MCE380: Measurements and Instrumentation Lab

Lab 1 - Spring 2010
Statistical Data Analysis

In this experience, groups will be measuring various dimensions of steel bolts. The measurements will be combined in a formula to obtain an estimate of the bolt's volume. The bolts will also be weighed using an electronic scale. Weight (mass) will be divided by volume to give an estimate of density. The dimension between flat faces of the hexagonal head, the thickness of the head and the bolt diameter will be obtained with a micrometer. The length of the bolt will be obtained with a caliper. As an alternative, the volume will be measured by immersion in water and measuring the displaced liquid volume.

In the lab:

1. Find out the accuracy of the micrometer, caliper and scale and write them down.
2. Measure the face-to-face distances of the hexagonal head for all the bolts using the micrometer.
3. Measure the thickness of the head for all bolts using the micrometer.
4. Measure the diameter at the unthreaded section. You will assume that this is the diameter for the whole length. Use the micrometer.
5. Measure the length of the shank for all bolts using the caliper.
6. Weigh all bolts.
7. Immerse enough bolts in the graduated container so that an readable increment is obtained. Divide the displaced volume by the number of bolts and dry the bolts.

At home:

1. Calculate the volume of any one bolt. Then use the weight to find the density in kg/m^3.
2. Repeat with the immersed volume estimation. Which method gives a value closer to the average density of the various steels (7860 kg/m^3)?
3. Calculate the volumes of all bolts individually and then the densities. Find the average density.
4. Use the root mean square formula to estimate the uncertainty in the density calculation. Use the accuracies of all individual readings (not just volume and weight, but all lengths and weight). You will have to write down the formula that gives density from all measurements and then take the partial derivatives.
5. Consider the calculated densities as a statistical sample. Find the standard deviation and average. Use $n - 1$, since it's a sample, not a population.
6. Plot a histogram using a computer. Use a reasonable number of bins. Do the data look normal?

7. Run Chauvenet's criterion to see if you eliminate some density data points.

8. Use probability graph paper (`http://www.reliasoft.com/pubs/paper_normal.pdf`) to assess the normality of the density data. Include all tabulations in the report.

9. Obtain confidence intervals for the mean density at 90%, 95% and 99.9%.

10. Write a short description of what could be done to find the volume with significantly higher accuracy. Give a rough sketch of a measuring device built for the specific purpose of finding the volume of a bolt.

Report:
Write a high-quality technical report. Don't fall for sloppiness, spelling mistakes and poor graphics. A well-written account of a failed experiment is better than a poorly-written report about a successful experiment.
DATE DUE: February 22nd in class.