



AI First Engineering

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING: A Conversational Approach

CHAPTER 3

LAB-3: Engineering Report Template

When Is the Water Ready?

How accurately can we predict when the water reaches the target temperature — and how do we know whether the answer is accurate enough?

Team Information

Team name / number	
Team members	1) 2) 3) 4)
Date	
Section (if applicable)	

How to use this template: *replace every gray italic guide with your team’s actual evidence and reasoning, insert your photographs, tables, plots, and code excerpts in the marked places, and delete nothing else. Concise evidence + engineering reasoning beats pages of polished prose. Your AI analyst may help assemble this report from your engineering record — Section 19 is where the humans take responsibility for it.*

1. Problem / Objective

What engineering question did this investigation answer? What does “ready” mean here — and why is a prediction incomplete until its accuracy is known? Two or three sentences.

2. Reduced-Order Model

Lumped cooling model — *the whole mug as ONE temperature; every simplified physical effect (convection, evaporation, conduction, radiation, probe response) is absorbed into a single constant k.*

$$T(t) = T_{\infty} + (T_0 - T_{\infty}) \cdot e^{(-k \cdot t)}$$

Crossing-time prediction — *step the model forward in time by dt; the prediction is the first grid time with T at or below the target.*

$$t_{40} \approx \text{first } t = n \cdot dt \text{ with } T(t) \leq T_{\text{target}}$$

Symbol	Meaning	Units
T(t)	water temperature at elapsed time t	°C
T0	initial water temperature at t = 0	°C
T∞	ambient room temperature near the mug	°C
k	effective cooling constant — estimated from YOUR data	1/min
t	elapsed time since logging began	min

Symbol	Meaning	Units
T_target	target temperature ≈ 40 (nominal — instructor may adjust)	$^{\circ}\text{C}$
t_40	predicted target-crossing time	min
dt	prediction time step — the resolution knob	s (or min)

3. Assumptions

Documented with the problem — before the data. Complete the right column concisely; the last rows are for additional team assumptions.

Water is well mixed — ONE temperature for the whole mug	
Effective cooling constant k is constant during the run	
Ambient temperature T_{∞} is constant near the mug during the run	
Mug uncovered — lid OFF for the entire baseline run	
Water volume ≈ 175 mL (nominal — as actually poured by the instructor/TA)	
Probe near the center of the liquid · never touching wall or bottom	
Target temperature $T_{\text{target}} \approx 40$ $^{\circ}\text{C}$ (nominal — may be adjusted after pilot testing)	
Tolerance $\pm$ ____ min belongs to the engineering purpose — stated in Section 7	
Additional team assumption:	
Additional team assumption:	

4. Apparatus, Setup & Safety

– Roles for the run — reader · timer · recorder · analyst — and how you rotated them:

- Mug (red 16-oz stoneware) · TempPro thermometer — display step: ____ °C · water volume as poured: ____ mL
- Anything nonstandard at your station (bench location, drafts, probe handling), noted for the class comparison:
- Safety acknowledgment — all members: warm water only ($\approx 50\text{--}55\text{ }^{\circ}\text{C}$), prepared and poured by the instructor/TA · no student microwaves or tops up water · two-hand carry, lid for transport only · spill protocol reviewed. ☐ ACKNOWLEDGED (initials: ____ ____)

PHOTOGRAPH OF THE STANDARDIZED STATION

Insert one photo — mug on its marked spot, probe near the center of the liquid, timer and record in view

Caption: *(what does this figure show, in one sentence?)*

5. Instrument / Resolution Check

Before the warm water: nominally identical thermometers read the same room. Row 1 — every station's reading of the same condition. Rows below — your own station's repeated readings: does YOUR instrument repeat itself?

Station →	1	2	3	4	5	6	7 · 8

Display resolution (smallest step): ____ °C **Spread across the eight stations:** ____ °C

Digits we can honestly defend in a single reading: _____

Do NOT “calibrate away” the disagreement — it is evidence, and it returns at the class data checkpoint.

Hypotheses for the spread: _____

6. Experimental Conditions

Measured at the station, before and at $t = 0$ — with units. The model uses YOUR values, not the nominal plan.

Ambient T_{∞} = ____ °C **Initial T_0** = ____ °C **Volume $\approx$** ____ mL

Reading interval = _____ s Station # _____ Start clock time _____

Probe at the **CENTER** of the liquid, touching neither wall nor bottom: **VERIFIED** ☐

Nominal vs actual: (if what was poured or measured differs from the plan (≈ 175 mL, ≈ 50 – 55 °C), record what actually happened — a condition is a measurement, not a default.)

7. Target & Tolerance — the Requirement

The prediction will be judged against these. The tolerance decision is YOURS — write it down, with its reason, before the analysis.

Target temperature T_target [°C]	≈ 40 (nominal)
Purpose of the prediction (state it)	
Selected tolerance [$\pm$ min]	
Who owns this tolerance?	the engineering purpose — not the code
Prediction time step dt at report time [s]	
Justified reported precision [digits]	

Our tolerance is $\pm$ _____ min because: _____

8. Committed Predictions P1–P4

RECORDED BEFORE ANY DATA — DO NOT EDIT AFTERWARD.

P1 — Predicted crossing time: _____ min $\approx$ clock time _____

P2 — The cooling rate will be: **FASTER AT THE START / STEADY / FASTER AT THE END**
Reason: _____

P3 — Eight stations run nominally the same experiment — our answers will agree within: *SECONDS*
/ *A FEW MINUTES* / *MANY MINUTES*

Reason for P3: _____

P4 — We believe we can predict the crossing to: $\pm$ _____ min (returns in Section 7's tolerance)

After Phase 8 — what did the evidence say about each prediction? Answer here; never edit the originals above.

9. Temperature–Time Data + Measured Crossing

Paste your T – t table (or a compact screenshot) AND your cooling plot — axes labeled with units, the crossing marked.

T–t DATA TABLE + COOLING PLOT

Compact table + one labeled plot — mark the reading where the display first showed $\leq 40.0\text{ }^{\circ}\text{C}$

Measured crossing time: _____ min Reading interval: _____ s

The measured crossing is known to $\pm$ one interval = $\pm$ _____ s — the reference's own resolution

Gaps, odd readings, or procedure notes (nothing deleted — “—” marks a missed reading):

10. Estimated k + Hand Check

YOUR k ESTIMATE — THE ARITHMETIC SHOWN, ON PAPER FIRST.

Pick one clean mid-run reading (t, T): $k = \ln((T_0 - T_{\infty}) / (T - T_{\infty})) / t$. Then check with a **SECOND** reading — the spread between the two estimates is evidence about the model, not a bug to hide.

reading 1 (t = _____ min, T = _____ $^{\circ}\text{C}$): k = _____ 1/min reading 2 (t = _____ min, T = _____ $^{\circ}\text{C}$): k = _____ 1/min spread: _____

11. AI Analysis + Human Evaluation

At least ONE evaluated AI analysis or claim. Quote it concisely — do NOT paste the whole conversation.

AI analysis / claim (quoted concisely)	Verdict — ACCEPT / MODIFY / REJECT	Why?	What changed, if anything

AI analysis / claim (quoted concisely)	Verdict — ACCEPT / MODIFY / REJECT	Why?	What changed, if anything

Critical evaluation does not require disagreement — a correct AI analysis is ACCEPTED once the team has verified it.

12. Python Implementation — Model + Prediction Loop

Paste the smallest code excerpts needed to show your implementation — not pages of code.

```
# cooling_T(t, T0, Tinf, k) - minutes in, °C out; must reproduce the hand-checked point
```

```
# estimate_k(t, T, T0, Tinf) - one logarithm; checked against a second reading
```

```
# the stepping loop - tests the NEXT grid time, so t + dt is the predicted crossing
```

Can every team member explain the code used in the submitted analysis? YES / NO

13. Refinement & Convergence Study

Change ONLY dt — rerun the prediction at each row. The change column is the convergence evidence — evidence, not proof. CONVERGED ≠ CORRECT.

dt (s)	Predicted t_40 (min)	Change from previous (min)	Model evaluations	Verdict vs tolerance	Change vs reading interval
60		—			
30					
10					
1					
(finer — optional)					
AI-suggested dt (optional)					

14. BREAK THE AI — Attack the Accuracy Claim

At least THREE attacks on the overconfident accuracy claim (lab deck, Phase 10). “The claim survived” is a finding too — show HOW you verified it. Do not stage a failure.

Attack / question	What the claim needs	Your evidence	Finding	Verdict

The REWRITTEN conclusion — your defensible version of the claim:

“At dt = _____ s the prediction changed _____ s from the previous refinement;

error vs the measured crossing: _____ min (_____ %); tolerance: ± _____ min;

therefore the model IS / IS NOT accurate enough for: _____ (the stated purpose).”

A confident sentence without evidence is typography, not accuracy.

15. Validation ×4 + Justified Precision

Four checks — and, for each, what it shares with the others. Independence is not binary.

① Hand-checked model point

- Evidence:
- What this check supports:
- What it shares (assumptions / methods):

② Loop ↔ exact-inversion agreement

- Evidence:
- What this check supports:
- What it shares (assumptions / methods):

③ Measured-crossing comparison

- Evidence:
- What this check supports:
- What it shares (assumptions / methods):

④ Physical reasonableness + class consistency

- Evidence:
- What this check supports:
- What it shares (assumptions / methods):

$$t_{\text{exact}} = \ln((T_0 - T_{\infty}) / (T_{\text{target}} - T_{\infty})) / k$$

Provided — use it with YOUR k; no derivation required. The stepping loop reports the first grid time past this value.

Evidence	Value (min)	Differs from refined by	What the gap tests
Refined loop (finest dt)			
Exact inversion t_exact			

Evidence	Value (min)	Differs from refined by	What the gap tests
MEASURED crossing			

Smaller dt → _____ but the measurement supports only

16. Class Data Checkpoint — Eight Stations

One Microsoft Forms submission per station; the instructor's Excel view compares all eight.

Quantity	Our station	Class min	Class max	Within our tolerance?	Most likely source of spread
Measured t_{40} (min)					
Estimated k (1/min)					

Did the eight stations agree within YOUR tolerance — and did P3 survive? YES / NO

Sort the disagreement — name the source, with evidence: numerical resolution · instrument differences · initial conditions · probe placement and timing · environment · model inadequacy. Which could produce the spread you actually see? Variation between stations is NOT automatically “numerical error.”

17. Final Engineering Statement

“Under the stated assumptions ($T_0 = \underline{\hspace{1cm}}$ °C, $T_\infty = \underline{\hspace{1cm}}$ °C, $V \approx \underline{\hspace{1cm}}$ mL, uncovered mug, $k = \underline{\hspace{1cm}}$ 1/min from our data), the model predicts the 40 °C crossing at $\underline{\hspace{1cm}}$ min ($dt = \underline{\hspace{1cm}}$ s; change from the previous refinement $\underline{\hspace{1cm}}$ s). The measured crossing was $\underline{\hspace{1cm}}$ min. Error: $\underline{\hspace{1cm}}$ min ($\underline{\hspace{1cm}}$ %) against our $\pm \underline{\hspace{1cm}}$ min tolerance → the model IS / IS NOT accurate enough for this purpose.”

One concise line of evidence for each check:

- ① Hand-checked model point:
- ② Convergence evidence — the change column:
- ③ Measured-crossing comparison:
- ④ Class consistency / limitations:

NUMBER + ASSUMPTIONS + EVIDENCE + JUDGMENT. A bare number is a guess wearing a lab coat.

18. Accuracy Budget + Limitations

- One more unit of engineering effort — where would it go? finer dt · better thermometer · more readings · better k estimate · better model · nowhere (already sufficient). Choice + reason:
- One limitation of the one- k lumped model for this mug:
- One limitation of our measurement (instrument, interval, procedure):

19. Human Review & Approval

“Before submission, we reviewed the completed report against our original engineering record — measurements, calculations, observations, code, plots, tests, validation evidence, and conclusions. We accept responsibility for the submitted engineering work.”

Human reviewed and approved.

This approval happens BEFORE FINAL SUBMISSION — after the completed report has actually been reviewed. Would you confidently put your name on this result? Sign only when the answer is yes.

Name · Signature · Date

Name · Signature · Date

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AI assists. Humans observe. Humans verify. Humans decide. Humans approve.

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