

Units and Measurement · Concept 4

Rounding Off and Order of Magnitude

The definitive rules for mathematical precision, managing uncertain digits, and avoiding compounding errors in physics calculations.

Order of Magnitude
(The fundamental scale of the quantity)

$$a \times 10^b$$

Base Number $1 \leq a \leq 10$

Flowchart: Approximation Logic for 'a'

If $a \leq 5$

Approximate as 10^0 (1)

If $5 < a \leq 10$

Approximate as 10^1 (10)

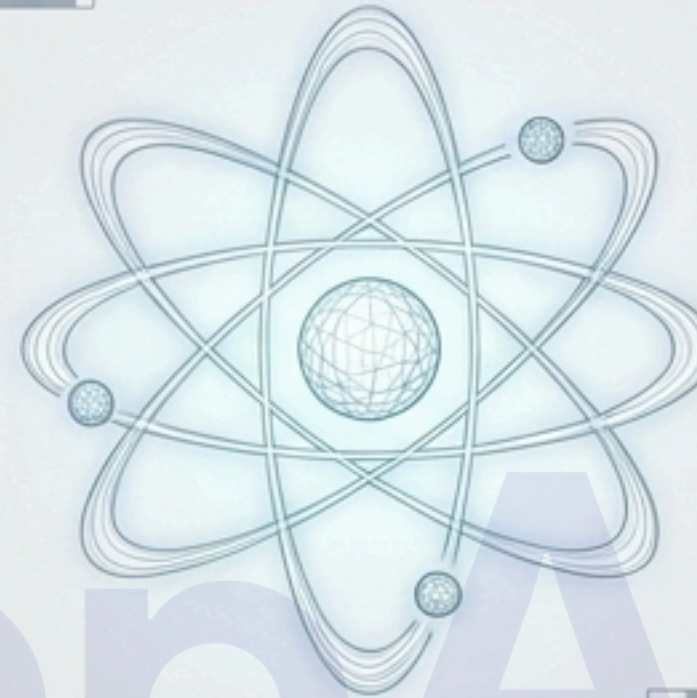
Macro Scale



$$1.28 \times 10^7 \text{ m}$$

Since $1.28 \leq 5$, the order of magnitude is 10^7 m (Magnitude 7).

Micro Scale



$$1.06 \times 10^{-10} \text{ m}$$

Since $1.06 \leq 5$, the order of magnitude is 10^{-10} m (Magnitude -10).

Scale Difference: Earth is 17 orders of magnitude larger than a hydrogen atom.



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$$E=mc^2$$



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ROUND DOWN DEMONSTRATION

Dropped
digit < 5

1.744 → **1.74**

Dropped ↙ ↘ Unchanged

ROUND UP DEMONSTRATION

Dropped
digit > 5

2.746 → **2.75**

Dropped ↙ ↘ +1 Action



Trap Alert: The Exact 5 Rule

A dropped digit of exactly 5 rounds to the nearest EVEN preceding digit — it does not always round up.

Always look at the preceding digit before applying a mathematical change.

EVEN

2.7**4**5 → 2.74

Preceding digit 4 is EVEN
→ Stays unchanged.

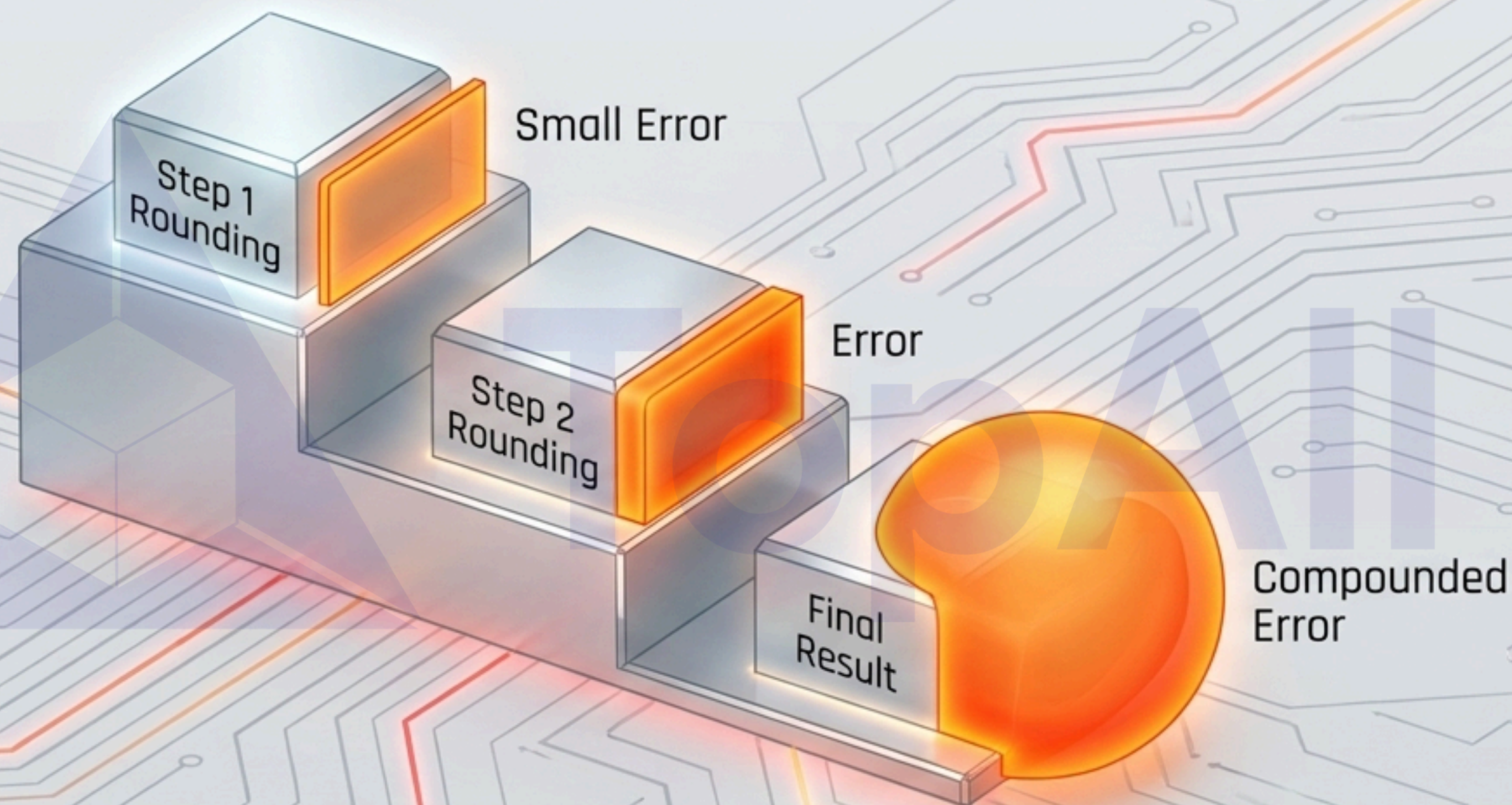
ODD

2.7**3**5 → 2.74

Preceding digit 3 is ODD
→ Rounds up by 1.

2.74

The Compounding Error Problem



In multi-step calculations, applying standard rounding at every intermediate step builds a snowball of error, permanently corrupting your final result.

Calculating the Reciprocal of a Reciprocal: $1 / (1 / 9.58)$

// Incorrect //

$$\frac{1}{9.58} = 0.104$$

(Rounded to 3 sig figs too early)

$$\frac{1}{0.104} = 9.62$$

⚠ Original value lost ($9.62 \neq 9.58$)

// Correct //

$$\frac{1}{9.58} = 0.1044$$

(Retained 4 digits)

$$\frac{1}{0.1044} = 9.58$$

✓ Original value retrieved!

Retain one extra digit until the final calculation step.

Exact Constants (Infinite Precision)

Speed of Light (c)

Actual: 2.99792458×10^8 m/s

Computation standard: 3×10^8 m/s

Pi (π)

Actual: 3.1415926...

Computation standard: 3.142 or 3.14 (depending on required sig figs)

Exact Formula Factors

Example: The 2 in $2\pi r$

Rule: Exact numbers possess an infinite number of significant digits (2.000...) and never restrict the precision of a calculation.

Key Takeaways

- ✓ Order of magnitude determines absolute scale; base numbers ≤ 5 round down to 1, > 5 round up to 10.
- ✓ Exactly 5 $\rightarrow$ round to even.
- ✓ Retain an extra digit through intermediate calculation steps to avoid compounding error.



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