



AI First Engineering

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING

Chapter 4 / Lab-4 Lab Extension Challenge Report

One Cup, Five Targets — Choose the Method

LAB EXTENSION CHALLENGE — INDIVIDUAL SUBMISSION

Individual submission: The main Chapter 4 / Lab-4 laboratory is performed collaboratively. This Extension Challenge is completed and submitted individually so that every student independently practices the method-selection, certification, and AI-auditing 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 run the five-target computation with your own Lab-4 geometry and functions, produce the comparison table and plot, audit the AI shortcut, and make your own engineering judgment. No equipment is needed.

You may begin this challenge during the laboratory period or complete it outside the laboratory. 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 COMPUTING — DO NOT EDIT AFTERWARD.

Five targets bisected from $[0, H]$ to my Lab-4 tol_h — total model evaluations I predict:

A 1-mm sweep of $V(h)$ from 0 to H — evaluations: _____ the $\pm$ it certifies per target:
_____ mm meets my tol_h ? ☐ YES ☐ NO

Cheaper for five targets: ☐ bisection $\times 5$ ☐ the sweep ☐ neither alone The AI's
“guaranteed ± 0.05 mm” by interpolation — can any theorem I know guarantee it? ☐ YES ☐
NO

2. Inputs — Held Fixed from Lab-4

Your own Lab-4 geometry, the calibrated target-line volume V_{target} , and the height tolerance tol_h derived from the posted acceptance tolerance — copied exactly. Five targets: four design inputs plus your lab target. Every target must lie below the brim-full model volume $V(H)$: a target above it has no sign change in $[0, H]$.

$$f_i(h) = V(h) - V_i, \quad i = 1 \dots 5$$

FIXED: $r_b = \text{___ mm}$ $r_t = \text{___ mm}$ $H = \text{___ mm}$ $tol_h = \text{___ mm}$ TARGETS: $V = 200, 250, 300, 350 \text{ mL} + lab$ $V_{target} = \text{___ mL}$ $V(H) = \text{___ mL} \rightarrow \text{all targets below } V(H)? \text{ YES / NO}$

Five roots, one continuous, climbing $V(h)$. Bisection certifies each root separately; a single sweep sees all five crossings at once — and draws the curve. The question is which certification THIS job needs, at what cost.

3. Five-Target Table — Two Methods

Reuse your Lab-4 f and loop: one extra loop over the five targets, bisecting each from $[0, H]$ to tol_h (stop on width, never on a count). Then one sweep of $V(h)$ every 1 mm from 0 to H ; for each target, read the 1-mm sweep bracket. Count evaluations honestly — endpoint checks included.

Target V _i (mL)	Sweep bracket (mm)	Bisection: $n \cdot h^* \pm$ bound (mm)	Evaluations (bisection)
200	_____ - _____	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \pm$	
250	_____ - _____	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \pm$	
300	_____ - _____	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \pm$	
350	_____ - _____	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \pm$	
Lab V _{target} = _____	_____ - _____	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \pm$	

Totals: bisection $\times 5 =$ _____ evaluations $\cdot$ sweep (1 mm) = _____ evaluations, once, for all five
 $\cdot$ sweep bracket certifies ± 0.5 mm per target — *compare with tol* $h =$ _____ mm.

4. One Plot — $V(h)$ with Five Targets and Five Roots

ONE plot. Horizontal axis: height h [mm]. Vertical axis: volume V [mL]. Draw $V(h)$ from the sweep, the five horizontal target lines, and mark the five bisection roots. Before reading on: does your committed prediction of the cheaper method survive contact with the totals?

PLOT — $V(h)$ from the sweep · five target lines · five bisection roots

Insert your plot — both axes labeled with units

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

5. Cost & Bound — Multiplicative vs Additive

Two questions, answered from your own totals: which method was cheaper for five targets, and which one actually met tol_h ? Then the asymmetry: halving the sweep step doubles its cost for one more halving of its bound: one more bisection halving costs ONE evaluation for the same gain.

Cheaper for five targets: _____ Met tol_h: bisection ☐ sweep ☐ A
sweep step that WOULD meet tol_h: _____ mm, costing _____ evaluations

What the sweep bought that five bisections did not: _____

What bisection bought that the sweep did not: _____

For a design study over MANY targets, or one certified number? Which method for which job — one sentence each:

6. AI Analyst — the Shortcut, and Its Contract

AI is used AFTER your own five-target computation. Give any capable AI assistant (your engineering analyst) the following prompt, with your own numbers filled in:

“Here is the cup model $V(h) = (\pi \cdot h/3)(r_b^2 + r_b \cdot r_h + r_h^2)$ with my measured $r_b = [value]$, $r_t = [value]$, $H = [value]$ mm, and a sweep of $V(h)$ every 1 mm. For target $V = [value]$ mL the sweep brackets the root between $h = [value]$ and $[value]$ mm. Propose the fastest way to locate the mark to ± 0.05 mm from these two sweep points, and state the guarantee behind your bound. Do not invent data. Do not change my model.”

AI's proposed method and its claimed bound (concise summary — not the whole conversation):

7. Audit the Shortcut

Which theorem backs the claimed bound — a certified sign change, or an assumption about the curve's shape? _____

Check it: bisect from the SAME sweep bracket to ± 0.05 mm — halvings needed: _____

AI's root: _____ mm bisection root: _____ $\pm$ _____ mm agree within the bound? YES / NO

Did it invent a geometry value, a bound, or a “nearly linear” assumption you did not certify? YES / NO — which: _____

AI shortcut verdict: ☐ ACCEPT ☐ MODIFY ☐ REJECT Why?

The ONE change that would make its answer certifiable:

Critical evaluation does not require disagreement — an interpolated root may be ACCURATE; the question is whether it is CERTIFIED. A correct AI answer that states its guarantee honestly may be ACCEPTED after you verify it.

8. Known-Case Validation

Verify without repeating the analysis: plug each bisection root back into $V(h)$ and compare with its target; for the lab target, compare h^* with the target line you MEASURED in Lab-4. A gap larger than the bound is model or measurement — name it.

$V(h^*) - V_i$ for the five targets (mL): _____
all within the posted acceptance tolerance $\pm$ _____ mL? YES / NO

Lab target: $h^* =$ _____ $\pm$ _____ mm vs measured line _____ mm gap
_____ mm $\rightarrow$ attributed to: _____

What does this check support? _____

9. ENGINEERING JUDGMENT — WHICH METHOD FOR THIS JOB

In 3–5 sentences: (1) For placing five fill lines on this product line, which method do you recommend — bisection per target, the sweep, or sweep-then-bisect — and at what evaluation cost? (2) What does each method certify, and what does it not? (3) What, in this job, would remain unvalidated no matter which method you chose?

Bisection certifies a number → the sweep draws the landscape → no method validates the model — that is what validation is FOR

10. Suggested Assessment Rubric — 10 Points

Criterion	Points
Committed predictions (recorded before computing)	1
Five-target bisection table with certified bounds	3
Sweep comparison — cost and what each method buys	2
AI shortcut audit — ACCEPT / MODIFY / REJECT with evidence	2
Known-case validation	1
Final method judgment	1
TOTAL	10

11. Human Review & Approval

“I reviewed the computations, the table and plot, the AI contribution, the verification, and the 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.