

Self-Assessment 6

The Measurement Disappears · Build It, Fill It · Check It With Physics · Automate It, Guard It · Interrogate the AI & Transfer



Ungraded · for your own learning · work at your own pace

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AI TUTOR MODE — read this first

You do not need to complete every question in one sitting. Start with each group. If you can confidently answer the first questions independently, sample the rest. Spend more time in the groups where you need AI or human help. In Chapter 6 your AI is an ENGINEERING ANALYST and you are its CRITIC — it may fill a gap with numbers, which is exactly why every number it hands you must arrive with its method, its assumptions, the evidence behind it, and a label that says ESTIMATE. If you become stuck, instead of asking for the answer, try:

“I am working on this problem. Do not solve it or tell me which choice is correct. Ask me one question or give me one small hint at a time. Help me reason through what was measured and what was assumed, the local straight-line model, the difference between validating the arithmetic and validating the model, the evidence for ACCEPT / MODIFY / REJECT, and why an estimate never becomes a measurement — until I can explain it myself.”

The purpose of this self-assessment is to determine what YOU understand — not what your AI can answer. Choose the single best answer to each question, and be ready to say in one sentence WHY the others are weaker: the reasoning is the point, not the letter. AN ESTIMATE IS NOT A MEASUREMENT — LABEL IT. THE MODEL IS YOURS, NOT THE TOOL'S.

After each group, rate yourself with the four checkboxes. Your pattern of ratings — not a score — is the output: it tells you exactly what to review, practise, or bring to office hours before moving forward. A calculator is all you need — no computer, and no clock. Every question here is one question in disguise: what can we know about something we did not measure?

GROUP 1 · See It — The Measurement Disappears

The physical system continued; the measurement disappeared. Before any formula: what is a number that nobody measured?

Reference data for the whole assessment — the authentic Chapter 6 Gap 1 excerpt (Tracker, 120 fps, bead on the bicycle wheel). The four blank rows are the frames in which the bead was hidden behind the support post.

t (s)	x (m)	y (m)	Data Type
0.050000	-0.117594	-0.293563	MEASURED
0.058333	-0.093531	-0.301857	MEASURED
0.066667	-0.068832	-0.308022	MEASURED
0.075000			MISSING
0.083333			MISSING
0.091667			MISSING
0.100000			MISSING
0.108333	+0.059576	-0.307425	MEASURED
0.116667	+0.082395	-0.301627	MEASURED
0.125000	+0.106590	-0.293238	MEASURED

1. Measurement or estimate? Tracker records the position of the bead on the rotating wheel. Four consecutive frames are blocked by the support post, so no x measurements exist for those times. An

engineer uses the neighbouring measured values to calculate x at one of the missing times. Which statement is most accurate?

- A. The calculated value is a recovered measurement, because it lies between two measured values.
- B. The calculated value is an interpolated estimate that rests on a model of the bead's local behaviour.
- C. The calculated value becomes a measurement once Excel and Python return the same number.
- D. The calculated value is exact as long as the requested time lies between the two measured times.

RATE YOURSELF on this group before moving on:

- I can do this independently.
- I can do this with a small AI hint.
- I need substantial AI help.
- I still need human/instructor help.

GROUP 2 · Build It, Fill It

The straight line you drew is a model — yours, not the spreadsheet's. Predict first, then compute, then decide what the numbers mean.

2. Predict, then compute one missing value Using the bounding measurements of Gap 1, $(t_1, x_1) = (0.066667 \text{ s}, -0.068832 \text{ m})$ and $(t_2, x_2) = (0.108333 \text{ s}, +0.059576 \text{ m})$, estimate x at $t = 0.083333 \text{ s}$ by linear interpolation. Before you compute: $t = 0.083333 \text{ s}$ is 0.016667 s after t_1 and 0.025000 s before t_2 , so the estimate should sit closer to x_1 than to x_2 — use that to check your arithmetic.

- A. -0.04315 m
- B. -0.01747 m
- C. $+0.00821 \text{ m}$
- D. $+0.03389 \text{ m}$

3. What assumption did you make? A student fills the four missing x values by drawing a straight line between the measured values immediately before and after the gap. Which statement best describes the engineering assumption the student has made?

- A. The bead moved at exactly constant speed during the entire experiment.
- B. The x coordinate changed at an approximately constant rate over this local interval of $1/30 \text{ s}$.
- C. The bead radius was exactly 0.3048 m , so the straight line is consistent with the wheel.
- D. Measurement error is zero at the two bounding points, so the line through them is exact.

4. Same gap, same method — same confidence? The same four missing frames occur in $x(t)$ and $y(t)$. Linear interpolation of x gives x estimates that lie on the local trend; the same formula applied to y gives an almost flat run of values near -0.3079 m , while the measured y values on both sides of the gap are curving downward toward a minimum inside the gap. Which conclusion is best supported?

- A. Linear interpolation must be equally trustworthy for x and y , because the missing times, the sampling rate and the formula are identical.
- B. Linear interpolation is trustworthy whenever four or fewer consecutive frames are missing.
- C. Confidence depends on the local behaviour of the quantity being interpolated — x is at its straightest here while y is at an extremum — not only on the size of the gap.
- D. The y estimates should be rejected because interpolation is only defined for the horizontal coordinate.

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GROUP 3 · Check It With Physics

The spreadsheet knows ten rows of numbers. You know the bead is bolted to a wheel. Use it as evidence — then reach a verdict for each coordinate.

5. Validation with physics After estimating both x and y in the gap, an engineer adds the diagnostic column $r = \sqrt{x^2 + y^2}$. The measured neighbours give $r \approx 0.3156$ m just before the gap and $r \approx 0.3131$ m just after; the linearly reconstructed points give $r \approx 0.3109, 0.3083, 0.3078$ and 0.3094 m. The nominal bead radius is 0.3048 m. Which check provides the strongest independent evidence about the reconstruction?

- A. Confirm that the spreadsheet formula copied down without an error message.
- B. Compare $r(t)$ through the reconstructed region with the neighbouring measured r values: the reconstructed point dips 5–8 mm inward, so the (x, y) pair does not stay on the measured trajectory.
- C. Note that the reconstructed r values (≈ 0.308 – 0.311 m) are closer to the nominal 0.3048 m than the measured neighbours are, so the reconstruction is validated.
- D. Confirm that x and y were produced by the same formula, so they must be mutually consistent.

6. ACCEPT / MODIFY / REJECT Using the evidence from Question 5 together with the local $x(t)$ and $y(t)$ behaviour, which decision best matches the Chapter 6 workflow?

- A. ACCEPT both, because the same interpolation equation was used for both coordinates.
- B. REJECT both, because linear interpolation is never valid for a bead moving on a circle.
- C. ACCEPT the x estimates; MODIFY the y estimates using the additional physical knowledge that the bead stays on the wheel trajectory — and keep both labelled as estimates.
- D. ACCEPT the y estimates and MODIFY x , because the vertical coordinate is the one the physics constrains.

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GROUP 4 · Automate It, Guard It

Good engineering code does not merely calculate — it checks. Read each program like an engineer; you do not need to run anything.

```
t1 = 0.06666667;    x1 = -0.06883248
t2 = 0.1083333;    x2 =  0.05957638
missing_times = [0.075000, 0.083333, 0.091667, 0.100000]
slope = (x2 - x1) / (t2 - t1)
for t in missing_times:
    if t < t1 or t > t2:                # guardrail 1
        print(t, "WARNING: outside measured interval")
        continue
    x = x1 + slope * (t - t1)
    if x < min(x1, x2) or x > max(x1, x2):    # guardrail 2
        print(t, "WARNING: outside bounding values")
    else:
        print(t, round(x, 5), "INTERPOLATED")
```

interpolate_gap1.py — the Chapter 6 program, as taught in Part 4.

7. Interpolation or extrapolation? A teammate changes the list to `missing_times = [0.075, 0.150]`. For $t = 0.150$ s the straight-line equation would return $x \approx +0.188$ m. What should the program do at $t = 0.150$ s, and why?

- A. Return $+0.188$ m normally — the equation produced a number, so the estimate is as good as the others.
- B. Return $+0.188$ m but label it INTERPOLATED, since the same equation was used for all four times.
- C. Warn that $t = 0.150$ s lies outside the measured interval $[t_1, t_2]$ — the same equation is now extrapolating, which assumes the trend continues where nothing was measured.
- D. Replace 0.150 s with $t_2 = 0.108333$ s so that the request becomes an interpolation.

8. A program that runs — and is wrong A student's version of the program has one changed line: `slope = (x2 - x1) / (t2 + t1)`. It runs without error and prints `0.075 -0.06272 INTERPOLATED, 0.083333 -0.0566 INTERPOLATED, 0.091667 -0.05049 INTERPOLATED, 0.1 -0.04437 INTERPOLATED`. Which observation exposes the bug?

- A. Guardrail 2 prints a warning, because the values are outside the bounding values.
- B. Nothing exposes it — no Python error occurred and the four numbers increase smoothly, so the program is correct.
- C. The known case: the hand and Excel value at $t = 0.075$ s is -0.04315 m, not -0.06272 m — the printed slope, 0.7338 m/s instead of 3.0818 m/s, then localises the fault to the denominator.
- D. The number of printed decimal places: rounding to five digits hides the error, so printing nine digits would reveal it.

9. What can Guardrail 2 detect? Another student's version prints `0.075 WARNING: outside bounding values for a time that is inside [t1, t2]; the value that triggered it was +0.16230 m`. What does this warning most strongly indicate?

- A. The interpolation arithmetic or its implementation is wrong — a straight line between (t_1, x_1) and (t_2, x_2) cannot produce an interior value outside $[x_1, x_2]$.
- B. The bead moved off the wheel during the gap, so the physics changed.
- C. The estimate is more accurate than usual, because it extends the local trend further.
- D. The request should be reclassified as extrapolation and reported with that label.

10. Precision versus confidence Python reports the Gap 1 estimate at $t = 0.100$ s as $x = 0.033894688$ m. Which statement best reflects engineering practice?

- A. All nine decimals are trustworthy because the computer calculated them.
- B. The reported digits should be limited to what the evidence for the estimate supports — the local behaviour, the size of the gap and the scatter of the measurements — not to what the calculator can print.
- C. Interpolated values must always be reported to exactly three decimal places.
- D. Displaying more digits makes the interpolation more accurate.

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GROUP 5 · Interrogate the AI & Transfer

The AI is an engineering analyst; you are the critic. Audit the method, the assumptions, the evidence and the context — then take the workflow somewhere with no wheel at all.

11. BREAK THE AI — interrogate the method An AI is given the Gap 1 data with t , x and y and returns four complete rows of numbers for the missing frames. It does not state what method it used, what it assumed, or what it checked. What should the engineer do next?

- A. Accept the values — the AI filled every blank, and the numbers follow the trend.
- B. Reject all use of AI here, because missing data can never be estimated responsibly.
- C. Ask what method it chose, what it assumed about the bead between frames, what it actually verified, what evidence supports the numbers, and whether it distinguished estimates from measurements — then judge the answer against the class's own evidence.
- D. Treat the values as measured data once they are rounded to the same number of decimals as the Tracker output.

12. BREAK THE AI — the context probe The engineer tells the AI: "The bead is attached to a bicycle wheel; the nominal bead radius is approximately 0.3048 m." The AI replies that it has "corrected" the y estimates using $x^2 + y^2 = 0.3048^2$, giving $y \approx -0.3017, -0.3043, -0.3047$ and -0.3029 m, and states that the reconstruction is now validated because it satisfies the circle constraint exactly. The measured y values on either side of the gap are -0.308022 m and -0.307425 m, and the measured neighbours give $r \approx 0.3156$ m and 0.3131 m. What is the best verdict, with evidence?

- A. ACCEPT — the reconstruction now satisfies the physical constraint exactly, which is stronger evidence than the original straight line.
- B. MODIFY — keep the AI's y values but round them to four decimals to match the measurements.
- C. REJECT — the "corrected" bead now jumps about 6 mm upward into the gap relative to both measured neighbours; the AI trusted a nominal design dimension over the instrument's measured neighbours ($r \approx 0.313$ – 0.316 m), and "satisfies the constraint exactly" is circular because the constraint was imposed, not checked.
- D. ACCEPT — 0.3048 m is the wheel's true radius, so any reconstruction that disagrees with it must be the one in error.

13. Did AI recover the measurements? After the improvement prompt, the AI's revised reconstruction agrees with the class's own accepted x values and physics-modified y values to within a millimetre, labels every value as an estimate, and proposes two independent checks. Did the AI recover the missing measurements?

- A. Yes — the agreement with the physics shows that the AI recovered what Tracker failed to record.
- B. Yes — because the physical motion was continuous, the reconstruction is an exact measurement of it.
- C. No — the AI produced estimates. Good ones, verified by the class's own evidence, and still estimates: the four frames were never measured.
- D. Partly — the x values are measurements because they passed every check, while the y values remain estimates.

14. Transfer beyond Tracker — the handbook table A handbook lists the dynamic viscosity of water as $1.0016 \text{ mPa}\cdot\text{s}$ at 20°C and $0.7972 \text{ mPa}\cdot\text{s}$ at 30°C . A process runs at 25°C . An engineer brackets 25°C with those two rows and estimates $\mu \approx (1.0016 + 0.7972)/2 = 0.8994 \text{ mPa}\cdot\text{s}$. A fuller table gives $0.8900 \text{ mPa}\cdot\text{s}$ at 25°C . Which statement best interprets the 1 % difference?

- A. The fuller table must contain a typographical error, because a value exactly halfway between two tabulated rows is exact.
- B. Linear interpolation produced a reasonable estimate between two known values, but the actual relationship is not perfectly linear. Whether the difference is acceptable depends on the engineering use.
- C. The interpolation equation was misapplied, because tabulated properties are always linear between adjacent rows.
- D. A 1 % discrepancy proves that linear interpolation should never be used with handbook tables.

15. The bridge to Chapter 7 Which statement best distinguishes the Chapter 6 interpolation problem from the modelling problem Chapter 7 introduces?

- A.** Interpolation estimates a value between nearby measured points and passes through the bounding data; the Chapter 7 problem asks for one model that represents the overall trend of many measured points, which may pass near rather than through the measurements because real data contain scatter.
- B.** Interpolation uses equations, while modelling from data uses only graphs.
- C.** Interpolation is experimental, while modelling is purely theoretical and needs no data.
- D.** There is no important distinction — both methods must pass exactly through every measured point.

RATE YOURSELF on this group before moving on:

- I can do this independently.
- I can do this with a small AI hint.
- I need substantial AI help.
- I still need human/instructor help.

Reading your ratings. Mostly “independently” → you own Chapter 6: you can fill a gap, say what you assumed, check it against evidence the model did not produce, and label what you made. “Small AI hint” clusters → redo just those questions tomorrow without the hint. “Substantial AI help” → rework the matching Chapter 6 Part (See it · Build it · Check it · Guard it · Interrogate it), then retry. Any “human/instructor help” → bring that exact question to your instructor. If you can answer these small scenarios, you can answer the chapter’s question: what can we know about something we did not measure? AI assists. Humans verify. Engineers decide.