Significant Figures

Rules, Rounding, and Calculations: A Student Reference

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You measure a table with a ruler marked in millimeters and get 1.5 meters. Your calculator, dividing that by three, insists the answer is 0.5000000 meters. But your ruler never knew the table to seven decimal places, so six of those digits are fiction. **Significant figures** are the rule set that stops you from claiming precision your measurements never had, and they are one of the first things every physics, chemistry, and engineering student has to get right.

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1 What Are Significant Figures?

Significant figures (also called significant digits or sig figs) are the digits in a measured value that carry real information about its precision. They include every non-zero digit, any zeros

trapped between non-zero digits, and any trailing zeros that sit after a decimal point. The placeholder zeros that only fix the size of a number, like the leading zeros in 0.0025, are not significant.

The core idea is honesty about precision. A measured number is a claim: writing 4.60 grams says you are confident to the nearest hundredth of a gram, while 4.6 grams only claims the nearest tenth. The count of significant figures is how you communicate that confidence, and getting it right keeps a calculation from inventing precision at the end that no instrument supplied at the start.

2 Precision vs Accuracy

Accuracy is how close a measurement is to the true value. **Precision** is how close repeated measurements are to each other. They are independent: you can be precise and wrong, or accurate on average but scattered.

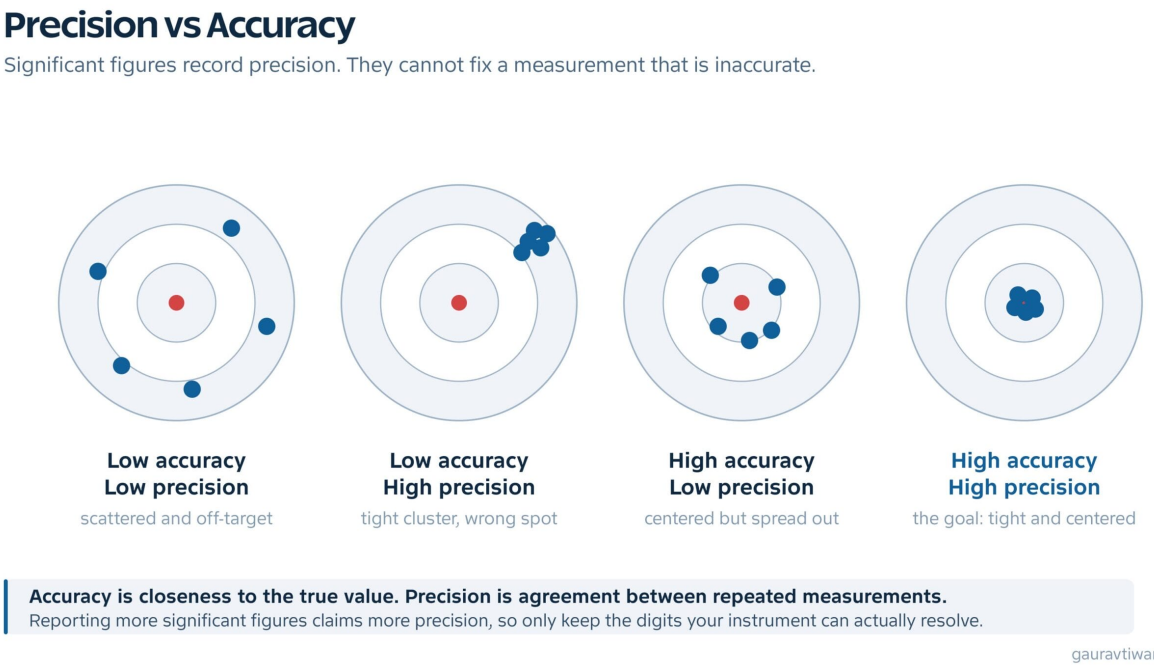

Figure 1: *Precision is agreement between measurements; accuracy is closeness to the truth. Significant figures report the first, not the second.*

Significant figures are a statement about precision only. A number written to five significant figures claims fine precision, but it can still be badly inaccurate if the instrument was mis-calibrated. The honest rule is to keep exactly the digits your instrument can resolve, and no more.

3 The Rules for Counting Significant Figures

There are five rules, and every number you will ever meet is covered by them.

#	Rule	Example	Sig figs
1	All non-zero digits are significant	48.29	4
2	Zeros between non-zero digits are significant	50079	5
3	Leading zeros are never significant	0.000012	2
4	Trailing zeros after a decimal point are significant	0.0001200	4
5	Trailing zeros with no decimal point are ambiguous	120000	2

Table 1: *The five counting rules.*

Rule 5 causes arguments, because 120000 could mean two significant figures or six. The standard convention treats trailing zeros without a decimal point as not significant, which is why scientific notation exists: writing 1.2×10^5 fixes it at two significant figures, and 1.20000×10^5 fixes it at six.

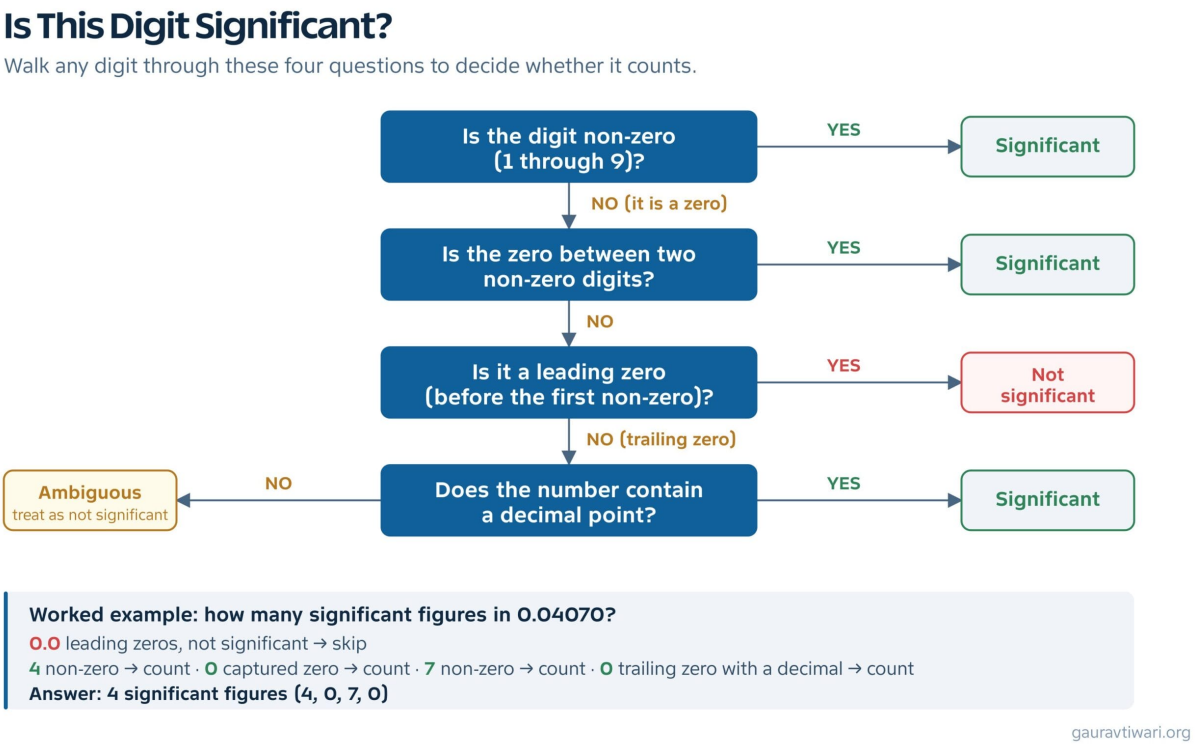

Figure 2: *Run any digit through these four questions to decide whether it counts.*

The rules applied across a range of numbers:

Number	Sig figs	Which digits count
48.29	4	**4**, **8**, **2**, **9** (all non-zero)
7.003	4	**7**, **0**, **0**, **3** (captive zeros count)
0.00420	3	0.00**420** (leading out, trailing in)
5000	1	**5**000 (no decimal)
5000.	4	**5000** (decimal makes them count)
0.030040	5	0.0**30040**
6.022×10^{23}	4	**6**, **0**, **2**, **2** (mantissa only)

Table 2: Counting significant figures, digit by digit.

4 Significant Figures in Scientific Notation

Scientific notation writes a number as a mantissa between 1 and 10 times a power of ten:

$$N = m \times 10^{e}, \qquad 1 \leq |m| < 10$$

The rule is simple: **only the mantissa carries significant figures.** The power of ten is a scale factor and never counts. This is why scientists prefer it, since every digit in the mantissa is significant and the ambiguity of rule 5 disappears.

Ordinary form	Scientific notation	Sig figs
0.0000546	5.46×10^{-5}	3
1200 (2 sf)	1.2×10^{3}	2
1200 (4 sf)	1.200×10^{3}	4
93000000	9.3×10^{7}	2
299792458	2.998×10^{8}	4 (rounded)

Table 3: Scientific notation removes trailing-zero ambiguity.

5 Rounding to Significant Figures

Rounding is a three-step routine. Count from the left to your target number of significant figures, look at the very next digit, then drop everything from that digit onward, rounding the last kept digit up if the dropped part is 5 or more.

Round 3.14159 to	Look at next digit	Result
4 sig figs	5 (round up)	3.142
3 sig figs	1 (round down)	3.14
2 sig figs	4 (round down)	3.1
1 sig fig	1 (round down)	3

Table 4: Rounding one number to successive precisions.

Round half to even. When the dropped digit is exactly 5 with nothing after it, many science courses round to the nearest even digit to avoid a systematic upward bias: 2.5 rounds to 2 and 3.5 rounds to 4. For everyday coursework the simpler round-half-up rule is fine.

6 Significant Figures in Calculations

The rule depends on the operation. Round only at the very end, never at intermediate steps.

6.1 Multiplication and Division

The result keeps as many significant figures as the input with the **fewest significant figures**.

$$4.56 \times 1.4 = 6.384 \longrightarrow 6.4$$

Here 4.56 has three significant figures and 1.4 has two, so the answer is rounded to two significant figures.

6.2 Addition and Subtraction

The result keeps as many **decimal places** as the input with the fewest decimal places.

$$12.11 + 0.3 + 1.014 = 13.424 \longrightarrow 13.4$$

The term 0.3 has one decimal place, so the sum is rounded to one decimal place.

Operation	What you count	Match the fewest
Multiplication	Significant figures	significant figures
Division	Significant figures	significant figures
Addition	Decimal places	decimal places
Subtraction	Decimal places	decimal places

Table 5: The two carry-over rules, side by side.

7 Exact Numbers: When Sig Figs Do Not Apply

Exact numbers have unlimited significant figures and never limit a result:

- **Counted quantities.** 24 students is exactly 24, with infinite significant figures.
- **Defined constants.** Exactly 100 centimeters in a meter, exactly 12 in a dozen.
- **Integer factors in formulas.** The 2 in $C = 2\pi r$ is exact; only the measured radius limits precision.

8 Common Mistakes to Avoid

- **Rounding at every step.** Carry a guard digit or two and round only the final answer.
- **Using the sig-fig rule for addition.** Addition and subtraction follow the decimal-places rule.
- **Counting leading zeros.** The zeros in 0.0047 are placeholders, never significant.
- **Treating exact numbers as measurements.** A counted or defined number never limits precision.
- **Ignoring trailing-zero ambiguity.** For 1500 to three sig figs, write 1.50×10^3.

9 Quick Reference Cheat Sheet

Situation	Rule
Non-zero digits	Always significant
Zeros between non-zero digits	Always significant
Leading zeros	Never significant
Trailing zeros with a decimal point	Significant
Trailing zeros without a decimal point	Ambiguous, treated as not significant
Scientific notation	Only the mantissa counts
Multiplication and division	Match the fewest significant figures
Addition and subtraction	Match the fewest decimal places
Exact (counted or defined) numbers	Infinite; never limit the result

10 Quick Revision: Questions and Answers

How do I count significant figures quickly?

Start from the first non-zero digit on the left and count every digit to its right, including

captive zeros and trailing zeros after a decimal point. Skip leading zeros. For 0.04070 you count 4, 0, 7, 0, giving four.

What is the difference between significant figures and decimal places?

Significant figures count all meaningful digits; decimal places count only digits after the decimal point. 0.0520 has three significant figures but four decimal places.

What is the rule for multiplication and division?

The answer keeps as many significant figures as the factor with the fewest. 4.56 times 1.4 gives 6.4, matching the two significant figures of 1.4.

What is the rule for addition and subtraction?

The answer keeps as many decimal places as the term with the fewest. 12.11 + 0.3 + 1.014 rounds to 13.4 because 0.3 has one decimal place.

Do exact numbers have significant figures?

Exact numbers (counted or defined) have infinite significant figures and never limit the precision of a result. Only measured values constrain the final answer.

Read the full guide, with the interactive calculator, at
gauravtiwari.org/significant-figures