

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING: A CONVERSATIONAL APPROACH

Taner Onsay, Ph.D. & Sebnem Onsay
Authors
August 2026 · Revision 1.0

© 2026 AI First Engineering



The engineering workflow you will use throughout this book
by Taner & Sebnem Onsay,

CHAPTER - 3

PART 2 · ≈ 35 MIN

Measuring Error

Off by 0.37 — is that a lot? Absolute, relative, and percent error give “it depends” a number. Engineering context decides whether it matters.

2

Problem



Model



Compute



Analyze



Validate



Improve



Absolute error — how far, in real units

THE DEFINITION — BORN ON THE BOARD

$$E_{abs} = | v_{ref} - v_{num} |$$

$$= | 20.368 - 20.0 |$$

$$= 0.368 \text{ m/s}$$

How far the numerical answer sits from the reference, in the original units.

Error is a physical quantity — it has units, and you report them.

THINK

Why always below — never above?

Every step size produced 20.0, 20.3, 20.36 ... — all at or below 20.37. Look at your own loop: it reports the last SAFE speed it confirmed, so it approaches the limit from the safe side. **Knowing the direction of an error is engineering information.**

Absolute error answers “how far?” It cannot yet answer “does it matter?” — 0.368 m/s might be nothing, or everything. That takes a comparison.

Problem



Model



Compute



Analyze



Validate



Improve



Is 0.368 m/s a big error? Compared with what?

TWO MINUTES OFF — EVERYDAY

An arrival estimate 2 minutes off is not much on a 6-hour drive — but,

An arrival estimate 2 minutes off on a 10-minute dash for a train — everything!

Same absolute error. Different scale.

THE SAME 0.368 m/s, TWICE — ENGINEERING

0.368 m/s - Against the 20.37 m/s highway answer: 1.8 % of the reference.

0.368 m/s - Against a 0.5 m/s conveyor-speed answer, the same error would be 74 % — **the answer would be junk.**

$$E_{\text{rel}} = E_{\text{abs}} / |v_{\text{ref}}| = 0.368 / 20.368 = 0.018 \quad E_{\%} = 100 \cdot E_{\text{rel}} = 1.8 \%$$

Three tools, three jobs. Absolute error: how far, in original units. Relative / percent error: how large that distance is compared with the reference scale. Engineering context: whether it matters — **no percent threshold replaces that judgment.**



Measure the error in your own results — by hand

PREDICT

Step 0.5 gave an error of ~ 1.8 %. Now cut the step to 0.1. Will the error definitely become 5× smaller? YES / NO — commit before calculating.

WHY BY HAND, WHY NO AI

This is the calculation your laboratory record and your examinations will ask for on demand — thirty seconds each, forever yours.

AI returns in Part 3 — to automate what you can now check.

1

step 0.1 gave 20.3 m/s. Compute E_{abs} and $E_{\%}$ against $v_{\text{ref}} = 20.368$ m/s.

2

step 0.01 gave 20.36 m/s. The same two numbers again.

3

Compare with a neighbor — then against the board. Keep the units in view.

Reconcile — an observation, not a rule: in THIS pair of cases the error fell ≈ 5.4× when the step fell 5×. Nothing guaranteed that — the actual error depends on where the reference crossing falls on the search grid. Part 3 makes it visible.

Problem



Model



Compute



Analyze



Validate



Improve



Which digits would you sign your name to?

THE REFERENCE, COMPUTED — 17 DIGITS APPEAR

```
●●● v_ref.py

import math
t_r, a, d = 1.0, 7.0, 50.0
# the Chapter 2 quadratic, solved
v_ref = -a*t_r + math.sqrt(
    (a*t_r)**2 + 2*a*d)
print(v_ref)

20.367864366808018
```

SEVENTEEN DIGITS — HOW MANY JUSTIFIED?

At step 0.01 the demonstrated error is ≈ 0.008 m/s — evidence supporting a report of ≈ 20.36 m/s. All 17 digits would claim accuracy the evidence does not support. **The error is evidence about defensible digits — no rule sets decimal places.**

CHAPTER 1 RETURNS

Significant figures · accuracy vs. precision · the suspicious many-digit answer — first exposure then, formal footing now. **A printout can be precise-looking and still inaccurate.**

MORE DIGITS $\neq$ MORE KNOWLEDGE. Reported precision is a claim that must be supported — matched to the evidence and to the engineering purpose.

Problem



Model



Compute



Analyze



Validate



Improve



Where does a reference value come from?

AN ANALYTICAL SOLUTION

Today's luxury — the quadratic. Exact algebra for an idealized model. Rare in engineering practice.

AN EXPERIMENT OR HAND CHECK

Measured behavior, or one full case worked on paper — Chapter 2's validation ladder still stands under everything.

AN INDEPENDENT METHOD OR BENCHMARK

A second implementation, a published table, a trusted standard — independence is what you are buying.

NO REFERENCE? USE REFINEMENT EVIDENCE

No trustworthy reference available? Rerun at finer resolution and compare successive results. This creates no reference value — it provides evidence of numerical convergence and stability. Part 4 formalizes the idea.

Most real problems are computed numerically precisely because no analytical answer exists. Parts 3 and 4 are about what to do then — starting with the one knob you already own.

Problem



Model



Compute



Analyze



Validate



Improve