



AI First Engineering

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING: A Conversational Approach

CHAPTER 6

LAB-6: Engineering Report Template

Recover the Missing Data

A smartphone measured a vibrating beam. The program withheld part of the record. You predicted what was there before the reveal — and then compared your prediction with the experiment. When does an interpolated number deserve your trust?

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Team Information

Team name / number	
Team members	1) 2) 3) 4)
Date	
Section (if applicable)	
Phone used (make / model)	
phyphox Excel filename	

How to use this template: replace every gray italic guide with your team's actual evidence and reasoning, insert your figures, tables and calculations in the marked places, and delete nothing else. Concise evidence + engineering reasoning beats pages of polished prose. Your AI teammate may help you organise and communicate this report from your engineering record; it may not invent, replace, or clean up your measurements. Section 8 is where the humans take responsibility for it.

Two rules that run through every section: (1) committed predictions are copied exactly as typed into the program — never edited after the reveal; (2) every number traces to your team's own phyphox Excel file, which is submitted unchanged. No part of this report may be based on the instructor sample file phyphox-accel-20s.xlsx.

1. Experimental Setup and Data Acquisition

Two or three sentences: the Lab 5 cantilever beam, where and how the phone was secured (face-up, near the free end, rubber bands), how the beam was displaced and released, and who did what. Note anything nonstandard about your station.

Setup description:

Phone orientation on the beam (which phone axis was normal to the beam surface?):

1.1 phyphox recording settings

Setting	Value used	Note
Experiment	Acceleration (without g)	
Start delay	____ s (specified: 3.0 s)	
Experiment duration	____ s (specified: 20.0 s)	
Export format	Excel (.xlsx)	
phyphox Excel filename (submitted unchanged)		exact name, as typed into the programs

1.2 Sampling-rate observation

Open the "Raw Data" sheet. Count the rows, read the first and last time values, and compute your sampling rate. Nominal values from the deck (about 2,000 rows, about 100 per second) describe the instructor's phone — report YOURS.

Quantity	Your value · units	Where it came from
Number of measurements (rows)	_____	Raw Data sheet
Recording duration, $t_{\text{last}} - t_{\text{first}}$	_____ s	Raw Data sheet / program printout
Typical time step Δt between rows	_____ s per sample	difference between consecutive rows
Sampling rate $\approx 1/\Delta t$	_____ samples per s	calculated
Largest $ Z \text{ acceleration} $ in the record	_____ m/s^2	Raw Data sheet or Figure 1

1.3 Raw Z-acceleration figure

FIGURE 1 — RAW Z ACCELERATION vs TIME (your record)

Insert the Program 1 Figure 1 (x, y, z stacked) or the Program 2 Figure 1 (Z only) — screenshot from your own run

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

1.4 Acquisition issues and rerun decisions

Did anything disturb a run (phone slipped, beam touched the stand, table bumped, recording cut short)? Which run is the one analysed, and why? A rerun is a recorded decision, not a failure. Write "none" if the first run was used.

Run	What happened	Decision (kept / repeated) and reason
1		
2		
3		

2. Program 1 — Oscillatory Signal Interpolation

Program: Lab6_Vibration_Signal_Interpolation.py. The program selects a short Z-acceleration window near the middle of your recording and withholds five consecutive measurements near a vibration PEAK (Challenge A) and five near a ZERO CROSSING (Challenge B). Use the straight-line interpolation relation between the two bounding measurements the program prints. Record the bounding measurements, show one substitution in full, list every committed prediction, then copy the revealed table exactly.

THE RELATION YOU USED

$a(t) = a_1 + (a_2 - a_1) \cdot (t - t_1) / (t_2 - t_1)$ (t_1, a_1) and (t_2, a_2) are the two bounding measurements; a in m/s^2 , t in s

CHALLENGE A — MISSING DATA NEAR A VIBRATION PEAK

Bounding measurement	t (s)	Z acceleration a (m/s ²)
before the gap (t ₁ , a ₁)		
after the gap (t ₂ , a ₂)		

Slope $(a_2 - a_1)/(t_2 - t_1) = \underline{\hspace{2cm}}$ m/s² per s. Show the substitution for the first missing time in full; the other four may be summarised.

$$a(t) = \underline{\hspace{1cm}} + (\underline{\hspace{1cm}} - \underline{\hspace{1cm}}) \cdot (\underline{\hspace{1cm}} - \underline{\hspace{1cm}}) / (\underline{\hspace{1cm}} - \underline{\hspace{1cm}}) = \underline{\hspace{1cm}} \text{ m/s}^2$$

COMMITTED PREDICTIONS — copied exactly as typed into the program, BEFORE the reveal. Do not edit.

Missing time t (s)	Committed prediction (m/s ²)	Revealed measurement (m/s ²)	Absolute error (m/s ²)	% difference (as printed)
Mean absolute error for this gap (as printed)			<u> </u> m/s ²	—

FIGURE 2 — Lab6_Peak_Interpolation_Validation.png

Insert the saved figure: available measurements · your interpolated predictions · withheld experimental measurements

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

CHALLENGE B — MISSING DATA NEAR A ZERO CROSSING

Bounding measurement	t (s)	Z acceleration a (m/s ²)
before the gap (t ₁ , a ₁)		
after the gap (t ₂ , a ₂)		

Slope = m/s² per s. First missing time: $a(t) = \underline{\hspace{1cm}} + \underline{\hspace{1cm}} \cdot (\underline{\hspace{1cm}}) / (\underline{\hspace{1cm}})$
 $= \underline{\hspace{1cm}} \text{ m/s}^2$

COMMITTED PREDICTIONS — copied exactly as typed, BEFORE the reveal.

Missing time t (s)	Committed prediction (m/s ²)	Revealed measurement (m/s ²)	Absolute error (m/s ²)	% difference (as printed)

Missing time t (s)	Committed prediction (m/s^2)	Revealed measurement (m/s^2)	Absolute error (m/s^2)	% difference (as printed)
Mean absolute error for this gap (as printed)			_____ m/s^2	—

FIGURE 3 — Lab6_Zero_Crossing_Validation.png

Insert the saved figure

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

2.1 Which comparison is appropriate — and why

Near a zero crossing the measured value is close to 0 m/s^2 , so a small absolute error can appear as an enormous percentage (or "N/A"). State which measure you use to compare the two challenges and why. Absolute error in m/s^2 is always reportable; percent difference only where the measured value is not near zero.

Comparison used and reason:

2.2 Engineering explanation of the differences

Three to five sentences from YOUR two figures and tables. Where was the signal nearly straight and where was it strongly curved? Over how many seconds did the withheld measurements span, compared with one vibration cycle ($1/f$ from Section 4)? Did measurement scatter play a visible role? Which challenge did the straight line handle better, by how much, and what in the local shape of the signal explains it? Do not adjust a prediction or a measurement to make the comparison look better — explain what you found.

Peak region — what happened and why:

Zero-crossing region — what happened and why:

Same rule, same spacing, same number of withheld points — different result because:

3. Program 2 — Decay-Envelope Interpolation

Program: Lab6_Vibration_Decay_Analysis.py. The program identifies the positive and negative peaks of every cycle, converts them to absolute peak amplitudes $|peak|$, and withholds three consecutive $|peak|$ measurements in an EARLY region (near 2 s) and a LATE region (near 15 s).

Each region prints five rows: a bounding measurement, three MISSING times, a bounding measurement. Same straight-line relation, now applied to the envelope.

CHALLENGE A — EARLY DECAY REGION (near 2 s)

Bounding measurement	t (s)	peak amplitude (m/s ²)
before the gap (t ₁ , a ₁)		
after the gap (t ₂ , a ₂)		

Slope = _____ m/s² per s. First missing time: a(t) = _____ + _____ · (_____) / (_____) = _____ m/s²

COMMITTED PREDICTIONS — copied exactly as typed, BEFORE the reveal.

Missing time t (s)	Committed prediction (m/s ²)	Revealed peak measurement (m/s ²)	Absolute error (m/s ²)	% difference (as printed)
Mean absolute error (as printed)			_____ m/s ²	—

FIGURE 4 — Lab6_Decay_Early_Validation.png

Insert the saved figure

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

CHALLENGE B — LATE DECAY REGION (near 15 s)

Bounding measurement	t (s)	peak amplitude (m/s ²)
before the gap (t ₁ , a ₁)		
after the gap (t ₂ , a ₂)		

Slope = _____ m/s² per s. First missing time: a(t) = _____ + _____ · (_____) / (_____) = _____ m/s²

COMMITTED PREDICTIONS — copied exactly as typed, BEFORE the reveal.

Missing time t (s)	Committed prediction (m/s ²)	Revealed peak measurement (m/s ²)	Absolute error (m/s ²)	% difference (as printed)

Missing time t (s)	Committed prediction (m/s^2)	Revealed peak measurement (m/s^2)	Absolute error (m/s^2)	% difference (as printed)
Mean absolute error (as printed)			_____ m/s^2	—

FIGURE 5 — Lab6_Decay_Late_Validation.png

Insert the saved figure

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

3.1 Comparison and interpretation

Three to five sentences. In the early region the amplitude is large and the envelope is steep; in the late region the amplitude is small and the envelope is flat. Compare the two absolute errors AND the two errors relative to the local amplitude. Which region was "easier" for a straight line — and does "easier" mean the same thing at both amplitudes? Where did the withheld peaks sit relative to your line (above / below / scattered on both sides), and what does that suggest about the local shape of the envelope and about measurement scatter?

Early region (≈ 2 s):

Late region (≈ 15 s):

Compare your confidence in the straight-line interpolation in the two regions. Explain using your experimental evidence:

4. Exponential Decay Model

After the reveal, Program 2 fits the exponential model $A(t) = A_0 e^{(-\lambda t)}$ to your measured |peak| amplitudes and prints the values below. Copy each one exactly as printed, with units. The fitted curve is a model of the measured envelope — not a replacement for the measurements.

FIGURE 6 — Lab6_Decay_Exponential_Model.png

Insert the saved figure: experimental |peak| measurements and the fitted exponential decay model

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

Quantity	Symbol	Value as printed by the program	Units
Fitted initial amplitude	A_0		m/s ²
Decay constant	λ		s ⁻¹
Period of oscillations	T : consider several cycles, then $T = \#cycles / (in \Delta t \text{ time interval})$		s
Measured damped vibration frequency	f_d : Measured from T : $f_d = 1/T$		Hz
Estimated damping ratio	ζ (estimate): $\zeta \approx \lambda / (2\pi f_d)$		—
Estimated percent damping	$100 \times \zeta$		%
Decay-model R ²	R ² (indicates model fit quality, closer to 1 better it is)		—

Note that, a larger % ζ indicates faster decay relative to the vibration frequency.

Fitted model, written out with your numbers: $A(t) = \underline{\hspace{2cm}} \cdot e^{-(\underline{\hspace{2cm}} \cdot t)}$ (m/s², t in s)

4.1 Physical interpretation of λ

Two or three sentences in your own words. What does λ describe about this beam-and-phone system? A larger λ means faster decay — roughly how many seconds (about $1/\lambda$) until the amplitude falls to about a third of its starting value on YOUR record, and does that agree with what you saw in Figure 1? Check the units of $\lambda \cdot t$.

$\lambda = \underline{\hspace{2cm}} \text{ s}^{-1}$ means:

—

$1/\lambda \approx \underline{\hspace{2cm}} \text{ s}$ — consistent with Figure 1? YES / NO, because:

—

4.2 The estimated damping ratio

The program estimates ζ from λ and the measured frequency using a light-damping relation, $\zeta \approx \lambda / (2\pi f)$. Report ζ as an ESTIMATE — one sentence on what "lightly damped" means for your record (many visible cycles before the amplitude dies away). No vibration-theory derivation is required.

Check: $\lambda / (2\pi \cdot f_d) = \underline{\hspace{2cm}} / (2\pi \cdot \underline{\hspace{2cm}}) = \underline{\hspace{2cm}}$ — agrees with the printed ζ ? YES / NO

In words, the estimated damping ratio of $\underline{\hspace{2cm}}$ ($\approx \underline{\hspace{2cm}} \%$) means:

—

4.3 Where the measurements depart from the model

Look at Figure 6. Where do the measured |peak| points sit above or below the curve — early, late, throughout? One or two sentences on what that pattern is evidence of (the release, the attachment, the beam, the sensor, or the model itself). This is evidence, not a verdict.

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5. Engineering Analysis / Validation

Answer each prompt in one to three sentences, citing the figure or table row that supports it. The interpolation values were committed before the reveal; the measurements were never edited. Validation here does not mean "the numbers match" — it means a prediction was compared with experimental evidence and the difference was explained.

Prompt	Your answer — with the evidence it rests on (figure / table)
Where did straight-line interpolation work reasonably well, and where did it not? (Program 1 and Program 2)	
Local curvature — how did the shape of the signal inside each gap decide the result?	
Measurement spacing — how long was each gap compared with one vibration cycle ($1/f_d$)? Would a slower sampling rate have changed the outcome?	
Signal amplitude — did large or small amplitude change how the error should be judged (absolute vs relative)?	
Experimental noise / scatter — where was point-to-point scatter comparable to the quantity being estimated?	
Interpolation versus physical measurement — in your own words, what is the difference between the values you typed in and the values the program revealed?	
What did "validation" mean in this experiment — and what did agreement or disagreement between prediction and measurement actually establish?	

AN ESTIMATE IS NOT A MEASUREMENT — LABEL IT. THE MODEL IS YOURS, NOT THE TOOL'S.

6. Limitations / Sources of Experimental Variation

For each source, say whether it could have affected YOUR record, what evidence you have (a figure, a number, an observation during the run), and how it would show up. Add your own rows. Do not speculate without pointing at evidence; "no evidence either way" is an honest entry.

Source of variation	Could it affect our record?	Evidence / observation	How it would show up
Smartphone sensor (sampling rate, resolution, noise floor)	YES / NO / UNSURE		
Phone attachment (rubber bands; slipping or rattling)	YES / NO / UNSURE		

Source of variation	Could it affect our record?	Evidence / observation	How it would show up
Beam release (how displaced, how cleanly let go, timing vs recording start)	YES / NO / UNSURE		
Phone orientation (which axis carried the vibration; X and Y leakage)	YES / NO / UNSURE		
Beam response (clamp, free length, added phone mass)	YES / NO / UNSURE		
Sampling (Δt relative to the vibration period)	YES / NO / UNSURE		
Experimental noise / scatter	YES / NO / UNSURE		
Other (your entry):			

One more unit of engineering effort — where would it go: a stiffer attachment · a more repeatable release · a second run for repeatability · a higher sampling rate · nowhere (sufficient for the question asked)? Choice + reason:

7. Required Submission

Submit everything together. A reader must be able to trace every claim in this report back to your measured data.

Item	Filename	Included?
Completed Lab 6 engineering report (this document; PDF unless instructed otherwise)		YES / NO
Team's ORIGINAL phyphox Excel (.xlsx) export — unchanged		YES / NO
Program 1 figure — peak validation	Lab6_Peak_Interpolation_Validation.png	YES / NO
Program 1 figure — zero-crossing validation	Lab6_Zero_Crossing_Validation.png	YES / NO
Program 2 figure — early decay validation	Lab6_Decay_Early_Validation.png	YES / NO
Program 2 figure — late decay validation	Lab6_Decay_Late_Validation.png	YES / NO
Program 2 figure — exponential decay model	Lab6_Decay_Exponential_Model.png	YES / NO
Calculations, committed predictions and engineering interpretations (Sections 2–6)	in this report	YES / NO

FINAL CHECK — answer honestly before signing

- Can another engineer trace your report back to your measured data? YES / NO
- Did you keep prediction separate from reveal — every committed value copied as typed? YES / NO
- Did you explain disagreement instead of hiding it? YES / NO
- Did you use YOUR team's data for the main lab — nothing from the instructor sample file? YES / NO

8. Human Review & Approval

"Before submission, we reviewed the completed report against our original engineering record — the phyphox Excel file, the committed predictions, the revealed measurements, the saved figures, the calculations, and the 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 comparison between prediction and experiment? 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.