Debug Day: When the Math and the Robot Disagree

Review: Diagnose errors and recalculate

Name: _____ **Date:** _____

In class today you compared your calculated tip position to the actual robot position. Tonight, work through the error analysis so you come back ready to fix it.

Part 1: Record Your Class Data

Fill in the values from your robot session today.

Arm segment lengths: L1 = _____ cm L2 = _____ cm
Joint angles used: θ1 = _____° θ2 = _____°

Calculated tip position (from your FK formula):
x(calculated) = _____ y(calculated) = _____

Measured tip position (physical robot):
x(measured) = _____ y(measured) = _____

Part 2: Calculate the Error

Find the distance between calculated and measured positions using the distance formula:

$$d = \sqrt{[\,(x_2 - x_1)^2 + (y_2 - y_1)^2\,]}$$

Show your work.

Part 3: Pythagorean Identity Check

Use your measured tip coordinates to run a quality check.

For a single-segment arm at angle θ:
Expected: $x^2 + y^2$ should equal r^2 (arm length squared)

Your calculation: $x^2 + y^2$ = _____ + _____ = _____
r^2 = _____

Do they match? ▢ Yes ▢ No Difference: _____

Part 4: Diagnose the Error

Based on your error distance and identity check, which cause is most likely? Circle one and explain.

A. Measurement error (string or ruler imprecision)
B. Rounded intermediate values (should have used exact values)
C. Angle reading error (joint not at the angle we assumed)
D. Physical play in the robot joint (mechanical looseness)

My diagnosis:

Part 5: Recalculate

Fix the most likely error and recalculate the expected tip position.
New θ1 = _____ New θ2 = _____ (or corrected arm lengths)
New x(calculated) = _____ New y(calculated) = _____

Is the new calculation closer to the measured position? By how much?

Part 6: Reflection

In 2–3 sentences: What did this debug process teach you about the relationship between math models and physical machines?