Accuracy & Precision in Medicine
How many digits do you keep?

Determining accuracy & precision of numbers

When you do calculations in a calculator, have you ever wondered how many digits you should keep? The answer is that it depends on the amount of digits that you put in, because your answer is only as precise as the least precise number that you put into your calculator.

The smaller the unit of measurement, the more precise the number is. Which number do you think is the most precise? 2.5 meters or 3.81 meters?


en.wikipedia.org/wiki/Calculator

That's right – 3.81 meters is more precise because the person who measured used a tool that can measure to another decimal point. The more data you have, the more accurate your measurement.

What about this comparison. Which is more precise? 5.82 feet or 1.25 inches?

1.25 inches is more accurate because it measures the smallest scale division. If you think about 5.82 feet, that's actually 69.8 inches, so it has less precision than 1.25 inches.

This means that the first thing we need to talk about is precision in individual numbers.

Determining the number of significant figures

If you are going to multiply the numbers, you need to identify how many are significant in the original values. To determine the number of significant figures follow these rules:

1. All non-zero numbers ARE significant
   3456 has four significant figures, 198 has three significant figures
2. Captive zeroes ARE significant
   309 or 400001 have captive zeroes as they are between non-zero numbers
3. Leading zeroes are NOT significant
   ex. 0.00034 is only 2 significant figures, 0000125 is only 3 significant figures
4. For the zeroes at the end remember the rule: ***YES DOT, NO DOT NO***
   If there is a decimal in the number, the zeroes at the end are significant
   If there is **no** decimal, they are not significant.
   ex. 34000 is only 2 significant figures because the zeroes at the end represent a rounded value.
   4.4000. is 5 significant figures because the zeroes at the end represent a measured value

TIP: If you have an exact number, add a decimal to the end to indicate that all of the digits are significant! For instance…. 2000 would be assumed to be rounded, so it has only 1 significant figure. If you have counted exactly 2000 of something, add a decimal at the end to indicate significance: 2000.

Determining the final place of significance

If you are going to add or subtract the numbers, you need to identify the last place of significance
To do this, find the last significant figure (using the directions above), then identify what place the last one is in. (100's, 10's, 1's, 10ths, 100ths… etc)

References

http://www.ccpe-cfpc.com/en/pdf_files/drug_lists/normal_values.pdf

Name(s): **Period:** **Date:**

Accuracy & Precision in Medicine: Part 1

Practice

Determine the number of significant figures for each value and its last place of significance. Using the internet, research each of the tests and fill in what the test is telling a person about their health. If it's within the normal values your diagnosis should be "normal".

Parameter	Normal Values
Vital Signs	
Heart Rate	60-80 beats per minute (bpm)
Respiration Rate	12-18 breaths per minute
Body Temperature	36.5-37.5˚C
Electrolytes	
Bicarbonate (HCO_3) serum	24-30mEq/L
Chloride Serum	98-106mEq/L
Potassium	3.5-5.0 mmol/L
Sodium serum	135-145 mEq/L
HEMATOLOGICAL PARAMETERS	
Red Blood Count (RBC) (Erythrocytes)	Female: $4.0\text{-}5.2 \times 10^{12}$/L Male: $4.2\text{-}5.7 \times 10^{12}$/L
Hemoglobin	Female: 12.3-15.7 g/dL Male: 14.0-17.4 g/dL
White Blood Cell Count	$4.0\text{-}10.0 \times 10^3/mm^3$
Platelet Count	$130\text{-}400 \times 10^3/mm^3$
Hormones	
Aldosterone	19-34 ng/dL
Estrogens (as Estradiol)	Female: 50-450 pg/mL Male: <55
Insulin	5-25 µU/L
Testosterone	Female: <62 ng/dL Male: 300-1000ng/dL
Thyroid Stimulating Hormone	0.4-5.0 µU/mL

Problem	# of Sig Figs	Last place of significance	Diagnosis
Your patient has a heartbeat of 120 bpm.			
Your patient has a body temperature of 39.6˚C			
Your patient's potassium levels are 2.9mmol/L			
Your female patient has an RBC count of 3.1×10^{12} /L			
Your patient has a white blood cell count of $1.5 \times 10^5/mm^3$			
Your patient's aldosterone level is at 38ng/dL			
Your patient's insulin level is at 4 µU/L			
Your patient's Thyroid Stimulating Hormone levels are at 0.12 µU/mL			
Your patient has a respiration rate of 8 breaths per minute			
Your patient's sodium serum level is at 38 mEq/L			
Your male patient's hemoglobin levels are at 12.8 g/dL			
Your female patient's estrogen level is at 125 pg/mL			
Your male patient's testosterone level is at 825 ng/dL			

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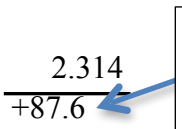
Adding & Subtracting – Based on place of significance

When you add or subtract a number you are essentially doing the same mathematical function, since subtracting is the same as adding a negative number.
If you think about how you line up numbers to add them together, you always line them up using the decimal.

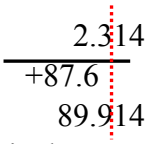
Try this problem: 2.314inches + 87.6inches = ?

Your calculator will give you the answer 89.914inches, however, that answer does not match the accuracy of our measured values.

Set up the problem like you learned in elementary school…



Notice that there is nothing there to add to the numbers up above… this means that the 6 is rounded. Since it's the least precise figure we need to cut off our answer at the same place value. The final answer is rounded based on what you cut off



Final answer: 89.9

If you look closely at the way you do basic addition, you will notice that it's lined up so that you add the same place with its place. (10ths + 10ths, 100's + 100's, etc). This means that the last significant place in your values you are adding together determines the how many digits you keep in your final answer.

Because most of the values we use have a decimal, this rhyme may help: When you ADD look at the DAD (Digits After Decimal). Whichever value has the least DAD's will determine your rounding of the answer.

References

http://www.ccpe-cfpc.com/en/pdf_files/drug_lists/normal_values.pdf

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Accuracy & Precision in Medicine: Part 2

Practice Addition Accuracy

Problem – Underline the last digit in each number	Calculator answer: Underline the last digit you can keep	Accurate Answer: Rounded
31.5 + 0.17	31.67 *This gets rounded up because the next number is over 5.	31.7
2800 + 1250	4050 *We round everything after the last digit you can keep and turn it to a zero	4100
12.89 + 123		
357 + 1.56		
200 + 1		
200. + 1 + 24		
78.3 - 1.005		
2.98 - 31		
45 - 0.921		

Multiplying and Dividing – Based on the number of significant figures

In order to determine the number of digits you will use when you multiply or divide, you merely need to determine the number of significant figures in each of the initial values. The calculator answer is then rounded to have the same number of significant figures as the least of your initial values.

Practice Multiplication Accuracy

Problem – Underline all significant figures in each number	Calculator answer: Underline the significant figures you can keep	Accurate Answer: Rounded
418 x 0.31	129.58 *This gets rounded up because the next number is over 5.	120
3805 x 0.00540	20.547	20.5
1.584 x 3200		
7100 x .25		
35007 x 0.00019		
100 x 0.523		
67 x 90		

Medical Application Problems

Solve each problem using the correct rules from the lesson

1. A nurse adds 5.0mL to an IV bag containing 250.mL. How many mL are now in the IV bag?

2. A patient's blood sample is 8.5mL, and 3 drops of a chemical are added to test the solution. Each drop is 0.05mL. What is the final volume of the solution?

3. A doctor has ordered 1.5 liters of normal saline for a patient. If it has to be given over 10 hours, how many liters per hour will drip into the patient's IV?

4. A patient is going to take 12mL of cough syrup each night and the doctor gives the patient a bottle containing 100.mL. How many doses of cough syrup are in the bottle?