Significant Figures and Rounding

Why are significant figures and rounding important?

Let's say you have to calculate the speed of a bus which took 35s to travel about 300m, from Jadibutti to Koteshwor. You press the calculator ($\frac{300}{35}$) and see 8.571428571. It is so tempting to write all those digits in your answer, as more digits "look" accurate. However, your measurements of distance and time are not precise enough to be able to calculate the speed precisely up to 0.000000001 m/s.

So, how do you know how many digits to keep in your answer? Have a look at these rules.

Rules to identify the number of significant figures:

- All non-zero numbers are always significant.
  eg: 273, 273.18, and 273.1896 have 3, 5, and 7 significant figures.
- Zeros between non-zero digits are significant.
  eg: 102, 102.04, and 12.06 have 3, 5, and 4 significant figures.
- Leading zeros are not significant.
  eg: 0.5, 0.005, and 0.00506 have 1, 1, and 3 significant figures.
- Trailing zeros in a number containing a decimal point are significant.
  eg: 1.00, 13.40, and 0.0010 have 3, 4, and 2 significant figures.
- Trailing zeros in a number not containing a decimal point may or may not be significant.
  eg: 1200 may have 2, 3, or 4 significant figures.
- When using scientific notation, the same rules apply.
  eg: 1.43×10^5 and 1.000×10^2 have 3 and 4 significant figures.
  Note: the significance of a number is independent of its order of magnitude. Also, using scientific notation can sometimes avoid ambiguity, like writing 1.000×10^2 instead of 100.
- Numbers that are not measurements (eg: constant in a formula like g, G, $\bar{x}$) do not determine the significant figures of the answer.
  eg: The force acting on a body of mass 1.500 kg is $1.500\times9.8 = 14.70$ N, and not 15 N.

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Rules to round a number:

- If the digit immediately to the right of the last significant figure is greater than 5, add 1 to the last significant figure.
  eg: after rounding to 2 significant figures, 1.97 and 2.1501 will become 2.0 and 2.2.
- If the digit immediately to the right of the last significant figure is less than 5, leave the last significant figure as it is.
  eg: after rounding to 2 significant figures, 3.449 and 5.210 will become 3.4 and 5.2.
- If the digit immediately to the right of the last significant figure is a 5 not followed by any other digits or followed only by zeros, round to the nearest even number.
  eg: after rounding to 2 significant figures, 7.15 and 7.250 will become 7.2; and 7.350 and 7.45 will become 7.4.
- Replace non-significant figures in front of the decimal point by zeros. eg: after rounding to 2 significant figures, 2074 and 1234 will become 2100 and 1200.

  Note: Always round at last of a calculation to avoid truncation error.

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Rules to write an answer in a calculation with proper significant figures:

A chain is no stronger than its weakest link. Similarly, in physics, an answer is no more precise that the least precise number used to get the answer.

- In addition or subtraction, use the least number of decimal places while rounding.
  eg: $2.3\text{m} + 1.42\text{m} - 0.009\text{m} = 3.711\text{m} \simeq 3.7\text{m}$

- In multiplication or division, use the least number of significant digits, not the least number of decimal places while rounding.
  eg: $\frac{5.00m^2}{3m} = 1.667m \simeq 2\text{m}$

Exercises:

A) Write the number of significant figures of the following.

1) 29 2) 41.07 3) 0.010 4) 0.500
5) 500 6) 6.023×10^{23}

B) Round the following numbers to two significant figures.

7) 12.1 8) 2.49 9) 1.25 10) 3.150
11) 8.2501 12) 6.626×10^{-34}

C) Use proper significant figures in the calculation of the following.

13) If m = 0.52kg and M = 1kg, what is their average mass?

14) A block has volume 0.032m^3 and mass 76.50kg. Find its density.

15) Calculate the gravitational force of attraction between two bodies of masses 12.40kg and 1.500kg at a distance of 1.100m from each other. ($G = 6.67\times10^{-11}\text{Nm}^2\text{kg}^{-2}$)

16) The base and the perpendicular of a right angled triangle are found to be 0.4cm and 0.90cm respectively. What is the length of its hypotenuse?

Answers:

1) 2 2) 4 3) 2 4) 3
5) 1, 2 or 3 6) 4
7) 12 8) 2.5 9) 1.2 10) 3.2
11) 8.3 12) 6.6×10^{-11}
13) 0.8kg
14) $2.4\times10^3\,\text{kg m}^{-3}$ (Writing 2400 would cause ambiguity)
15) 1.000×10^{-9} N (All measurements have 4 significant figures and the universal constant does not affect the significant figure of the answer)
16) 1cm

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