

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING

Chapter 5 / Lab-5 Lab Extension Challenge Report

Same Beam, Six Starts — Where Newton Begins Matters

LAB EXTENSION CHALLENGE — INDIVIDUAL SUBMISSION

Individual submission: The main Chapter 5 / Lab-5 laboratory is performed collaboratively. This Extension Challenge is completed and submitted individually so that every student independently practices the start-selection, domain-checking, and AI-auditing skills developed during the team lab. You may discuss concepts with classmates and may use an AI critic as directed in the assignment, but you must independently run the six-start computation with your own Lab-5 measurements, posted E and functions, produce the table and plot, audit the AI's start recommendation, and make your own engineering judgment. No equipment is needed — the beam, the masses and the caliper stay in the laboratory; everything here is computed from the values you already recorded. 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.

$a_0 = 0$ — the convenient start: $f'(0) = \underline{\hspace{2cm}}$; the first correction $-f/f'$ is $\underline{\hspace{2cm}}$; I

predict: ☐ converges ☐ fails before step 1 ☐ flies off the bar

Near the clamp — $a_0 = 5$ mm: $a_1 \approx \underline{\hspace{2cm}}$ mm on the bar? ☐ YES ☐ NO $a_0 = L/4$: $a_1 \approx \underline{\hspace{2cm}}$ mm on the bar? ☐ YES ☐ NO

Past the end — $a_0 = 1.2 \cdot L$: ☐ converges to my a^* ☐ converges elsewhere ☐ diverges

The AI's "Newton converges from any start on this smooth model" — can any result I know guarantee it? ☐ YES ☐ NO

2. Inputs — Held Fixed from Lab-5

Your own Lab-5 measurements (L , b , t , F , the unloaded tip height h_0), the posted E , the target $\delta_{(L\text{-target})} = 10$ mm, and the position tolerance tol_a derived from the 1-mm deflection tolerance — copied exactly from your Lab-5 report. Six starts: five design inputs plus your lab's committed a_0 . The model, f and f' are the lab's (Stage B: F fixed, a unknown); only the START changes.

$$f(a) = \delta_L(a) - \delta_{(L\text{-target})}, \quad \delta_{(L\text{-target})} = 10 \text{ mm} \quad \delta_L(a) = F \cdot a^2 \cdot (3L - a) / (6EI),$$

$$f'(a) = F \cdot a \cdot (2L - a) / (2EI)$$

FIXED: $L = \underline{\hspace{1cm}} \text{ mm} \cdot b = \underline{\hspace{1cm}} \text{ mm} \cdot t = \underline{\hspace{1cm}} \text{ mm} \cdot F = \underline{\hspace{1cm}} \text{ N (three masses)} \cdot E = \underline{\hspace{1cm}} \text{ N/mm}^2 \cdot \delta_{(L\text{-target})} = 10 \text{ mm} \cdot \text{tol}_a = \underline{\hspace{1cm}} \text{ mm}$ STARTS: $a_0 = 0 \cdot 5 \text{ mm} \cdot L/4 = \underline{\hspace{1cm}} \cdot L/2 = \underline{\hspace{1cm}} \cdot L = \underline{\hspace{1cm}} \cdot 1.2 \cdot L = \underline{\hspace{1cm}} \text{ mm} + \text{lab } a_0 = \underline{\hspace{1cm}} \text{ mm}$

One model, one loop, six stories. Look at f' first: $f'(0) = 0$ and f' is small near the clamp — a small slope makes the correction $-f/f'$ enormous. The question is which starts are admissible, not whether Newton “works”.

3. Six-Start Table — One Loop, Six Verdicts

Reuse your Lab-5 f , f prime and loop: one extra loop over the six starts. Run it first WITHOUT the domain assert — to see where each start goes — then WITH it, to see which starts the guard refuses. Stop on $|\text{correction}| \leq \text{tol}_a$, never on a count; cap the steps at 50 and record “did not converge” honestly.

Start a_0 (mm)	$f'(a_0)$ (mm/mm)	a_1 (mm) · on the bar?	Unguarded: steps · a_{final} · $\delta_L(a_{\text{final}})$	Verdict
0		_____ · —		fails before step 1 / _____
5		_____ · YES / NO	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}}$	
$L/4 = \underline{\hspace{1cm}}$		_____ · YES / NO	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}}$	
$L/2 = \underline{\hspace{1cm}}$		_____ · YES / NO	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}}$	
$L = \underline{\hspace{1cm}}$		_____ · YES / NO	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}}$	
$1.2 \cdot L = \underline{\hspace{1cm}}$		_____ · YES / NO	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}}$	
lab $a_0 = \underline{\hspace{1cm}}$		_____ · YES / NO	$n = \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}} \cdot \underline{\hspace{1cm}}$	the lab’s march

Verdict vocabulary: converged to a^* (the lab’s root) · converged elsewhere (a root of the cubic that is not on the bar) · left the bar (guard would refuse) · failed before step 1. With the assert ON, which starts survive? _____ — compare with your committed predictions.

4. One Plot — $\delta_L(a)$, the 10-mm Target, the Domain, and the Tangent at 5 mm

ONE plot. Horizontal axis: load position a [mm] from 0 to $1.5 \cdot L$. Vertical axis: model tip deflection δ_L [mm]. Draw $\delta_L(a)$, the horizontal line $\delta = 10 \text{ mm}$, shade the physical domain $0 < a < L$, and draw the tangent at $a_0 = 5 \text{ mm}$ — where does it cross the target line? Mark the six starts and where each ended. Before reading on: does your committed prediction survive contact with the table?

PLOT — $\delta_L(a)$ · $\delta = 10 \text{ mm}$ target line · physical domain $0 < a < L$ · tangent at $a_0 = 5 \text{ mm}$ · six starts and their endings

Insert your plot — both axes labeled with units

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

5. Interrogate the Starts — Zero Slope, Flat Region, Off the Bar

Four questions, answered from your own table and plot. The zero-slope start: $f'(0) = 0$ makes $-f/f'$ undefined — what did your program actually do (an error, or a silent inf/nan), and which is honest? The flat region: near the clamp the slope is tiny, so the tangent reaches the target line far beyond the bar — how far, from 5 mm, in bar lengths? Off the bar: an iterate past L is a number the model produced and a place the beam does not have — unguarded, some starts recover and one finds a root that is not on the bar. Past the end: $1.2 \cdot L$ converged — was it a good start?

$a_0 = 0$ — what the program did: _____ From 5 mm, a_1 in bar lengths: _____
 _____ The unguarded start that converged OFF the bar: $a_0 =$ _____ $\rightarrow a_{\text{final}} =$ _____
 _____ mm (δ_L there = _____ mm = 10 mm? YES / NO)

What an engineer does with an iterate off the bar — continue · refuse · restart from a justified start · bracket first: _____ and why: _____

Was 1.2·L a good start? The loop says YES; the domain says _____. Convergence is not a defense of the start — one sentence on what is:

6. AI Critic — the Start Recommendation, and Its Guarantee

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

“Here is the cantilever model $\delta_L(a) = F \cdot a^2 \cdot (3L - a) / (6EI)$ with my measured $L = [\text{value}]$, $b = [\text{value}]$, $t = [\text{value}]$ mm, $F = [\text{value}]$ N, posted $E = [\text{value}]$ N/mm², and the target $\delta_{(L-\text{target})} = 10$ mm. I want to solve $f(a) = \delta_L(a) - \delta_{(L-\text{target})} = 0$ with Newton-Raphson. Which starting position do you recommend, and can you guarantee convergence from it? What about starting at $a_0 = 0$? Do not invent data. Do not change my model.”

AI's recommended start, its claimed guarantee, and what it said about $a_0 = 0$ (concise summary — not the whole conversation):

7. Audit the Recommendation

Did it justify the start from the physics (on the bar, away from the clamp, near the answer) — or from “a reasonable guess”? _____

Did it claim a guarantee? Which theorem — and does one exist for Newton from an arbitrary start? _____ Check it: run YOUR loop from its recommended start — steps: _____
 a_{final} : _____ mm every iterate on the bar? YES / NO

Did it catch $f'(0) = 0$ — or accept $a_0 = 0$ as “simple”? YES / NO — what it said: _____

AI recommendation verdict: ☐ ACCEPT ☐ MODIFY ☐ REJECT Why? _____

The ONE change that would make its claim defensible: _____

Critical evaluation does not require disagreement — a mid-bar start may be exactly right; the question is whether the GUARANTEE it attached is real. Newton's convergence is local: a correct AI answer that states its limits honestly may be ACCEPTED after you verify it.

8. Plug-Back Validation

Verify without repeating the analysis: substitute every converged a_{final} back into δ_L — including the one that converged OFF the bar. Compare every on-bar a^* with your Lab-5 a^* and the deflection you MEASURED at a^* ($\delta_a = h_o - h_a$). A root that satisfies the model but is not a place on the beam is a root, not an answer.

$\delta_L(a_{\text{final}}) - 10$ mm for each converged start (mm): _____
 _____ all ≈ 0 ? YES / NO the off-bar root satisfies the model too? YES / NO

On-bar a^* values vs the lab's $a^* =$ _____ mm: agree within tol_a? YES / NO measured
 $\delta_a = h_0 - h_a$ at the lab's a^* : _____ mm — inside 9–11 mm? YES / NO
What does this check support — and what can no start ever validate?

9. ENGINEERING JUDGMENT — WHICH STARTS ARE ADMISSIBLE

In 3–5 sentences: (1) For placing a load on this beam with Newton, which starts are admissible, and which is best? (2) What rule would you give a teammate for choosing a_0 on a NEW beam — and would one bisection halving of $[0, L]$ have supplied a defensible start (bracket first, move intelligently second)? (3) What, in this job, would remain unvalidated no matter which start you chose?

A justified start converges fast → a bad start fails, flies, or finds the wrong root → no start validates the beam model — that is what validation is FOR

10. Suggested Assessment Rubric — 10 Points

Criterion	Points
Committed predictions (recorded before computing)	1
Six-start table with verdicts, $f'(a_0)$ and the on-bar check	3
Interrogation — zero slope, flat region, off-bar meaning	2
AI start audit — ACCEPT / MODIFY / REJECT with evidence	2
Plug-back validation	1
Final judgment — admissible starts and a rule for a_0	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.