by ten?*

4. **Dosing injections**

a. **You have been asked to give Juno 0.3mg/kg of methadone IV for pain control. Juno weighs 24 pounds. Methadone is 10mg/ml. How many milliliters will you give to Juno?**

First we must convert Juno's weight to kilograms:

$\frac{24\cancel{lb}}{1} \times \frac{1kg}{2.2\cancel{lb}} = 24/2.2 = 10.9kg$

Next we must find the volume of methadone required:

$\frac{10.9\cancel{kg}}{1} \times \frac{0.3\cancel{mg}}{\cancel{kg}} \times \frac{1ml}{10\cancel{mg}} = (10.9x0.3)/10 = 0.3ml$

b. **Your doctor has asked you to give 0.5 grams/kg of mannitol IV over 20 minutes to Charlie. Mannitol is 20% solution and Charlie weighs 17.4kg. How many milliliters will you give?**

***Remember that % solution is the same as the number of grams per 100ml? So 20% is the same as 20g/100ml*

$\frac{17.4\cancel{kg}}{1} \times \frac{0.5\cancel{g}}{\cancel{kg}} \times \frac{100ml}{20\cancel{g}} = (17.4x0.5x100)/20 = 43.5ml$

c. **Your doctor needs you to give 10 units (U) of Humulin R insulin to Juliette, but you do not have U-100 insulin syringes. Humulin R is 100U/ml. How many milliliters will you draw up to use and which size syringe (1ml, 3ml, 6ml) syringe should you use for this?**

$\frac{10\cancel{U}}{1} \times \frac{1ml}{100\cancel{U}} = 10/100 = 0.1ml$

This is best given with the smallest syringe you can so you can be as accurate as possible. You should use a 1ml syringe here.

d. **Your doctor needs you to give 10 units (U) of Vetsulin insulin to Juliette, but you do not have U-40 insulin syringes. Vetsulin is 40U/ml. How many milliliters will you draw up to use and which size syringe (1ml, 3ml, 6ml) syringe should you use for this?**

$\frac{10U}{1} \times \frac{1ml}{40U} = 10/40 = 0.25$

This is best given with the smallest syringe you can so you can be as accurate as possible. You should use a 1ml syringe here.

e. **<u>Challenging question:</u> Your client picked up her new prescription for Vetsulin for her dog Rexie who is getting 8 units of Vetsulin insulin SQ twice a day. Vetsulin is 40U/ml and requires U-40 syringes. The client was accidentally sent home with 0.5ml U-100 syringes and right now the clinic is closed. Can you tell her how to give the evening and morning doses using the U-100 syringes? How many units using the U-100 syringes is the equivalent of 8U of 40U/ml Vetsulin?**

First we need to figure out what volume of insulin Rexie needs:

$\frac{8\cancel{U}}{1} \times \frac{1ml}{40\cancel{U}} = 8/40 = 0.2ml$

Next we need to figure out how to measure volume using the U-100 syringes. We know each U-100 syringe holds 0.5ml. This half-milliliter is divided into 50 units (this is because the syringe is 0.5ml, so we will need to be able to measure half of the units that are in each milliliter. If it is 100U for each milliliter, then the 0.5ml syringe holds half of this or 50 units.

There are 50 units for the 0.5ml and we want to know specifically how many milliliters per unit is represented

$$\frac{0.5ml}{50U} = 0.01ml/U$$

So each unit mark on the syringe represents 0.01ml. We know from our first calculation that we need 0.2ml. Next we need to figure out how many units will give us 0.2ml:

$$\frac{0.2\cancel{ml}}{1} \times \frac{1U}{0.01\cancel{ml}} = 20U$$

20U So you will draw up 20U on the U100 syringe to equal 8U of 40U/ml insulin

***We know this answer can make sense because regular insulin is 2.5 times more concentrated that Vetsulin (100/40 = 2.5). This means it takes 2.5 times more volume to give the 40U/ml insulin compared to 100U/ml. Do you see that 20U is 2.5 times greater than 8U?*

5. **Calculating fluid rates**
   a. **Your doctor has asked you to set up LRS fluids at a maintenance rate for a dog named Jackson. She would like you to use 60ml/kg/day as the maintenance rate. Jackson is 60 pounds. What fluid rate will you use for the LRS?**

First, we must convert Jackson's weight to kilograms:

$$\frac{60\cancel{lb}}{1} \times \frac{1kg}{2.2\cancel{lb}} = 60/2.2 = 27.3kg$$

Next, we must determine how many milliliters Jackson will be getting each day:

$$\frac{60ml}{\cancel{kg}*day} \times \frac{27.3\cancel{kg}}{1} = 60x27.3 = 1638ml/day$$

Finally, we must determine how many milliliters per hour to set the fluid pump. There are 24 hours in a day, so we divide the total daily fluid amount by 24 hours:

$$\frac{1638ml}{\cancel{day}} \times \frac{1\ \cancel{day}}{24\ hours} = 1638/24 = 68.25\ (round\ to\ 68\ ml/hour)$$

This can all be set up in one long series of calculations:

$$\frac{60\cancel{lb}}{1} \times \frac{1\cancel{kg}}{2.2\cancel{lb}} \times \frac{60ml}{\cancel{kg}*\cancel{day}} \times \frac{1\ \cancel{day}}{24\ hours} = (60x60)/(2.2x24) = 68.18\ (round\ to\ 68ml/hour)$$

***The second answer is 68.18 instead of 68.25 because in the first answer I rounded answers for each step - this can slightly affect your final calculations requiring a longer series of steps. In the second problem, I did all the calculations at once so this is a more precise number.*

Did you notice that the maintenance rate for this dog is close to the same value as his weight in pounds? This can give you a quick estimate of what to expect the correct answer should be. This is for a DOG. Cats have a lower daily maintenance rate of 45ml/kg/hour. **Can you estimate the hourly rate for a 10-pound cat based on this information?
Consider that if you had a dog, the estimated rate would be 10ml/hour. However a cat's rate is 3/4 (same as 75%) of that of a dog (because 45 is 75% of 60). In that case, you would take 75% of 10: 10ml/hour x 0.75 = 7.5ml/hour.

b. **Your doctor has asked you to set up LRS fluids at a maintenance rate for a cat named Percy. She would like you to use 45ml/kg/day as the maintenance rate. Percy is 10 pounds and in good body condition. What fluid rate will you use for the LRS?**

$$\frac{10\cancel{lb}}{1} \times \frac{1\cancel{kg}}{2.2\cancel{lb}} \times \frac{45ml}{\cancel{kg}*\cancel{day}} \times \frac{1\ \cancel{day}}{24\ hours} = (10x45)/(2.2x24) = 8.5ml/hour$$

***Refer to the previous question that addresses quick estimates for hourly maintenance fluid rates. Do you see how this answer is close to the estimated rate of 7.5ml/hour (75% of 10lb)? This tells you that you have calculated correctly.*

c. **Your doctor has asked you to set up LRS fluids at a maintenance rate for a cat named Toby. She would like you to use 45ml/kg/day as the maintenance rate. Toby is 18 pounds and morbidly obese - you estimate that he may weigh 12 pounds in lean body mass. What fluid rate will you use for the LRS?**
Obese cats can be easy to fluid overload. For this reason, it can be prudent to ask your doctor if a calculation based on his ACTUAL weight or estimated LEAN weight should be used. I will usually err on the side of using the estimated lean weight in an otherwise hydrated cat:

$$\frac{12\cancel{lb}}{1} \times \frac{1\cancel{kg}}{2.2\cancel{lb}} \times \frac{45ml}{\cancel{kg}*\cancel{day}} \times \frac{1\ \cancel{day}}{24\ hours} = (12x45)/(2.2x24) = 10ml/hour$$

d. **Your doctor has asked you to give a 200ml bolus of LRS fluids over 15 minutes. What fluid rate in ml/hour should you set the fluid pump to?**
We know how much volume we want to give per 15 minutes, now we need to convert to how much fluid we want to give in one hour:

$$\frac{200ml}{15\ \cancel{min}} \times \frac{60\ \cancel{minutes}}{1\ hour} = (200x60)/15 = 800ml/hour$$

***Do you see how 800 is 4 times as much as 200? Do you also appreciate that 1 hour is 4 times longer than 15 minutes (think of a clock and how the 15-minute position is 1/4 of the entire circle). A quick way to think about this is to just multiply the fluid volume by 4 here. You are not really giving 800ml because you are stopping 1/4 of the way into the hour - 1/4 of 800 is the 200ml you want to give. Does this make sense?*

e. **Your doctor has asked you to give 400ml of Norm-R fluids over 20 minutes. What fluid rate in ml/hour should you set the fluid pump to?**
This is very similar to the last problem only we are now using 20 minutes instead of 15:

$$\frac{400ml}{20\ \cancel{min}} \times \frac{60\ \cancel{minutes}}{1\ hour} = (400x60)/20 = 1200ml/hour$$

***Now there are only 3 segments of 20 minutes in each hour. In this case, you can multiply 400ml by 3 to get 1200 as your quick calculation. In order to get 400ml into your patient in 1/3 of an hour, you have to triple your hourly fluid rate.*

6. **Calculating CRIs**

a. **You are setting up a fentanyl CRI for surgery. The patient weighs 26kg, the fentanyl is 50ug/ml, and you want to have 4ug/kg/hour rate. You need to have enough fentanyl at this rate to run for 3 hours. What is the rate in ml/hour? How much fentanyl will you need to have to last all 3 hours ?**

$$\frac{26\cancel{kg}}{1} \times \frac{4\cancel{ug}}{\cancel{kg}*hr} \times \frac{1ml}{50\cancel{ug}} = (26x4)/50 = 2.1ml/hour$$

Do you see how we combined two steps in the above calculation? First we determined how many micrograms would be used per hour. Then we converted to milliliters per hour.

Now we must determine how many milliliters we need for 3 hours:

2.1ml x 3 ~~hours~~ = 6.3ml will be used in 3 hours
~~hour~~ 1

***We must also remember that you will likely have an infusion set up using IV tubing. You will need to take the volume of this infusion set-up into your calculation. So if it takes 3.0ml to fill the infusion line to the patient, you will also need to add this to the total volume needed:*
6.3ml + 3.0ml = 9.3ml total
This volume can vary depending on the equipment you use. Ask your doctor or a fellow technician if you are unsure of the volume you should add to your estimate.

b. You need to prepare propofol for induction and maintenance of anesthesia for Louie. Louie is 42kg and propofol is 10mg/ml. You will need to plan for up to 4mg/kg to use for induction. Then you will use 0.4mg/kg/min to maintain anesthesia. How much volume do you need to have ready for induction? What rate of propofol will you use for Louie in ml/min? What is the rate in ml/hour? How much volume should you have available for 45 minutes of anesthesia?

42~~kg~~ x 4~~mg~~ x 1ml = (42x4)/10 = 16.8 rounded up to 17ml available to induce
1 ~~kg~~ 10~~mg~~

42~~kg~~ x 0.4~~mg~~ x 1ml = (42x0.4)/10 = 1.7ml/min CRI rate
1 ~~kg~~*min 10~~mg~~

1.7ml x 60 ~~min~~ = 102ml/hour CRI rate See how this was a simple conversion from minutes to hours?
~~min~~ hour

1.7ml x 45 ~~min~~ = 76.5ml used in 45 minutes
~~min~~ 1

*** Remember you must add the volume of your fluid infusion lines to the calculated volume required. So if you have a long fluid line that holds 10ml, then you must add 10ml to the calculated 76.5ml for a total of 86.5ml.*

c. Xander needs to get 1.5mg/kg/day of metoclopramide as a CRI. Your doctor would like you to add this to Xander's IV fluids. Xander is 15kg and metoclopramide is 5mg/kg. His fluid rate is 35ml/hour. How many milliliters of metoclopramide to you need to add to his 1 liter bag of LRS?

First we must determine how many milligrams of metoclopramide Xander needs per day:

15~~kg~~ x 1.5mg = 22.5mg
1 ~~kg~~*day

Next we must determine how much fluid he will get each day:

35ml x 24 ~~hours~~ = 840ml/day
~~hour~~ day

Now we see that Xander will use less than 1 liter per day, so we already know we will need more than 22.5mg in the 1L fluid bag. We can make a proportion and cross multiply here. This is something we have not specifically showed you before. It is based on the idea that you can set up equal ratios that allow you to solve for a missing number. For example:

1 = 3
4 12

We know that 1/4 and 3/12 are both the same number (0.25). What if we didn't know what was 0.25 of 12?

1 = x
4 12

Mathematical principles allows us to multiply diagonally across the equal sign:

$\frac{1}{4} = \frac{x}{12}$ 4x = 12

Now to solve for "x", we will need to divide 12 by 4 (this assumes you know rules of basic algebra). In this case 12/4 = x = 3

We use this principle of cross-multiplication to figure out which ratio will be equal to the daily requirement of 22.5mg in 840ml:

$\frac{22.5mg}{840ml} = \frac{x}{1000ml}$ --> (840ml)x=22.5mg (1000ml) --> (840ml)x = 22,500mg*ml -->

x=22,500mg*~~ml~~/840~~ml~~ = 26.8mg

So now we know that 26.8mg in 1000ml (1L) of fluids gives us the same proportion as 22.5mg in 840ml. We therefore need to add 26.8mg to 1L of LRS. We know the concentration of metoclopramide is 5mg/ml so we know need to determine how many milliliters to add:

$\frac{26.8mg}{1} \times \frac{1ml}{5mg}$ = 5.4ml of metoclopramide need to be added to 1L of LRS fluids to give us 1.5mg/kg/day

d. **Xander needs to get 1.5mg/kg/day of metoclopramide as a CRI. Your doctor would like you to add this to Xander's IV fluids. Xander is 15kg and metoclopramide is 5mg/kg. His fluid rate is 35ml/hour. How many milliliters of metoclopramide to you need to add to the bag of LRS fluids? Right now he has 750ml left in his 1L bag of LRS.**
This is going to be similar to the problem in which you calculated how much KCl to add to a partial fluid bag. The first step here is to determine how many milliliters of metoclopramide to add to 1L of LRS. You did this in the previous question and came up with 5.4ml in 1L. Now you need to determine how many milliliters you will use for 750ml:
750/1000 = 75% or otherwise stated as 0.75
You will therefore only need 75% of the amount of metoclopramide you would have used for one full liter:
5.4ml x 0.75 = 4.1ml needed to add to 750ml to run at 1.5mg/kg/day at a fluid rate of 35ml/hour

7. **ER drug quick tricks**
   a. Emergency doses of diazepam, atropine, and epinephrine can all be estimated the following way:
   1ml per every 20 pounds or 0.5ml per cat-sized dog

   Glance quickly at your patient and consider how many 20 pound dogs will fit (like 4 beagles into a big Labrador). Then multiply that by 1ml.
   If your patient is a big lab that looks like the size for 4 beagles, you will get 4ml of the drug you need.

   Let's look at diazepam for an 80lb dog:
   Diazepam IV dose for seizures is 0.5mg/kg and diazepam is 5mg/ml
   $\frac{80\cancel{lb}}{1} \times \frac{1\cancel{kg}}{2.2\cancel{lb}} \times \frac{0.5\cancel{mg}}{\cancel{kg}} \times \frac{1ml}{5\cancel{mg}}$ = 3.6ml   4.0ml = 0.55mg/kg --> pretty darn close to 0.5mg/kg!

   Let's look at atropine for an 80lb dog:
   Atropine IV dose for CPR is 0.05mg/kg (range 0.04-.01) and atropine is 0.54mg/ml
   $\frac{80lb}{1} \times \frac{1kg}{2.2lb} \times \frac{0.05mg}{kg} \times \frac{1ml}{0.54mg}$ = 3.4ml   4.0ml = 0.06mg/kg --> pretty darn close to 0.05mg/kg!

Let's look at epinephrine for an 80lb dog:
Epinephrine IV high dose for CPR follows this short cut. These days, it is suggested to start with a low dose first which is 1/10th the volume of the high dose. You can still use this shortcut to find the high dose volume, then give 1/10th of this volume to start.
Epinephrine low dose is 0.01mg/kg (range 0.01-0.1(high dose)) and epinephrine is 1.0mg/ml

$\frac{80lb}{1} \times \frac{1kg}{2.2lb} \times \frac{0.01mg}{kg} \times \frac{1ml}{1.0mg} =$ 0.36ml for the low dose, 3.6ml for the high dose

4.0ml = 0.11mg/kg - target dose for the high dose epinephrine!

***Now you see how closely these doses are to the calculated doses!*

b. Shock doses of crystalloid fluids

The shock dose of crystalloid fluids for a dog is about 90ml/kg. We like to give this in "quarter shock dose boluses" meaning we only give 1/4 of the total estimated fluid volume at a time to make sure we don't run the risk of fluid overload. Let's use a 20 pound dog as an example:

$\frac{20lb}{1} \times \frac{1kg}{2.2lb} \times \frac{90ml}{kg} \times \frac{1}{4}$ = 204ml for each quarter dose

Now look at the weight in pounds. See that it is 20? Now add a zero to the end of this to get the number 200. See how 200 is nearly the same as 204ml that took much longer to calculate? It is much quicker to add a zero to the end of a dog's weight in pounds to give you the quarter shock dose to use for fluid resuscitation.

A cat's shock dose is 45ml/kg. This is HALF of the dog dose of 90ml/kg. This means you can give a cat HALF of what you would give a dog. So if you had a 10 pound cat, you would use 100ml if it was a dog. But since it's a cat, you will use half of this and use 50ml instead. Does this make sense?

c. Tips and tricks for anesthesia

Anesthesia can be scary and requires split second decisions and quick calculations. As you have seen in this document, some calculations take time. For this reason, it is smart to be prepared with pre-calculated doses for medications you might be more likely to use like atropine, glycopyrrolate, fentanyl and propofol boluses, etc. Also keep a chart of volume rate changes for medication CRI adjustments.

Remember to always check your work (especially your units!), always ask questions when you are not absolutely sure, and keep up the good work!