Numerical Computations

Accuracy

The accuracy of a numerical value is often expressed in terms of the number of *significant digits* that the value contains. What are significant digits? Any nonzero digit is considered significant; zeroes that appear to the left or right of a digit sequence are used to locate the decimal point and are not considered significant. Thus the numbers 0.00345, 3.45, 3450, and 3,450,000 all contain three significant digits represented by the sequence 3–4–5. Zeroes bounded on both sides by nonzero digits are also significant; 0.0005067, 5.067, 50.67, and 506,700 each contain four significant digits, as represented by the numerical sequence 5–0–6–7.

The accuracy of a solution can be no greater than the accuracy of the data on which the solution is based. For example, the length of one side of a right triangle may be given as 20 ft. Without knowing the possible error in the length measurement, it is impossible to determine the error in the answer obtained from it. We will usually assume that the data are known with an accuracy of 0.2 percent. The possible error in the 20-ft length would therefore be 0.04 ft.

To maintain an accuracy of approximately 0.2 percent in our calculations, we will use the following practical rule: use four digits to record numbers beginning with 1 and three digits to record numbers beginning with 2 through 9. Thus a length of 19 ft becomes 19.00 ft, a length of 20 ft becomes 20.0 ft, and a length of 43 ft becomes 43.0 ft.

You will notice one exception to this rule throughout the text: values of the trigonometric functions are traditionally written to four decimal places, and that practice will be followed here, not for increased accuracy, but to clarify the computations used in worked examples.

Rounding Off Numbers*

If the data are given with greater accuracy than we wish to maintain (see Fig. 1.1), the following rules may be used to round off their values:

1. When the digit dropped is greater than 5, increase the digit to the left by 1. *Example:* 23.56 ft becomes 23.6 ft.
2. When the digit dropped is less than 5, drop it without changing the digit to the left. *Example:* 23.34 ft becomes 23.3 ft.
3. When the digit dropped is 5 followed only by zeros, increase the digit to the left by 1 only if it becomes even. If the digit to the left becomes odd, drop the 5 without changing the digit to the left. *Example:* 23.5500 ft rounded to three numbers becomes 23.6 ft, and 23.4500 ft becomes 23.4 ft. (This practice is often referred to as the *round-even rule*.)

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*American Society of Mechanical Engineers (ASME) *Orientation and Guide for Use of SI (Metric) Units*, 9th edition, 1982, p 11. By increasing the digit to the left for a final 5 followed by zeros only if the digit becomes even, we are dividing the rounding process evenly between increasing the digit to the left and leaving the digit to the left unchanged.

Calculators

Electronic calculators and computers are widely available for use in engineering. Their speed and accuracy make it possible to do difficult numerical computations in a routine manner. However, because of the large number of digits appearing in solutions, their accuracy is often misleading. As pointed out previously, the accuracy of the solution can be no greater than the accuracy of the data on which the solution is based. Care should be taken to retain sufficient digits in the intermediate steps of the calculations to ensure the required accuracy of the final answer. Answers with more significant digits than are reasonable should not be recorded as the final answer. An accuracy greater than 0.2 percent is rarely justified.