

# MENG203 EXPERIMENTAL METHODS FOR ENGINEERS

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- ▶ What is a "significant figure"?
  - ▶ The number of significant figures in a result is simply the number of figures that are known with some degree of reliability. The number 13.2 is said to have 3 significant figures. The number 13.20 is said to have 4 significant figures.
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# Rules for deciding the number of significant figures in a measured quantity:

- ▶ 1) All nonzero digits are significant:  
1.234 g has 4 significant figures, 1.2 g has 2 significant figures.
- ▶ (2) Zeroes between nonzero digits are significant:  
1002 kg has 4 significant figures, 3.07 mL has 3 significant figures.

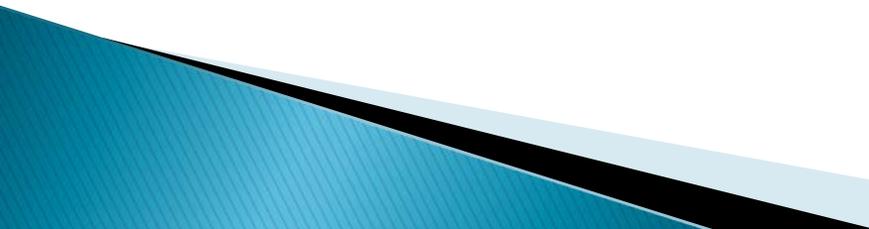
- ▶ (3) Leading zeros to the left of the first nonzero digits are not significant; such zeroes merely indicate the position of the decimal point: 0.001 °C has only 1 significant figure, 0.012 g has 2 significant figures.
- ▶ (4) Trailing zeroes that are also to the right of a decimal point in a number are significant: 0.0230 mL has 3 significant figures, 0.20 g has 2 significant figures.
- ▶ (5) When a number ends in zeroes that are not to the right of a decimal point, the zeroes are not necessarily significant: 190 miles may be 2 or 3 significant figures, 50,600 calories may be 3, 4, or 5 significant figures.

# Tutorial on the Use of Significant Figures

- ▶ All measurements are approximations—no measuring device can give perfect measurements without experimental uncertainty. By convention, a mass measured to 13.2 g is said to have an absolute uncertainty of plus or minus 0.1 g and is said to have been measured to the nearest 0.1 g. In other words, we are somewhat uncertain about that last digit—it could be a "2"; then again, it could be a "1" or a "3". A mass of 13.20 g indicates an absolute uncertainty of plus or minus 0.01 g.

- ▶ The potential ambiguity in the last rule can be avoided by the use of standard exponential, or "scientific," notation. For example, depending on whether the number of significant figures is 3, 4, or 5, we would write 50,600 calories as:
- ▶  $5.06 \times 10^4$  calories (3 significant figures)  
 $5.060 \times 10^4$  calories (4 significant figures), or  
 $5.0600 \times 10^4$  calories (5 significant figures).
- ▶ By writing a number in scientific notation, the number of significant figures is clearly indicated by the number of *numerical figures* in the 'digit' term as shown by these examples. This approach is a reasonable convention to follow.

# What is an "exact number"?

- ▶ Some numbers are exact because they are known with complete certainty.
  - ▶ Most exact numbers are integers: exactly 12 inches are in a foot, there might be exactly 23 students in a class. Exact numbers are often found as conversion factors or as counts of objects.
  - ▶ Exact numbers can be considered to have an infinite number of significant figures. Thus, the number of apparent significant figures in any exact number can be ignored as a limiting factor in determining the number of significant figures in the result of a calculation.
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- ▶ In carrying out calculations, the general rule is that the accuracy of a calculated result is limited by the least accurate measurement involved in the calculation.
- ▶ (1) In addition and subtraction, the result is rounded off to the last common digit occurring furthest to the right in all components. Another way to state this rule is as follows: in addition and subtraction, the result is rounded off so that it has the same number of digits as the measurement having the fewest decimal places (counting from left to right). For example,
  - ▶  $100$  (assume 3 significant figures) +  $23.643$  (5 significant figures) =  $123.643$ , which should be rounded to  $124$  (3 significant figures). Note, however, that it is possible two numbers have no common digits (significant figures in the same digit column).
- ▶ (2) In multiplication and division, the result should be rounded off so as to have the same number of significant figures as in the component with the least number of significant figures. For example,
  - ▶  $3.0$  (2 significant figures)  $\times$   $12.60$  (4 significant figures) =  $37.8000$  which should be rounded to  $38$  (2 significant figures).

# Rules for rounding off numbers

- ▶ (1) If the digit to be dropped is greater than 5, the last retained digit is increased by one. For example,
    - ▶ 12.6 is rounded to 13.
  - ▶ (2) If the digit to be dropped is less than 5, the last remaining digit is left as it is. For example,
    - ▶ 12.4 is rounded to 12.
  - ▶ (3) If the digit to be dropped is 5, and if any digit following it is not zero, the last remaining digit is increased by one. For example,
    - ▶ 12.51 is rounded to 13.
  - ▶ (4) If the digit to be dropped is 5 and is followed only by zeroes, the last remaining digit is increased by one if it is odd, but left as it is if even. For example,
    - ▶ 11.5 is rounded to 12,
    - ▶ 12.5 is rounded to 12.
- This rule means that if the digit to be dropped is 5 followed only by zeroes, the result is always rounded to the even digit. The rationale for this rule is to avoid bias in rounding: half of the time we round up, half the time we round down.

▶ QUIZ:

- ▶ **Question 1** Give the correct number of significant figures for 4500, 4500., 0.0032, 0.04050
- ▶ **Question 2** Give the answer to the correct number of significant figures:  
 $4503 + 34.90 + 550 = ?$
- ▶ **Question 3** Give the answer to the correct number of significant figures:  
 $1.367 - 1.34 = ?$
- ▶ **Question 4** Give the answer to the correct number of significant figures:  
 $(1.3 \times 10^3)(5.724 \times 10^4) = ?$
- ▶ **Question 5** Give the answer to the correct number of significant figures:  
 $(6305)/(0.010) = ?$

▶ **Answers:**

- ▶ (1) 2, 4, 2, 4
- ▶ (2) 5090 (3 significant figures – round to the tens place – set by 550)
- ▶ (3) 0.03 (1 significant figure – round to hundredths place)
- ▶ (4)  $7.4 \times 10^7$  (2 significant figures – set by  $1.3 \times 10^3$ )
- ▶ (5)  $6.3 \times 10^5$  (2 significant figures – set by 0.010)

# Scientific Notation

$$10000 = 1 \times 10^4$$

$$1000 = 1 \times 10^3$$

$$100 = 1 \times 10^2$$

$$10 = 1 \times 10^1$$

$$1 = 10^0$$

$$1/10 = 0.1 = 1 \times 10^{-1}$$

$$1/100 = 0.01 = 1 \times 10^{-2}$$

$$1/1000 = 0.001 = 1 \times 10^{-3}$$

$$1/10000 = 0.0001 = 1 \times 10^{-4}$$

$$24327 = 2.4327 \times 10^4$$

$$7354 = 7.354 \times 10^3$$

$$482 = 4.82 \times 10^2$$

$$89 = 8.9 \times 10^1 \text{ (not usually done)}$$

$$0.32 = 3.2 \times 10^{-1} \text{ (not usually done)}$$

$$0.053 = 5.3 \times 10^{-2}$$

$$0.0078 = 7.8 \times 10^{-3}$$

$$0.00044 = 4.4 \times 10^{-4}$$