



AI First Engineering

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING: A Conversational Approach

CHAPTER 5

LAB-5: Engineering Report Template

Slide to the Target

Where along a cantilever beam must a known load hang so that the tip deflection $\delta = h_o - h$ reaches 10 mm — and when does “Newton converged” mean the beam agrees?

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, logs, tables, plots, and code excerpts in the marked places, and delete nothing else. Concise evidence + engineering reasoning beats pages of polished prose. Your AI critic may help assemble this report from your engineering record — Section 19 is where the humans take responsibility for it. Every number marked ILLUSTRATIVE in the lab deck is a worked example on a nominal bar — never your data.*

1. Problem / Objective

What engineering question did this investigation answer — first by validating a beam model against the real bar (Cases 0–3: unloaded tip height h_0 , then one, two, three masses at the free end, $a = L$), then by physically marching Newton-Raphson (compute the step from the model, slide the load, settle, read the tip height h) to the load position a^* at which the tip deflection $\delta_a = h_0 - h_a$ is 10 mm (Case 4, success zone 9–11 mm)? What does “validated” add to “converged”? Two or three sentences.

2. The Physical Activity — Rules & Roles

The rules you marched under — *a clamped mild-steel flat bar · free length L , width b , thickness t measured by us (three readings each), every mass weighed · positions a from the clamp face to the loop centre · every tip HEIGHT h read from the fixed base (datum), every deflection CALCULATED as $\delta = h_0 - h$ · the model validated with 1, 2, 3 masses at the free end ($a = L$, Cases 1–3) before it drives anything · $\delta_{(L-target)} = 10\text{ mm}$ with success zone $9 \leq \delta_a \leq 11\text{ mm}$; E posted by the instructor · a_0 committed with a reason · each step: a_{n+1} computed from the MODEL at a_n , then the loop slid, the beam settled, h read and $\delta = h_0 - h$ recorded beside δ_L · the measured δ never enters the Newton formula · STOP when $|a_{n+1} - a_n| \leq tol_a$ (derived from the 1-mm deflection tolerance and the caliper) — never on a count · iterate off the bar ends the march as a finding · success = validated model + computed steps + honest readings + a defended stop.*

Role	Who (rotation)	What the role owned
Computing engineer		ran the model: $\delta_L(a_n)$, f , f' , the correction, a_{n+1} ; announced the next position; checked $0 < a_{n+1} < L$

Role	Who (rotation)	What the role owned
Slider		hung the masses; slid the loop from a_n to a_{n+1} measured from the clamp face; let the beam settle
Caliper reader		read b , t and every tip HEIGHT h from the datum to the caliper resolution; computed $\delta = h_0 - h$; called LESS $\cdot 10 \cdot$ MORE
Recorder / data engineer		started every march row BEFORE the loop moved; kept the model and beam columns separate

Our plan, written before the first slide (a_0 and its reason, tol_a and its derivation, who computes, who slides, who reads): _____

3. Assumptions

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

The bar is a uniform, straight, linearly elastic cantilever (Euler–Bernoulli, small deflections)	
The clamp is perfectly rigid: the free length L begins at the clamp face	
The sliding loop with its masses acts as a POINT load at the loop centre	
L , b , t are measured with tape/caliper (three readings each); masses on the scale — nominal values are not used	
E is the INSTRUCTOR/PROTOTYPE value posted for this station — a reference, not a measured property	
$\delta_{target} = 10\text{ mm}$ and the 9–11 mm success zone are the specification — never chosen by the team; h_0 is the reference for every deflection	
The Newton iteration follows the model only; measurements are recorded beside it for validation	

Additional team assumption:	
Additional team assumption:	

4. Apparatus, Setup & Safety

- Mild-steel flat bar (24 in nominal, $\approx 1 \text{ in} \times 1/8 \text{ in}$) rigidly clamped over $\approx$ ____ in · three nominal 250-g masses on a sliding loop (hook mass ____ g) · Vernier caliper (resolution ____ mm) reading tip heights h from a fixed base (datum) under the free end · scale (resolution ____ g) · march log sheet
- Anything nonstandard at your station (clamp, bar, loop, datum), noted for the class comparison:
- Safety acknowledgment — all members: clamp checked before the first mass · masses hung and slid gently, never dropped or bounced · hands clear of the free end while a mass moves · masses low over the bench · never more than three masses. ☐
ACKNOWLEDGED (initials: ____ _)

PHOTOGRAPH OF THE STATION

Insert one photo — clamped bar with the loop and masses, the caliper reading the tip height from the datum, the log sheet in view

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

5. Committed Predictions P1–P4

RECORDED BEFORE THE FIRST MASS IS HUNG — DO NOT EDIT AFTERWARD.

P1 — Tip deflection δ_1 we predict for ONE 250-g mass at the free end, $a = L$ (Case 1; from the nominal bar, before any measurement): ____ mm

P2 — With two and three masses at the free end (Cases 2, 3), we predict $\delta_2 : \delta_1$ and $\delta_3 : \delta_1$ will be: ____ . Reason: ____

P3 — Physical slides we predict from our committed a_0 until the correction falls below tol_a : ____

P4 — At a^* (Case 4), we predict $\delta_a = h_0 - h_a$ WILL / WILL NOT land inside $9 \leq \delta_a \leq 11 \text{ mm}$; if not, LESS / MORE than 10 mm, because: ____

*After Phase 4 (P1, P2) and Phase 7 (P3, P4) — what did the evidence say about each prediction?
Answer here; never edit the originals above.*

6. Measurement Log — the Bar, the Loads, and the Baseline (Case 0)

Every quantity the model needs, measured by you: three readings, the mean with units, and the instrument resolution. Nominal values (24 in, 1 in, 1/8 in, 250 g) are labels, not data. CASE 0 — BASELINE: with no mass attached, measure and record the unloaded tip height h_0 from the fixed base (datum); every deflection in this report is calculated from it as $\delta = h_0 - h$. Thickness enters the model as t^3 — say what a 2 % error in t does to the prediction.

Quantity	Symbol	Instrument	Reading 1	Reading 2	Reading 3	Mean · units	Resolution
free length, clamp face → tip	L	tape / rule				____ mm	____ mm
width	b	caliper				____ mm	____ mm
thickness	t	caliper				____ mm	____ mm
mass 1	m_1	scale				____ g	____ g
mass 2	m_2	scale				____ g	____ g
mass 3	m_3	scale				____ g	____ g
mass, hook / loop	m_{hook}	scale				____ g	____ g
CASE 0 — unloaded tip height, datum → tip	h_0	caliper				____ mm	____ mm
clamped length (for the record)	—	tape / rule				____ mm	____ mm

$F = m_{\text{total}} \cdot g = \text{____ N}$ ($m_{\text{total}} = \text{____ kg}$ incl. hook) $I = b \cdot t^3 / 12 = \text{____ mm}^4$ posted $E = \text{____ N/mm}^2$ $EI = \text{____ N} \cdot \text{mm}^2$

Sensitivity: a 2 % error in t changes I by ____ % — which measurement dominates the uncertainty of δ_L ? _____

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

7. STAGE A — Validate the Model: Cases 1–3 at the Free End ($a = L$)

THE MODEL EARNS THE MARCH HERE — OR IT DOES NOT. READ THE MODEL, PREDICT, THEN MEASURE.

The model under test: $\delta_L(a) = F \cdot a^2 \cdot (3L - a) / (6EI)$ predicts the static tip deflection when a load F hangs at position a from the clamp. With the load at the free end ($a = L$) it reduces to $\delta_L = F \cdot L^3 / (3EI)$. Before we allow this model to drive Newton-Raphson, we test whether it predicts the behaviour of OUR beam adequately: one, two and three masses at the free end, predicted δ_L against measured $\delta = h_0 - h$. Predict with YOUR L , b , t , masses and the posted E ; then hang one mass at $a = L$, settle, read h_1 ; add the second, read h_2 ; the third, read h_3 — every height from the same fixed datum as h_0 . Baseline h_0 (Section 6) = ____ mm.

Case · load at a = L	$m_{total} (kg)$ & Applied Force $F = m_{total} g (N)$	$\delta_{L,model}$ $= F \cdot \frac{L^3}{3EI}$ (mm)	$h_{measured}$ (mm)	$\delta_{L,measured}$ $= h_0 - h$ (mm)	difference $= \delta_{L,model} - \delta_{L,measured}$ (mm)	% difference $= \frac{\text{difference}}{\delta_{L,measured}} \times 100$
Case 1 · 1 mass			$h_1 =$	$\delta_1 =$		
Case 2 · 2 masses			$h_2 =$	$\delta_2 =$		
Case 3 · 3 masses			$h_3 =$	$\delta_3 =$		
ratios	δ_2/δ_1 model = 2.00 δ_3/δ_1 model = 3.00	δ_2/δ_1 measured = _____	δ_3/δ_1 measured = _____	linear with load? YES / NO		

In two or three sentences: is the gap random (mixed signs) or systematic (all the same sign)? If systematic, which source is most likely — E (posted, not measured), t (cubed), clamp compliance (adds deflection), the finite loop (shifts the effective a), the caliper and settling? Is the model within 1 mm (the tolerance you must hit) at every load — is it allowed to drive Newton? MODEL ACCEPTED / ACCEPTED WITH A NOTED BIAS OF _____ % / NOT READY: Chapter 1 returns: model, experiment and AI may disagree; the engineer decides.

8. The Target (10 ± 1 mm), the Posted E — and Reachability

The target is the specification, the same for every station; E is the instructor's posted value — an INSTRUCTOR/PROTOTYPE VALUE, a reference with its own uncertainty, not the truth. Copy exactly, with units.

TARGET TIP DEFLECTION δ_{target} [mm]	10 mm
SUCCESS ZONE $\delta_{target} \pm 1$ mm → $9 \leq \delta_a \leq 11$ mm (in heights: $h_0 - 11 \leq h_a \leq h_0 - 9$)	9 to 11 mm → h_a between _____ and _____ mm
E [N/mm ²] (INSTRUCTOR/PROTOTYPE VALUE, posted)	_____ N/mm ²
Reachability (model): $\delta_L(L)$ with three masses [mm] → $10 \text{ mm} < \delta_L(L)$?	_____ mm → YES / NO
Reachability (beam): measured $\delta_3 = h_0 - h_3$ (Section 7) → $10 \text{ mm} < \delta_3$?	_____ mm → YES / NO

If 10 mm were NOT reachable, what would $f(a) = 0$ have no solution of — and how would Chapter 4's cage $[0, L]$ have told you (signs of $f(0)$ and $f(L)$)? _____

9. STAGE B — The Same Model, a New Unknown: $f(a)$, $f'(a)$ + Hand Check (Case 4)

Cantilever model — a point load F at distance a from the clamp deflects the free end (at L) by the Euler–Bernoulli small-deflection formula below — the general model of Section 7, back in full. WHAT CHANGED: in Cases 1–3 the position was fixed ($a = L$) and the load varied; now all three masses stay on, F is FIXED, and the load position a is the UNKNOWN. The requirement $\delta_L(a) = 10$ mm becomes the root-finding problem $f(a) = 0$. Beam theory is the vehicle, not the subject: the model is provided, not derived — and tested in Sections 7 and 15.

$$I = b \cdot t^3 / 12 \quad \delta_L(a) = F \cdot a^2 \cdot (3L - a) / (6 \cdot E \cdot I) \quad f(a) = \delta_L(a) - \delta_{\text{target}}$$

$$, \quad \delta_{(L-\text{target})} = 10 \text{ mm} \quad f'(a) = F \cdot a \cdot (2L - a) / (2 \cdot E \cdot I)$$

Units — b, t, a, L in mm; F in N; E in N/mm^2 ($1 \text{ GPa} = 1000 \text{ N/mm}^2$); then I is in mm^4 , EI in $\text{N} \cdot \text{mm}^2$, δ in mm, and f' in mm of deflection per mm of position. Heights h are read from the datum; deflections are differences, $\delta = h_0 - h$. One system, written once.

Symbol	Meaning	Your value · units
L	free length, clamp face to tip (Section 6)	_____ mm
b, t	width, thickness (Section 6) — t enters as t^3	_____ mm, _____ mm
F	total hanging load = $m_{\text{total}} \cdot g$ (Section 6) — FIXED: all three masses stay on	_____ N
E	posted INSTRUCTOR/PROTOTYPE value (Section 8)	_____ N/mm^2
I, EI	second moment of area; bending stiffness	_____ mm^4 , _____ $\text{N} \cdot \text{mm}^2$
a	load position from the clamp face — the unknown, $0 < a < L$	_____ mm
$\delta_{(L-\text{target})}$	target tip deflection — the specification (Section 8)	10 mm
h_0	unloaded tip height from the datum (Section 6) — reference for every δ	_____ mm
$f'(a)$	slope: mm of tip deflection per mm of load position	mm/mm

HAND CHECK — ONE POINT, ON PAPER, BEFORE ANY CODE.

$\delta_L(L)$ by hand (three masses): $\delta = \frac{\text{_____} \cdot \text{_____}^2 \cdot (3 \cdot \text{_____} - \text{_____})}{6 \cdot \text{_____} \cdot \text{_____}}$
 = _____ mm — must reproduce the Case 3 prediction of Section 7 $\delta_L(L)$ in
 Python = _____ mm agree? YES / NO $f'(L)$ by hand = _____ mm/mm
 in Python = _____ agree? YES / NO

10. WRITE IT — $f(a) = 0$, the Sign, the Slope, the Domain

$$f(a) = \delta_L(a) - \delta_{(L\text{-target})} \quad [\text{mm}] \quad (\delta_{(L\text{-target})} = 10 \text{ mm}) \quad f'(a) = \frac{F \cdot a \cdot (2L - a)}{(2 \cdot E \cdot I)} \quad [\text{mm per mm}]$$

Give each sign its physical meaning for THIS beam — the caliper reader's LESS / 10 / MORE than 10 mm, now in millimetres of a model — then evaluate f at two positions and record the signs. Then the two facts about the slope that decide the march: $f'(a) > 0$ on the bar (sliding outward always increases δ — one crossing), and $f'(0) = 0$ (a load at the clamp bends nothing — $a_0 = 0$ has no slope).

$f(a) < 0$ means: _____

$f(a) = 0$ means: _____

$f(a) > 0$ means: _____

$f(\text{_____ mm}) = \text{_____ mm}$ (sign _____) $f(\text{_____ mm}) = \text{_____ mm}$ (sign _____)

Physical domain: _____ $< a <$ _____ mm Why is $a_0 = 0$ not a usable start? _____

11. COMMIT a_0 — and Derive the Stopping Criterion

The start comes from the physics (on the bar, away from the clamp, near the answer if the validation data suggest where); the stopping criterion is derived from the 1-mm deflection tolerance ($\delta_{(L\text{-target})} \pm 1 \text{ mm}$) through the slope — never chosen, never a count. Newton has no bracket: the domain check $0 < a < L$ is written here, before any slide.

Committed a_0 [mm]	_____ mm because: _____
Deflection tolerance tol_δ [$\pm$ mm]	$\pm 1 \text{ mm}$ (the specification, Section 8) — or a tighter value you adopt for margin: $\pm$ _____ mm, because _____
Slope near the expected root $f'(a)$ [mm/mm]	_____ mm/mm at $a \approx$ _____ mm
Position tolerance $\text{tol}_a = \text{tol}_\delta / f'(a)$ [mm]	_____ mm — derived, never chosen
Caliper resolution on the tip [mm] $\rightarrow$ position it can resolve = res / f'	_____ mm $\rightarrow$ _____ mm
Stopping rule, in words	STOP when $ a_{n+1} - a_n \leq \text{tol}_a$ AND every a_n is on the bar; then validate. Never “after N iterations”.

What the criterion promises: that the MODEL's iterates have settled to within tol_a . What it does not promise: anything about the real bar, E , t , the clamp, or the caliper — that is Section 14.

12. The First Newton Step(s) by Hand

NO AI, NO PYTHON, NO EXCEL — YOUR MEASUREMENTS, YOUR ARITHMETIC, YOUR JUDGMENT. At least row 0 by hand; continue only as far as the criterion demands — a fixed count is not a stopping rule.

n	a_n (mm)	$\delta_L(a_n)$ (mm)	$f(a_n)$ (mm)	$f'(a_n)$ (mm/mm)	correction $-f/f'$ (mm)	a_{n+1} (mm) · on the bar?	$ corr \leq tol_a$?
0	$a_0 = \underline{\hspace{1cm}}$					$\underline{\hspace{1cm}}$ · YES / NO	YES / NO
1						$\underline{\hspace{1cm}}$ · YES / NO	YES / NO
...							

After the hand row(s): is the first correction toward the tip or the clamp, and how large compared with tol_a ? $\underline{\hspace{1cm}}$ (compare with Section 13 rows 0–1: agree? YES / NO)

13. Excel / Python Newton Loop + Iteration Log

Paste the smallest excerpts that show your implementation — the Excel rows with the stop test exposed and/or the Python loop with its printed rows. Then complete the log from your own run. The loop stops on the CORRECTION, never on a count; the assert refuses an iterate off the bar.

What to show	Why it is there	Present?
$\delta_L(a)$, $f(a)$, $fprime(a)$ in code with $\delta_L(L-target) = 10.0$ — $\delta_L(L)$ reproduces the Section 9 hand check	the model, testable	YES / NO
The loop: $corr = -f(a)/fprime(a)$; $a_next = a + corr$; $assert\ 0 < a_next < L$; stop when $ corr \leq tol_a$	the algorithm — stop on the correction, guard on the domain	YES / NO
The printed rows $n \cdot a_n \cdot \delta_L \cdot f \cdot f' \cdot correction \cdot a_{n+1}$ and the final line “ $a^* = \dots$ mm”	the evidence	YES / NO
PASTE YOUR EXCEL TABLE OR PYTHON OUTPUT SCREENSHOT HERE — your own session, rows and final line visible		

Predicted slides (P3): $\underline{\hspace{1cm}}$ Run steps: $\underline{\hspace{1cm}}$ agree? YES / NO Every iterate on the bar? YES / NO REPORT: $a^* = \underline{\hspace{1cm}}$ mm (to the millimetre — digits justified by tol_a and the caliper, not by the printout)

14. The March Log — the Model Beside the Beam

Copy or photograph your complete march log — every slide, in order. Model columns are written BEFORE the loop moves; the tip height h , $\delta_measured = h_0 - h$ and the gap AFTER the beam settles. A reader must be able to replay the march from this table alone. The gap column is validation evidence — it never enters the Newton formula.

a_{n+1} is computed from $\delta_L(a_n)$, never from $\delta_measured(a_n) = h_0 - h$ — the model drives, the beam judges

an iterate off the bar ends the march as a FINDING; the stop is $|correction| \leq tol_a$, never a count

PHOTOGRAPH OF THE MARCH (optional)

The loop at a^* , the caliper reading the tip height from the datum visible

n	a_n (mm)	$\delta_L(a_n)$ (mm)	$f(a_n)$ (mm)	$f'(a_n)$	correction (mm)	a_{n+1} (mm) · on bar?	h at a_n (mm) → $\delta_{\text{meas}} = h_0 - h$	gap model – beam (mm)
0	$a_0 =$							
1								
2								
3								
4								
5								
...								
a^*					—	—		

Slides performed: _____ Stopping row: $n =$ _____ with $|\text{correction}| =$ _____ mm $\leq \text{tol}_a =$ _____ mm $a^* =$ _____ mm corrections in order: _____ → _____ → _____ → _____ — did they collapse the way Chapter 5 promised near a root?

Can every team member explain the code used in the submitted analysis — and say why the measured δ never enters it? YES / NO

15. TRUST IT — Case 4: Newton Converged. Did the Beam?

CASE 4 — HIT THE TARGET: keep all three masses attached, move the loop to a^* , allow the beam to settle, and read the tip height h_a from the SAME fixed datum used for h_0 . Deflection is calculated, never read: $\delta_a = h_0 - h_a$. The physical success criterion is $9 \text{ mm} \leq \delta_a \leq 11 \text{ mm}$. Keep two verdicts separate — numerical convergence (the model's corrections collapsed — a statement about the MODEL) and physical validation (δ_a inside the success zone — a statement about the BEAM) — then sort any disagreement by source. Newton's convergence covers the computation only.

h_a at $a^* =$ _____ mm $\delta_a = h_0 - h_a =$ _____ - _____ = _____ mm success zone $9 \leq \delta_a \leq 11$ mm: INSIDE / OUTSIDE Gap = $\delta_a - 10 =$ _____ mm Newton converged? YES / NO (last correction _____ mm $\leq \text{tol}_a$)

Source of disagreement	Could it produce THIS gap?	Evidence / estimate	What Newton's convergence says about it
Numerical — the Newton stop (model residual $f(a^*)$, tol_a)			covered — the model's root is found to within tol_a
E (posted) and t^3 — the stiffness EI		Section 7 bias: _____ %	not covered
The clamp — assumed rigid; effective L			not covered
The load — assumed a point at the loop centre; friction			not covered

Source of disagreement	Could it produce THIS gap?	Evidence / estimate	What Newton's convergence says about it
The caliper, the datum, the settle (h_0 and h_a both carry the caliper error)		resolution $\pm$ _____ mm	not covered
Small-deflection theory; a non-uniform bar		validation ratios: _____ / _____	not covered

THE THREE QUESTIONS OF CHAPTER 5 — answered from the log

- ① Is it a root? — the last corrections and $f(a^*)$ in mm:
- ② Is it THE root, on the bar? — $f' > 0$ on $0 < a < L$ (one crossing); every iterate on the bar, from the log:
- ③ Did the beam agree? — $\delta_a = h_0 - h_a$ vs the 9–11 mm success zone; the gap attributed to a named source:
- What convergence does NOT establish ($E \cdot t^3 \cdot$ the clamp $\cdot$ the loop $\cdot$ the caliper $\cdot$ the theory $\cdot$ the measurements) — in your words:

Known case: $\delta_{\text{model}}(a^*) =$ _____ mm vs $\delta_{(L\text{-target})} = 10$ mm $\rightarrow$ model residual = _____ mm;
 Section 7 bias predicted the gap's direction? YES / NO

16. COMPARE IT — Bisection on the Same f , and the AI Audit

First, Chapter 4 on your $f(a)$: bisection from the physics cage $[0, L]$ ($f(0) = -10$ mm < 0 ; $f(L) > 0$ by Section 8) to the same tol_a , stopping on the half-width. Then the comparison — no universal winner: which information did each method use, and what did each certify?

	BISECTION (Chapter 4) — computational	NEWTON (this lab) — physical march	Agreement / who owns it
information required	cage $[0, L]$ with signs $f(0) =$ _____, $f(L) =$ _____; continuity	$a_0 =$ _____ with reason; f and f' every step; the domain check	the engineer
evaluations to stop	_____ halvings + 2 endpoint checks = _____	_____ steps $\times (f + f')$ and _____ physical slides	the price list
what it guarantees	containment: $a^* =$ _____ $\pm$ _____ mm	nothing — last correction _____ mm is evidence	the contract
result	$a^*_{\text{bisection}} =$ _____ $\pm$ _____ mm	$a^*_{\text{Newton}} =$ _____ mm	Newton a^* inside the bisection bracket? YES / NO

At least ONE evaluated AI claim from your workspace, plus the planted BREAK THE AI claim from the lab deck. Quote concisely — do NOT paste conversations. Attack the CONVERGENCE, not the syntax. BREAK THE AI — “Newton from $a_0 = 254$ mm converged in 3 iterations to $a^* = 300.5165$ mm (residual 3×10^{-9} mm). Since it has converged, placing the three masses at 300.52 mm will put the tip deflection exactly on the 10-mm target.” At least THREE attacks: separate what is mathematically supported from what is experimentally unsupported. “The numerical part survived” is a finding too — show HOW you verified it and where the claim stopped being mathematics.

Attack / question	What a defensible result needs	Your evidence	Finding	Verdict
AI claim from OUR workspace (quoted concisely):				ACCEPT / MODIFY / REJECT

The REWRITTEN claim — your validated version:

“On our validated model (bias _____ % in Cases 1–3), Newton from $a_0 =$ _____ mm converged in _____ steps (corrections _____ $\rightarrow$ _____ $\rightarrow$ _____, last $\leq \text{tol}_a =$ _____ mm) to $a^* =$ _____ mm; every iterate was on the bar;

at a^* we read $h_a =$ _____ mm, so $\delta_a = h_0 - h_a =$ _____ mm against 10 ± 1 mm — INSIDE / OUTSIDE the success zone; the _____ mm gap is attributed to _____, not to the numerical method;

bisection on the same f needed _____ evaluations for $\pm$ _____ mm and agrees / disagrees within its bracket.”

A converged root with no measured δ_a beside it is not a physical claim; it is a model talking to itself.

17. Final Certified Statement

“For our bar ($L =$ _____, $b =$ _____, $t =$ _____ mm; $m_{\text{total}} =$ _____ kg; posted $E =$ _____ N/mm²; unloaded tip height $h_0 =$ _____ mm) the model predicted $\delta =$ _____ / _____ / _____ mm for 1 / 2 / 3 masses at the free end and we measured $\delta = h_0 - h =$ _____ / _____ / _____ mm (bias _____ %). For the target $\delta_{(L\text{-target})} = 10$ mm (success zone 9–11 mm) we wrote $f(a) = \delta_L(a) - \delta_{(L\text{-target})}$ and $f'(a)$, committed $a_0 =$ _____ mm because _____, and derived $\text{tol}_a =$ _____ mm from the 1-mm deflection tolerance through f' . Newton converged in _____ steps (corrections _____ $\rightarrow$ _____ $\rightarrow$ _____) to $a^* =$ _____ mm with every iterate on the bar. With the three masses at a^* we read $h_a =$ _____ mm, so $\delta_a = h_0 - h_a =$ _____ mm — INSIDE / OUTSIDE 9–11 mm; the _____ mm gap is attributed to _____. Bisection on the same f needed _____ evaluations for $\pm$ _____ mm and agrees / disagrees. Decision: the model IS / IS NOT adequate for placing the load on bars of this type.”

One concise line of evidence for each check:

- ① Measurements with resolution + validated model (Sections 6–7):
- ② a_0 justified + tol_a derived, hand row agrees with the loop (Sections 11–13):
- ③ Every step from the model, every iterate on the bar, corrections collapsed (Section 14):
- ④ Case 4: h_a read, $\delta_a = h_0 - h_a$ vs 9–11 mm + gap attributed + bisection comparison + stated limitations (Sections 15–16):

A ROOT + ITS CONVERGENCE EVIDENCE + ITS PHYSICAL VALIDATION + A DECISION. A bare converged root is a model talking to itself.

18. Method Judgment + Limitations

- If the deflection tolerance tightened tenfold (± 0.1 mm instead of ± 1 mm): what would tol_a become, how many more Newton steps would the model need — and could the caliper and the loop have followed, or would the instrument have hit its resolution wall first? Which limit is numerical, which is physical?
- One limitation of the cantilever model for this bar (rigid clamp · point load · posted E · small deflections):
- One limitation of our measurement (caliper, the datum and h_0 , settling, loop position, mass):
- One more unit of engineering effort — where would it go? measure E from the validation data · better t measurement · a stiffer clamp · a narrower loop · more Newton steps · nowhere (already sufficient). Choice + reason:

19. Human Review & Approval

“Before submission, we reviewed the completed report against our original engineering record — the measurement log, the validation table, the march log, calculations, code, tables, 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 validated root? Sign only when the answer is yes.

Name · Signature · Date

Name · Signature · Date

Name · Signature · Date

Name · Signature · Date

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

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