

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING

Chapter 3 / Lab-3 Lab Extension Challenge Report

When Does the Model Stop Being Good Enough?

LAB EXTENSION CHALLENGE — INDIVIDUAL SUBMISSION

Individual submission: The main Chapter 3 / Lab-3 laboratory is performed collaboratively. This Extension Challenge is completed and submitted individually so that every student independently practices the measurement, model-validation, and engineering-judgment skills developed during the team lab. You may discuss concepts with classmates and may use an AI analyst as directed in the assignment, but you must independently analyze the common lid-off cooling dataset supplied by the instructor/TA, produce the comparison table and overlay plot, evaluate the evidence and the AI analysis, and make your own engineering judgment. You do not perform an experiment at home and do not need access to a mug or thermometer. You may begin the analysis during the laboratory period or complete it outside the laboratory after the common dataset is supplied. Suggested Assessment: 10 points (rubric on the last page).

Student Information

Student name	
Student ID (if applicable)	
Date	
Lab section (if applicable)	

How to use this template: replace every gray italic guide with your own evidence and reasoning, and delete nothing else. Concise evidence + engineering reasoning beats pages of polished prose. This is a compact challenge — not another full laboratory report. The final section is where you take responsibility for your work.

1. Committed Predictions

RECORDED BEFORE OPENING OR ANALYZING THE SUPPLIED LID-OFF DATA — DO NOT EDIT AFTERWARD.

With the lid OFF the same standardized mug setup, I predict the water will reach the 40 °C target:

☐ SOONER ☐ AT ABOUT THE SAME TIME ☐ LATER

Predicted ratio $k_{\text{off}} / k_{\text{baseline}} \approx$ _____. My reasoning BEFORE analyzing the supplied data: _____

2. Model + Changed Condition

The same validated Lab-3 model — one physical boundary condition changes.

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

FIXED: same mug · V ≈ 175 mL · same thermometer · same procedure CHANGED: lid OFF →
QUESTION: is the baseline model still good enough?

In the main Lab-3 study the mug was covered with the lid ON. The extension uses a lid-OFF dataset collected once by the instructor/TA under the standardized setup. Removing the lid reopens evaporation and free-

surface convection, but the model equation never mentions a lid, so if the physics changes, k must absorb that change. Whether one new k is enough is exactly what this analysis tests.

3. Supplied Dataset — the Lid-Off Cooling Test

The instructor/TA will perform one standardized lid-OFF cooling run and provide the same measured dataset to everyone. Do NOT repeat the experiment at home. Use the supplied T_∞ , T_0 , time, and temperature readings exactly as provided; do not invent, smooth, or replace any measurement.

Quantity	Baseline (lid ON)	Lid OFF (Instructor/TA-supplied)	Compare
T_0 [°C]			$\Delta T_0 =$ _____
T_∞ [°C]			
Estimated k [1/min]			$k_{\text{off}} / k_{\text{baseline}} =$ _____
Predicted t_{40} using BASELINE k [min]	—		error vs supplied lid-off data = _____
Measured / extrapolated * lid-off t_{40} [min]			$E_{\text{abs}} =$ _____ · $E_{\text{\%}}$ = _____

* If the supplied dataset ends before the lid-off crossing, extrapolate with your estimated k_{off} — and say so explicitly.

4. One Plot — Supplied Lid-Off Data over the Baseline Model

ONE overlay plot. Horizontal axis: time t [min]. Vertical axis: temperature T [°C]. Show the supplied lid-off readings as points over the BASELINE lid-on model curve — the divergence is the finding.

PLOT — supplied lid-off readings vs baseline model curve

Insert your overlay plot — both axes labeled with units

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

5. Test the Prediction — Baseline k vs Lid-Off Data

A targeted model test — predict the lid-off crossing using the BASELINE lid-on k , then compare with what the supplied lid-off data says.

Predicted t_{40} (baseline k): _____ min
_____ min

Lid-off t_{40} (measured / extrapolated):

Absolute error: _____ min Percent error: _____ %

Against the Lab-3 engineering requirement (± 2.0 min), the baseline model here is:
ACCEPTABLE / NOT ACCEPTABLE

6. What Does the Evidence Say?

Does the exponential SHAPE still describe the supplied lid-off data? YES / NO

Did the numerical refinement converge just as beautifully with the wrong (baseline) k ? YES / NO

Measured ratio $k_{\text{off}} / k_{\text{baseline}} =$ _____ vs my predicted ratio: _____

One physical explanation — which heat-loss paths opened when the lid was removed (evaporation? convection from the free surface?), and why can — or can't — a single new k absorb that change?

7. AI Analyst — Analyze, Don't Invent

AI is used AFTER you have measured and interpreted the results. Give any capable AI assistant (your engineering analyst) the following prompt:

"Here are two cooling datasets from the same standardized mug setup — my Lab-3 lid-on baseline and the Instructor/TA-supplied lid-off dataset: [paste your compact data]. The lumped model $T(t) = T_{\infty} + (T_0 - T_{\infty})e^{(-kt)}$ fit the baseline with $k = [\text{value}]$. Analyze whether the same model form with a different k describes the lid-off data, propose physical reasons for the change, and state what evidence would justify continuing to use the baseline k . Do not invent data. Do not change my model."

AI's main analysis (concise summary — not the whole conversation):

8. Human Evaluation of AI

AI analysis verdict: ☐ ACCEPT ☐ MODIFY ☐ REJECT

Why?

If MODIFY — what would you change?

Critical evaluation does not require disagreement — a correct AI analysis may be ACCEPTED after you verify it.

9. Independent Verification

Verify the key claim — your k_{off} — without repeating the whole analysis. No derivation required.

$$k = \ln((T_0 - T_{\infty}) / (T - T_{\infty})) / t \quad (\text{use a SECOND supplied lid-off reading})$$

Reading used: $t =$ _____ min · $T =$ _____ °C First estimate: $k_{\text{off}} =$ _____ 1/min

Second estimate: $k_{\text{off}} =$ _____ 1/min Difference: _____

Do the two estimates agree to the digits you are defending? YES / NO

What does this check support?

10. ENGINEERING JUDGMENT — CONVERGED ≠ CORRECT

In 3–5 sentences: (1) Is the baseline model, with its baseline k , still acceptable for predicting the lid-off crossing — against the ± 2.0 min Lab-3 engineering requirement? (2) Why could the numerical convergence evidence not warn you that the model had gone wrong? (3) What should change in the engineering model or workflow before this prediction is used with the lid OFF?

Same model form → new physical condition → revalidated parameter — that is what validation is FOR

11. Suggested Assessment Rubric — 10 Points

Criterion	Points
Committed predictions (recorded before analyzing the supplied data)	1
Supplied lid-off data + overlay plot	3
k comparison · crossing error · ± 2.0 min requirement verdict	2
AI analysis + ACCEPT / MODIFY / REJECT verdict	2
Independent verification	1
Final judgment — CONVERGED ≠ CORRECT	1
TOTAL	10

12. Human Review & Approval

“I reviewed the measurements, plots, AI contribution, verification, and engineering conclusion in this extension. I accept responsibility for the submitted engineering work.”

Human reviewed and approved.

Would you confidently put your name on this result? Sign only when the answer is yes.

Student name · Signature · Date

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