Digits of Accuracy

This document provides additional clarification regarding Digits of Accuracy and how those are expressed throughout this course.

When you are given a problem that includes a number like 1000, you would normally use the context of the problem to determine if the 1000 means the number was rounded to the nearest thousand or if the number should be exactly 1 followed by three zeros (expressing a number that has not been rounded at all). For example, in the sentence, “There are 1000 meters in a kilometer,” it is clear that 1000 is an exact number.

However, in the following sentence, “The visibility is 1000 meters,” it would generally be understood that this is an estimate. The accuracy of the number could be clarified by writing it in scientific notation. For example, “The visibility is 1.0×10^3 meters,” means we know the visibility is between 950 meters and 1050 meters.

In physics a number written as an integer, such as 1000, is ambiguous.

Language can also be ambiguous. If I say, “He eats shoots and leaves,” you do not know if I am talking about a panda bear at the zoo, or if I am talking about my teenager’s friend stopping by after school to practice basketball. When we write things down, we can alter the meaning with punctuation. “He eats shoots and leaves,” has a different meaning than, “He eats, shoots, and leaves.” Using scientific notation in science is similar to using punctuation with the written word—both give clarity to the meaning of a statement.

The following rule helps clarify how to interpret an integer in this course.
Rule: “An integer number in a <u>question</u> is good to three digits of accuracy.”

Of course, we could still express the specific accuracy of the number in more detail by using scientific notation. However, when we provide multiple choice answers, it is inconvenient to use scientific notation in each answer choice to clarify the accuracy of the answer.

For example, consider this question:
What is the weight of a 5.1 kg object on the surface of the Earth? (use $g = 9.8\ m/s^2$)

The answer is $F = mg = (5.1\ kg)(9.8\ m/s^2) = 49.98\ N$. We need to express the answer to two digits of accuracy because both m and g were only written to two digits of accuracy. If the answer options were multiple choice, they could read:

Form 1:

A. 3.0 N
B. 8.0 N
C. 1.2×10^1 N
D. 1.6×10^1 N
E. 5.0×10^1 N

Or, we could make the answer selections read:

Form 2:

A. 3 N
B. 8 N
C. 12 N
D. 16 N
E. 50 N

For this question, we will use the second form because it makes it easier to gain an understanding of the actual size of the number. However, this contradicts our rule that integers can be considered to be accurate to three digits. But remember we said that, “An integer number in a <u>question</u> is good to three digits of accuracy.” The three digits of accuracy rule does not apply to multiple choice answers.

Above in answer A. “3 N”, the common usage would be that the first digit is 3 and we are making no claims about other digits, so that would be one digit of accuracy. For answer E. “50 N”, it is ambiguous since a student cannot tell if we rounded to one digit of accuracy, the 5, or if we are claiming both the 5 and the 0 are significant for two digits of accuracy. However, based on the answer options A through E, there would be no confusion as to which answer the student should select if he got 49.98N when doing the calculation. Because the integer 50 is an “ambiguous case,” it could be considered to represent either one or two digits of accuracy.

Remember, three digits of accuracy for integers are only guaranteed when we use an integer in a question. We are not restricting an integer written in an answer to also claim three digits of accuracy. If we were to do so, the multiple choice answers would have to be written in scientific notation (as in Form 1 above), and that is too cumbersome for a multiple choice test.

Writing an answer of 3 N is ambiguous since it could mean 1 digit of accuracy, 3 digits of accuracy, or an absolutely exact value (as when you use it to say 8 is 2 to the 3rd power). In this situation, you have to determine the meaning of 3 from the context of the problem.

Rule: When you see an integer in a multiple choice <u>answer</u>, you have to determine the digits of accuracy from the context of the problem. In a multiple choice answer, 1000 could mean the answer was rounded to 1 digit of accuracy. 1000 could also mean the answer is good to four digits of accuracy, for example if the 1, 0, 0, 0 are the digits showing for the odometer reading in your car. Or, the 1000 could mean it is an absolutely exact number such as the statement, “There are 1000 meters in a kilometer.”

Additional Examples

1) If the problem has three digits of accuracy, and part of the answers are written to three digits, usually all answers will be written to three digits.

A car that is moving at a speed of 15 m/s is coming to a complete stop in 5.20 seconds. What is the acceleration of the car?

A. 2.88 m/s^2
B. –2.88 m/s^2
C. 15.0 m/s^2
D. –15.0 m/s^2

2) If the problem is given in integers, our rules allow you to assume three digits of accuracy. The answers will be written as integers, so it would be reasonable to interpret the answers as also being good to three digits of accuracy.

A car decelerates at 3 m/s^2 for 5 s. How far does it take to stop if its initial velocity is 15 m/s?

A. 18 m
B. 20 m
C. 28 m
D. 38 m
E. 84 m

3) This question is good to two digits of accuracy (due to the 0.20), as are answers A and B. Therefore, you should interpret answers C and D as good to two digits of accuracy. Answers C and D were not written as 2.0×10^1 N and 2.9×10^1 N since answers A and B were not expressed using scientific notation.

A 5 kg block is pulled horizontally across a floor by a string attached to it with an acceleration of 2 m/s^2. What is the tension in the string if the coefficient of sliding kinetic friction between the block and floor is 0.20?

A. 5.6 N
B. 9.8 N
C. 20 N
D. 29 N

4) In this problem, since 5.0 is good to two digits of accuracy, the answers should be interpreted as good to two digits of accuracy. Answer A, while ambiguous, could be thought of as being 2.0 J.

An 80 N crate is pushed a distance of 5.0 m upward along a frictionless incline that makes an angle of 30° with the horizontal. The force pushing the crate is parallel to the slope. If the speed of the crate increases at a rate of 1.5 m/s^2, find the work done by the force.

A. 2 J
B. 110 J
C. 140 J
D. 200 J
E. 260 J

5) In this problem, answer E could be written as 1.1×10^1 m/s to show two digits of accuracy. Since answers A, B, C, and D are all two digits, it seems unnatural to write answer E as 1.1×10^1. From the context of the problem, you can assume that 11 represents two digits of accuracy.

A 0.20 kg particle moves along the x axis. The potential energy is given by $U(x) = 8x^2 + 2x^2$. If the particle has a speed of 5.0 m/s when it is at $x = 1.0$ m, its speed when it is at the origin is:

A. 0.0 m/s
B. 2.5 m/s
C. 5.7 m/s
D. 7.9 m/s
E. 11 m/s

6) In this problem, should we write p_1 as 0.000 or 0? Since 0 is ambiguous, we can write p_1 as either 0 or 0.000. Because the first car was not moving, we know the momentum is exactly zero, so it is convenient to use 0.

A car of mass m_1 =2500 kg stopped at a traffic light is rear-ended by a car with mass m_2 = 1000 kg. The cars become entangled. The second car was moving at v_i = 30.0 m/s before the collision. What are the initial linear momenta of the two cars?

A. $p_1 = 0 \text{ kg} \cdot \text{m/s}$
$p_2 = 3.00 \times 10^4 \text{ kg} \cdot \text{m/s}$

7) In this problem, should we write answer A) as 0.000 or 0? Since 0 is ambiguous, we can write answer A. as either 0 or 0.000. To be consistent, we will write it in a form similar to the other answer choices given in the problem.

A 1.00 kg mass at the end of a spring vibrates 2.00 times per second with amplitude of 0.100 m. What is its speed when it passes the equilibrium?

A. 0 .000 m/s
B. 0.310 m/s
C. 0.631 m/s
D. 1.26 m/s

8) The accuracy in this question is to three digits. Since answers A, B, and C are naturally written in scientific notation and reflect three digits of accuracy, should D be written to match? If you write 0.00 N/C, that shows only two digits of accuracy. We would have to use 0.000 N/C to reflect three digits of accuracy, and that format is not similar to the previous answers. Using the ambiguous answer 0 N/C does not break any rules and also implies the field may be exactly zero.

Two point charges of 30 μC each are 4 cm apart. What is the electric field at the midpoint between the two charges?

A. 4.50×10^7 N/C
B. 2.30×10^7 N/C
C. 5.00×10^6 N/C
D. 0 N/C