

CEEN 3320 - Behavior & Properties of Engineering Materials

Laboratory Experiment No. 1 - Measurement Techniques

Engineers rely on data from a wide variety of sources to design the things that make up our physical world and to ensure compliance with established specifications. The vast majority of this data comes from a variety of measurements. The depth of a concrete footing, the speed of a shaft in an engine, and the voltage across a resistor in an electronic circuit are all examples of measurements we as engineers rely on to facilitate the design process.

It is important (in many instances critically so) that the data generated from these measurements is as close to the “true” value as our instruments and techniques will allow. In the vast majority of cases, this “truth” is unknown so we rely on instruments that have been *calibrated*, or checked against a standard or known value, to provide us with an accurate assessment of whatever parameter we are interested in measuring.

Even though we have instruments that are properly calibrated we still face the challenge of choosing the correct measurement device, and once chosen, using it correctly. Engineers and scientists use the terms *resolution*, *precision*, *accuracy* and *bias* to describe very specific aspects of a device’s capability, and we as engineers need to understand what each means and how it impacts our decisions.

Resolution

Resolution (also referred to as *sensitivity*) is the smallest portion of an interval we can measure or distinguish on an object or specific parameter being measured, or on the instrument we are using. For instance, a measuring tape may be marked in 1/16” increments, and we can confidently say that we can distinguish the halfway point between these markings, giving us an *implied* maximum resolution of 1/32” while the *stated* maximum resolution is 1/16”. In contrast, the resolution of a digital device such as a caliper or balance is fixed at the number of decimal places the display presents.

It is important to note that resolution is not the same thing as *accuracy*. The measurement could be in error by much more than the device’s resolution due to improper calibration, instrument wear, changes in temperature and/or defective manufacturing, to name just a few possibilities.

Accuracy

Accuracy is a measure of how close a measurement is to truth. It can also be defined as the absence of *bias*, or the tendency to diverge from the true value in one direction. Figure 1.20 on page 28 of the text shows a graphical representation of accuracy, precision and bias. It follows that the greater the bias, the less accurate the measurement.

Precision

Precision is a measure of the variability of repeat measurements or trials. We may, for example, measure the length of a steel beam several times and each time obtain a slightly different result. The differences between readings can be caused by a number of reasons, such as small differences in how you use the instrument each time, operator experience and expertise, etc. Variance (**var**) is a statistical measure calculated as follows:

$$\text{var} = \frac{\sum (\theta - \bar{\theta})^2}{(n - 1)}$$

where θ is the value of each measurement, $\bar{\theta}$ is the arithmetic mean of all measurements, and n is the number of observations (measurements). It follows that the larger the variance, the less precise the data.

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OBJECTIVE: To determine the most suitable measuring tool for each specific task, proper use of those tools, and proper data recordation

EQUIPMENT: Load Cell, Data Acquisition System, Dial Caliper, Digital Caliper, Dial Gauge, Ruler, Measuring Tape, Potentiometer, Proving Ring, Static Weights for Calibration, Wood Test Specimens, Metal Test Specimens, Balance

ASTM REF: E 29-06

TEXT REF: Materials for Civil and Construction Engineers, 3rd ed
Chapter 1; Experiment 1, pp. 484-486

PROCEDURES:

Part A- Measurement of Length and Depth

1. Select a wood test specimen and record its length, width and depth to the maximum resolution of the tape measure. Record the weight using the balance.
2. Select a tensile test specimen and record length and diameter using both the dial and digital caliper.
3. Determine the dimensions of the metal cube using both the dial and digital calipers. Record its weight using the balance.
4. Determine the dimensions of the concrete cylinder. Record its weight using the balance.
5. Select a stack of paper and measure all relevant dimensions using the appropriate tool. Record the weight using the balance.
6. Determine the thickness of the aluminum plate using the dial gauge attached to the lab stand. Repeat using the linear potentiometer.

Part B- Measurement of Force

1. Place a series of increasing static weights on the load platen and record the displacement of the proving ring as shown on the dial gage.
2. Place the “unknown” test specimen on the proving ring and record proving ring deformation.
3. Place the proving ring in the Riehle Universal Test Machine such that it is resting on the bottom bolster. Place the load cell on top of the proving ring. Apply load very slowly through the load cell to the proving ring. Record both the load cell reading from the data acquisition system and proving ring deformation at several points during the load cycle. Continue loading to a maximum load cell reading of 1,000 pounds.

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Report:

1. Prepare a report which briefly describes the tests conducted and the results obtained.
2. Using the table of values determined in part A, calculate the unit weight, γ , and specific gravity, G_s , of each test specimen. Comment on these results.

$$\gamma = \frac{W}{V}$$
$$G_s = \frac{\gamma}{\gamma_w} = \frac{W}{V\gamma_w}$$

3. Using an Excel spreadsheet, prepare an X-Y scatter plot of proving ring load (y axis) vs. proving ring deformation (x axis) from the data obtained during Part B, step 1. Perform a linear regression analysis of this data to develop a calibration equation. Comment on the results.
4. Estimate the weight of the “unknown” test specimen using the developed calibration equation. Comment on the result.
5. Using data from Part B, step 3, and the developed proving ring calibration equation, prepare a plot of the estimated proving ring load (y axis) vs. the load cell data (x axis). Comment on the results.

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Lab Section/Time _____ Team # _____

Team Members _____

Part A Data Sheet 1

	Length, in	Width, in	Depth, in	Diameter, in	Weight, lb
Wood					
Tensile Test Specimen					
Aluminum Cube Dial Calipers					
Aluminum Cube Digital Calipers					
Concrete Cylinder					
Paper Stack					
Aluminum Plate Dial Gauge					
Aluminum Plate Potentiometer					

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Part B Data Sheet 2

Calibration Weight, lb					
Proving Ring Deformation, inch					
“Unknown” Specimen Proving Ring Deformation, inch					
“Unknown” Specimen Measured Weight, lb					
Load Cell Reading, lb					
Proving Ring Deformation, inch					