Worksheet 1: Uncertainty in Measurement (side 1)

Name: _____ **Due February 5, 2026**

Part I: Estimating uncertainties: Each student, not each group!

▪ Play the video of the pendulum from the course homepage. Use a stopwatch to record the time T for any **one** oscillation (called the "period")… but don't use the first oscillation. Estimate the uncertainty of this measurement. Convert everything to ms, so you don't need any decimals or scientific notation. Enter the result in Excel. Write the results here in presentation format:

$T = (\quad \pm \quad)$ ms

▪ Repeat this measurement 19 more times, so that you have a total of 20 measurements in Excel. Compute the average and standard deviation "σ" to get an "improved" result for the period. Copy the result here in presentation format:

$T = (\quad \pm \quad)$ ms

▪ Count to determine how many of the 20 total measurements were within $\pm 1\sigma$ of the average. Write this as a percentage, rounded to one decimal place:

$P_{1\sigma} =$ _____ %

▪ What percentage of your measurements fell within $\pm 2\sigma$ of the average? $P_{2\sigma} =$ _____ %

▪ What percentage of your measurements fell within $\pm 3\sigma$ of the average? $P_{3\sigma} =$ _____ %

Discuss all the factors that made this experiment difficult to do well. _____

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***Note**: For all worksheets for the rest of the semester, you must always use correct presentation format, but I will not continue to remind you of that. You need to just know it from now on!*

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▪ Use a ruler to estimate the diameter of a U.S. quarter dollar coin in mm: $D_{\text{ruler}} = (\quad \pm \quad)$ mm

▪ Repeat the previous measurement using a properly zeroed caliper: $D_{\text{caliper}} = (\quad \pm \quad)$ mm

▪ Obtain the caliper measurements from all the other students in this lab, and compute the average and standard deviation as before. Write the result here:

$D_{\text{class}} = (\quad \pm \quad)$ mm

▪ Use the internet to determine the expected diameter: $D_{\text{expected}} = (\quad)$ mm

Discuss the quality and agreement of these four results. _____

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Worksheet: Uncertainty in Measurement (side 2)

Part II: Video Analysis

▪ Use Tracker to analyze the video "HorizontalProjectile.mp4" from the course homepage. Start by using the EXPO whiteboard marker to set the scale, knowing that the marker is 12.0 cm long (including the cap). Try to use the center of each image of the ball. Use Excel to plot the horizontal position as a function of time (you don't need the vertical positions, but you are welcome to also plot them). Add a linear "Trendline" to your plot, and also use Linest to obtain the same values with uncertainties. Record your results in this table:

Quantity	Unit	Your Measured Value
Slope of line		±
Intercept of line		±
Horizontal velocity of ball		±

As you know, the uncertainty given by linest only includes *random* errors. List at least three factors that may have contributed to this random uncertainty. Do not list anything that would generate systematic errors.

The actual uncertainty might be even larger than as reported by linest, due to additional systematic errors. List at least three possible *systematic* errors that might have influenced your measurement.