MTE 201 Experimental Measurement and Statistical Analysis

Measurement System Project

Fall 2025

Overview

In this project, you will design, build, calibrate and demonstrate a system to measure one of the following:

1. The dimensions of Lego blocks

The project will be performed in groups of 4, including the demonstration and the summary report. The summary report will be submitted to **Crowdmark by 9 pm on Monday, Nov 10**. **The demonstrations will be held in UW RCH 212, from 1:30 pm to 3:50 pm on Monday, Nov 10th, and E5 2004 from 1 pm to 4 pm on Tuesday, Nov 11, and Friday, Nov 14.**

Detailed Description

The measurement system must adhere to the following general requirements:

1. It must be designed and built from first principles and not be based on the use of an existing measurement system. For example, use of a digital micrometer is not permitted and will be given a mark of 0.
2. The distance measurement system will be used to determine the length and width dimensions of single or multiple (up to 3) combinations of 2 x 4 Lego blocks. Lego bricks are manufactured to very high tolerances that have remained unchanged since the 1960s.

3. You are allowed to use an existing measurement device as a starting point for building a new device. For example, a protractor could be used to measure an angle that would then be converted to a distance measurement. **You may not use a digital or analog Vernier caliper to measure distance as part of your design.** If your design includes a distance measuring device, a ruler for example, the device resolution must be greater than the resolution of the ruler.
4. You will be required to demonstrate the operation of your system in a classroom lab environment with a minimum amount of setup time. (approx. 5 minutes per group)

WATiMake in DWE 3508/3509 is available for students to work on their projects. E3-3164 is also available for your use every Wednesday, Thursday, and Friday from 1:30 to 4:30 pm. Please note that questions regarding the design or fabrication of your devices should be addressed to the instructor or TAs and not the WATiMake staff or co-op students.

Additional equipment that may be required for sensor connection / signal modification / indicator such as a power supply, multimeter or test leads, may be accessed in DWE 3508/3509. Students are expected to purchase small components, such as resistors, potentiometers, etc.

Step 1: Design and submit a proposal

The first deliverable for the discovery exercise is a short (1/2 to 1 full page) proposal uploaded to the Dropbox provided on LEARN that includes the following:

1. Names of everyone in your group
2. A description of the method that will be used to perform the measurements
3. A sketch of the major components of the measurement system
4. A description of the secondary standard you will use for calibration
5. Your best estimate of the resolution of the measurement, i.e. what is the smallest change in measured value that your device can sense and react to.

Only one person per group should submit the proposal to Learn. The deadline for uploading the proposal is Wednesday, October 29, at 9:00 pm. The proposals will be reviewed by the instructional team, and feedback will be provided by Friday, October 31, at 5:00 pm. Students are expected to incorporate feedback before continuing with their measurements.

Step 2: Build, calibrate and measure

Once the proposal has been approved and any required changes to the apparatus and approach have been made, you may proceed with building and calibrating the device. The following elements must be included in your project and be part of the final report.

1. **Design -** Your measurement system design should include clear descriptions of the common elements of the measurement system (sensor, signal modification system, indicator or recorder) as well as the theory of operation. Briefly summarize all assumptions and describe any challenges that were faced in building and testing the measurement system.

2. **Calibration -** Your measurement system must be calibrated. Include a description of the standard(s) that you used for calibration and show a completed calibration curve.

3. **Uncertainty Analysis -** Using the results of your calibration exercise and a deviation plot, estimate the maximum uncertainty for your measurement system. You can assume that the uncertainty in support equipment, such as a digital micrometer is negligible. Based on the deviation plot, is there evidence of systematic error in your measured values? Is there evidence of random error? How can you tell the difference? Be prepared to answer these questions.

4. **Demonstration -** During the MTE262 lab times, 1 – 4 pm on Monday, Tuesday, and Friday, November 10, 11, and 14, each group will have the opportunity to demonstrate their measurement system. Your group is expected to give a short, verbal presentation on the design, calibration, and uncertainty for your measurement system. During the demonstration, the output of your measurement system plus or minus your predicted uncertainty will be compared to a measurement performed using the following secondary standards:

a. Distance measurements will be assessed using a Mititoyo digital micrometer, with an uncertainty of 0.001 inches

Grades for the demonstration will be based on successful operation of your device, accuracy of the measured values (plus or minus the predicted uncertainty), and the effectiveness of your presentation.

5. **Summary Report -** Your write-up for this lab exercise should be in the form of a 5-page executive summary that includes the following:
   - A summary of the design and construction of the measurement system, including the common elements of the measurement system, the theory of operation and description of assumptions. Photos and schematics are highly recommended as an effective method of describing the construction and operation of the system.
   - A description of the calibration procedure and results, including
     - Apparatus and procedure
     - Calibration data and calibration curve
   - Results of the uncertainty analysis, including deviation plot, estimate of maximum uncertainty, and evidence of systematic and random errors
   - Conclusions and recommendations for future work