Significant Figures in Data

Why?

The number of digits, i.e. significant figures, reported for a numerical quantity conveys the quality of the measurement or analysis to the reader. In any business involving numerical values, the precision of these values, which is represented by the number of digits, is vital information. In this course and in others, you will have to use a meaningful number of digits in reporting your results.

Learning Objectives

- λ Appreciate the difference between accuracy and precision.
- λ Understand the relationship between precision and the number of significant figures in a number.

Success Criteria

- λ Report computed values to the correct number of significant figures.
- λ Identify the accuracy and precision of a numerical value.

Resources

Olmsted and Williams (*Chemistry*, Wiley, 2002) pp. 23-28.

Prerequisites

metric system, SI units, scientific or exponential notation

New Concepts

Accuracy is the degree of conformity to a standard or true value.
Precision is the smallest repeatable digit of a measurement.
Significant figures are the repeatable digits and the first uncertain digit in a measurement or calculation.

Definitions

In your own words, write definitions of the terms in the **New Concept** section.

Model: Accuracy, Precision, and Significant Figures

Item	Values	Significant Figures
Bureau of Standards Time	9:15:13004	8
Jerry's analog watch	9:15	3
Jennifer's digital watch	9:17:52	5
average mass of gold coin	23.32 g	4
height of an index card	0.0770 m	3

Key Questions

1. In measuring time, which value in the model represents the true value?

2. Whose watch is more accurate? Explain.

3. Whose watch is more precise? Explain.

4. How do we represent precision in reporting a measurement?

5. What are two ways to improve
   (a) the precision or a measurement?

   (b) the accuracy of a measurement?

Exercises

1. Specify the number of significant figures in each of the following.

   (a) 101.1

   (b) 0.0125

   (c) 1.00×10^2

   (e) 100

   (d) 100. (Note: including the decimal point is a convention)

   (f) 0.005700

2. Express the number 500 clearly in two significant figures.

Problems

1. The mass of a gold coin was measured three times and each measurement was made to five digits. The mass values were 23.319 g, 23.341 g, and 23.296 g. The average mass was reported as 23.32 g. The actual mass of the coin is 25.5631 g.
   (a) Are these measurements precise? Explain your answer.

   (b) Are these measurements accurate? Explain your answer.

   (c) Why is the average mass of the gold coin reported to only four significant figures?

Model: Arithmetic Operations and Significant Figures

Addition

	23.26	g
	100.1	g
	0.03631	g
	123.39631	g
report as	123.4	g

Subtraction

	45.8	g
	- 3.26	g
	42.54	g
report as	42.5	g

Multiplication

30.21 m x 27 m = 815.67 m^2
report as 820 m^2

Division

4.203 m / 0.0920 s = 45.6847826087 m/s
report as 45.7 m/s

Detailed Consideration of the Multiplication Example

The least certain multiplicand has two significant figures. The value 27 m is uncertain by 1 unit. It could be 26 m, it could be 28 m. Examine multiplication with these two possibilities.

30.21 m x 26 m = 785.46 m^2

30.21 m x 28 m = 845.88 m^2

The first uncertain digit in the product is in the tens place so the product of the two numbers is reported to only two significant digits, 820 m^2. Notice that the product has the same number of significant figures as the least certain multiplicand.

Key Questions

6. When you add or subtract numbers, how do you identify the first uncertain digit in the result?

7. When you multiply or divide numbers, what is the relationship between the number of significant digits in the result and the number of significant figures in the numbers you are multiplying or dividing?

Exercises

3. Conduct a detailed consideration of the division example in the model just as was done under the heading **Detailed Consideration of the Multiplication Example** to show that the result for 4.203 m / 0.0921 s should only be reported to 3 significant figures.

4. Report the total mass of three people weighing 53 kg, 60.4 kg, and 75.67 kg. Explain the rationale for the number of significant figures in your answer.

5. Calculate the density (mass/volume) of a coin with a mass of 8.4 g and a volume of 0.942 cm^3. Explain the rationale for the number of significant figures in your answer.