**General Discussion:**

When discussing questions of how many digits (or decimal places) should be shown many instructors will simply say show one or two decimal places and round. Generally speaking this will provide an answer that is close enough to what is desired. Often scientific notation is used where each number is shown to have 3 places (units, tenths, hundredths) multiplied by 10 raised to a power. Most engineering and science based classes where very large or very small numbers are used will require the use scientific notation since it will give predictable answers.

**Precision & Accuracy:**

However, it is not always that simple. The reason for this is due to the *precision* and the *accuracy* involved in each step whether adding/subtracting or multiply/dividing/taking powers or roots. What does this mean? And why is this important? The answer to the second question of course is about the correctness of the answer. The answer to the first requires a little more discussion. The following will inspect and define what is involved when one adds or subtracts and when one may multiply, divide, take powers or roots.

1. **Precision**
   1. When adding and subtracting two or more numbers one is dealing with precision. Precision relates to how well a number is known. As an example the number 1.0 is not known as well as the number 1.01. The reason is 1.0 is known only to the tenths decimal position while 1.01 is known to the hundredths decimal position. One then may say that the number 1.01 is known more precisely than is the number 1.0.
   2. Generally stated the following rule applies when adding or subtracting:

*Rule #1: When adding or subtracting one is dealing with precision. The answer to a math problem involving only addition and subtraction therefore can be no more precise than the least precise number used in the calculation.*

* 1. Examples:
     1. Adding 100.12 to 5.5 does not equal 105.62, it equals 105.6. Why? Because the least precisely known number is 5.5 since it is only known to the tenths decimal position. Therefore the answer can only be asserted as being known to the tenths decimal position or 105.6.
     2. Subtracting 5.5 from 100.12 does not equal 94.62. Why? Because the least precisely known number again is 5.5 since it is only known to the tenths decimal position. Therefore the answer can only be asserted as being known to the tenths decimal position or 94.6.
     3. Subtracting and adding several numbers such as below:

100.12 – 5.5 + 45.198 + 14.6962 = ?

**Question:** What is the least precisely known number?

**Answer:** It is 5.5

Impact: The answer’s precision can only be asserted as being known to the tenths decimal position. Therefore:

100.12 – 5.5 + 45.198 + 14.6962 = 154.5

Note the raw answer before rounding was: 154.5142

**Question:** Why was the answer rounded to the tenths position? **Answer:** Because that was how well known the least precise number used in the adding and subtracting was known; therefore the answer can be no more precise than the least precise number (which was 5.5) used in the calculation.

1. **Accuracy:**
   1. When multiplying, dividing, taking powers or roots one is dealing with accuracy. The accuracy of the number is related to the number of significant digits used in the calculation. As an example if 1.175 is to be multiplied by 1.23 by inspection one can see the first number has 4 significant digits and the second number has 3 significant digits. The number 1.175 is therefore said to be more accurate than is 1.23 (4 significant digits versus 3 significant digits).
   2. Generally stated the following rule applies when multiplying, dividing, taking powers or roots:

*Rule #2: When multiplying, dividing, taking powers or roots one is dealing with accuracy. The answer to a math problem involving only multiplying, dividing,*

*taking powers or roots therefore can be no more accurate than the least accurate number used in the calculation.*

* 1. Examples:
     1. When multiplying 5.235 by 6.2 the first number has 4 significant digits where the second number has only 2. As a result the first number is said to be more accurate than the second number (Accuracy of 4 versus an Accuracy of 2). This then leads to the fact that when these two numbers are multiplied together the answer can be no more accurate than the least accurate number involved in the calculations. As a result this means that the product of 5.235 and 6.2 can only have two significant digits, or an answer of 32 (raw answer is 32.457 as displayed by your calculator).
     2. Similarly if one were to divide 5.235 into 6.2 the answer can only be as accurate as the least accurate number used in the calculation. As a result the answer can only have 2 significant digits, or 1.2 (raw answer based upon calculator display was 1.184336199)
     3. If there is a string of multiplication and divisions then the answer to the problem can be no more accurate than the least accurate number used in the calculation. Example:

32.78 / 15.103 x 12.678 x 14.1 = 388 (calculator displayed 387.9855819)

Note the answer may only have 3 significant digits. Also note in this answer the 0’s in 88,500 are not significant digits since they are simply place holders (see definitions on what is a significant number).

* + 1. If there is a string calculation involving multiplication, division, taking powers and roots the process is still the same.

2.05 x (6.1)2 / 3.75 x 4 = ?

Note the least accurate number here is 4. It has only 1 significant digit. Therefore the answer can only have one significant digit.

2.05 x (6.1)2 / 3.75 x 4 = 80

(The calculator displayed 81.36586667; since we can only have one significant digit we must round the answer to the tens position; the answer therefore must be 80. Note that the 0 in the unit’s position is not a significant digit since it simply is used as a place holder).

1. **Using Accuracy & Precision in the same problem**
   1. When performing a calculation that involves both precision and accuracy one must observe the order of precedence mathematical functions. What this means is that in a string calculation involving addition, subtraction, multiplication, division, taking powers and roots one must:
      1. First do the multiplication, division, taking powers and roots paying attention to the accuracy of the numbers they yield.
         1. Example: = 24.78 – [(5.2300 x 1.341 / 2.71)2] – 1.2

= 24.78 – *[(5.2300 x 1.341 / 2.71)2]* – 1.2

= 24.78 – *[2.59]2* – 1.2

= 24.78 – *6.70* – 1.2

Note, the number derived from the parenthetical operations (calculating using multiplication, division and taking powers and roots) has an accuracy of 3, since that is the least accurate number in the parenthetical statement.

* + 1. Then do the addition and subtraction paying attention to the precision of the number they yield.

= 24.78 – 6.70 – 1.2

= 16.8

Note, the final answer is only precisely known to the tenths position since the least precise number is only known to the tenths position.

* + 1. Keep in mind:
       1. If functions are grouped together parenthetically the calculations within the parentheses must be done first paying attention to the order of precedence of the functions.
       2. All addition and subtraction must be done from left to right as they appear in the calculation
       3. All multiplication and division must be done from left to right as they appear in the calculation
       4. Taking powers and roots are always done first before anything else unless they are to be taken on a parenthetical grouping.
       5. If the latter is the case then perform the mathematical operations in the parenthetical grouping first and only then take the power or root of the parenthetical results.
       6. Multiplying, dividing taking powers or roots takes precedence over addition and subtraction

1. **Recommendations and Advisements:** 
   1. It is recommended that the student refresh themselves on what are significant digits and how do you determine them give the numbers present.
   2. This tutorial is only informational only.
   3. In providing your answers for exams and quizzes do your complete calculation then round to units, tenths or hundredths depending on how the question is asked. Note: when selecting an answer in a multiple choice question always select the answer that is closest to your answer.