

How to Calculate Without Losing Precision



Arithmetic Rules for Significant Figures in the Laboratory

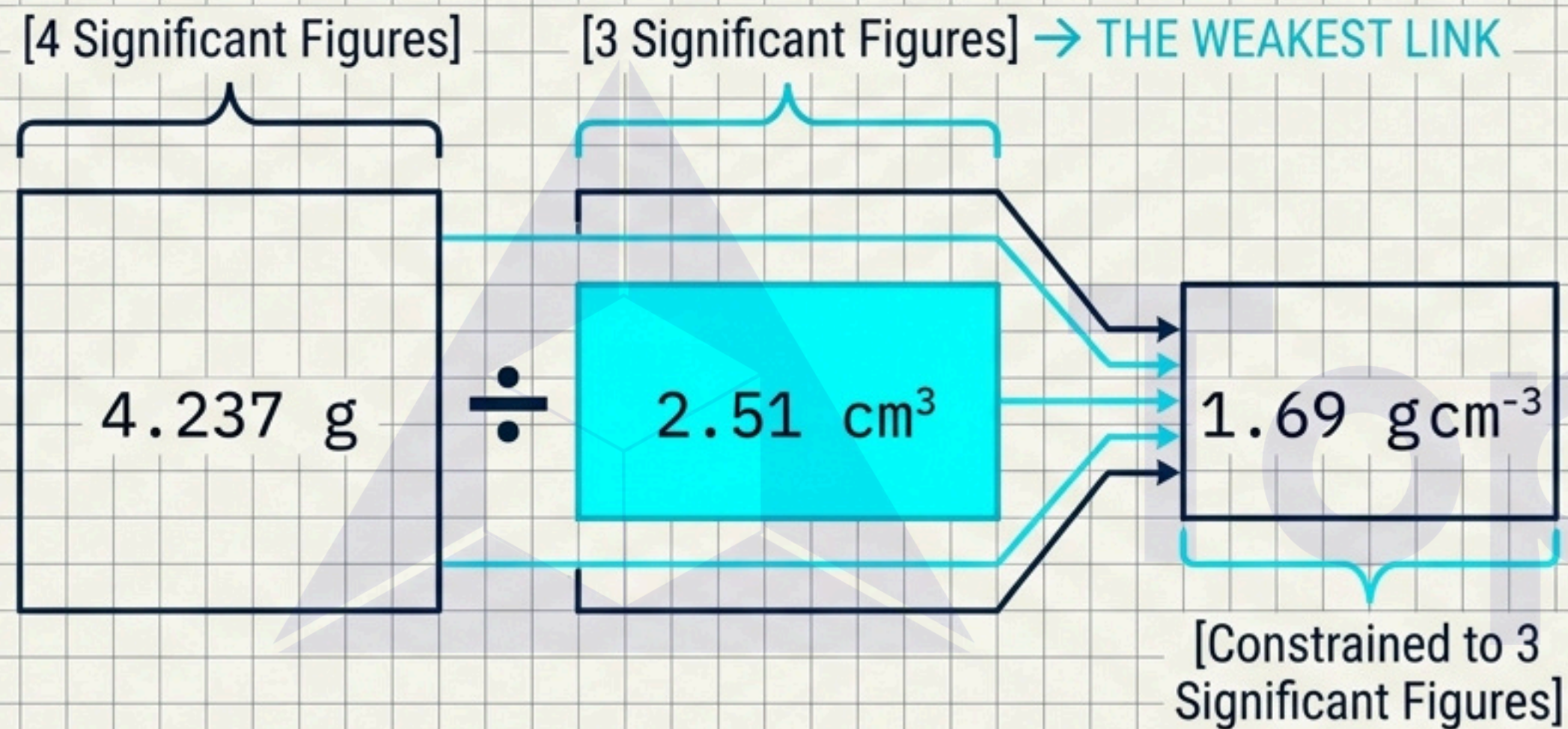
The Calculator Lie:
Mathematical precision
that physical instruments
cannot justify.

A calculated result can never be more accurate than the original measured values it is based on.

A graphic of a calculator screen displaying the number 1.68804780876. A thick red diagonal line is drawn across the screen, starting from the bottom left and ending at the top right, passing through the trailing zeros of the number. An arrow points from the text box on the left to the start of this line. The entire graphic is enclosed in a rounded rectangular frame.

1.68804780876

The Precision Funnel



Operation:

Multiplication ($\times$)
/ Division ($\div$)

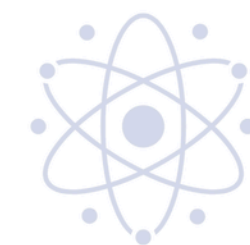
Rule:

The answer retains the same number of significant figures as the original number with the **LEAST** significant figures.



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$$E=mc^2$$



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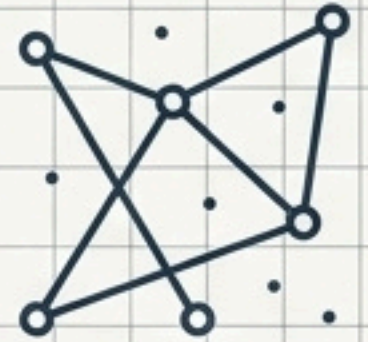
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Scaling the Rule: The Light Year Example



$$\underbrace{3.00 \times 10^8 \text{ m s}^{-1}}_{\text{[3 Sig Figs — The Limiting Factor]}} \times \underbrace{3.1557 \times 10^7 \text{ s}}_{\text{[5 Sig Figs]}} = \boxed{9.47 \times 10^{15} \text{ m}}_{\text{[Result: 3 Sig Figs]}}$$

Scientific Notation & Trailing Zeros

The **power of 10** is **mathematically irrelevant** to **precision**. All **trailing zeros** appearing in the base number (like the two zeros in 3.00) are explicitly measured and therefore significant.

Operation:

**Addition (+) /
Subtraction (-)**

Rule:

The answer retains as
many DECIMAL PLACES
as the original number
with the LEAST
decimal places.

The diagram illustrates the addition of three masses on a grid background. A vertical dashed blue line, labeled "The Precision Boundary Line", is positioned between the integer and decimal parts of the numbers. The numbers are aligned to the right of this line. The first number is 436.32 g, with its decimal part "32" shaded in light blue. The second number is 227.2 g, with its decimal part "2" shaded in light blue. The third number is 0.301 g, with its decimal part "301" shaded in light blue. A horizontal solid black line is drawn under the third number. Below this line, the sum 663.821 g is shown, with its decimal part "821" shaded in light blue. A light blue box highlights the result "663.8 g", with an arrow pointing from the sum to it. Another light blue box labeled "Weakest Link (1 Decimal Place)" has an arrow pointing to the decimal part "2" of the second number. A large, faint "TopAll" watermark is visible in the background.

$$\begin{array}{r} 436.32 \text{ g} \\ + 227.2 \text{ g} \\ + 0.301 \text{ g} \\ \hline 663.821 \text{ g} \end{array}$$

The Precision Boundary Line

Weakest Link
(1 Decimal Place)

663.8 g

Severe Precision Loss in Subtraction



$$\begin{array}{r} 0.307 \text{ m} \longrightarrow [3 \text{ Decimal Places}] \\ - 0.304 \text{ m} \longrightarrow [3 \text{ Decimal Places}] \\ \hline 0.003 \text{ m} \longrightarrow [\text{Result fixed at 3 Decimal Places}] \\ \downarrow \\ = 3 \times 10^{-3} \text{ m} \end{array}$$

The Decimal Override

Notice that the result ($3 \times 10^{-3} \text{ m}$) only has ONE significant figure, even though the inputs had THREE. Do not apply the multiplication rule here! Writing $3.00 \times 10^{-3} \text{ m}$ would falsely invent precision that the subtraction operation destroyed.

The Precision Blueprint: Operations Matrix

Multiplication / Division ($\times$ / $\div$)	Addition / Subtraction (+ / $-$)
Operations that Scale (Proportional) The Rule Count the Total SIGNIFICANT FIGURES. The Constraint Answer matches the input with the LEAST Sig Figs.  12.345 0.025 4560.	Operations that Accumulate (Absolute) The Rule Count the DECIMAL PLACES. The Constraint Answer matches the input with the LEAST Decimal Places. 45.67 12.3 8.901

Golden Rule: In complex, multi-step calculations, retain one extra digit during intermediate steps to avoid rounding errors, then apply these rules to the final result.



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