LAB#7

Measurement Errors

In this lab we are going to collect some simple measurement data and use it to study reliability and bias in making measurements. The lessons of the lab are very widely applicable because essentially every piece of data can be viewed as the result of making a measurement. For example, a person's response to a political poll is a measurement of that person's beliefs, just as the value that the doctor records in a patient's record after taking the patient's blood pressure is a measurement.

WARM UP

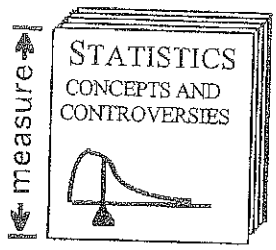
"MERMAID" is a system for monitoring pollution in coastal waters, estuaries, rivers, and lakes developed by the GKSS Research Center (www.coastlab.org) in Geesthact, Germany (MERMAID stands for Marine Environmental Remote-controlled Measuring And Integrated Detection). Of course, the concept of "pollution" is very complex, so the MERMAID system measures dozens of different variables such as chlorophyll levels, water pH, ammonia levels, nitrate and nitrite levels, phosphate levels, silicates, water temperature, oxygen levels, etc. ... A MERMAID system is actually a collection of modules that transmits signals to a land-based station from an ocean platform, a buoy, or even an unmanned ship (the picture shows a MERMAID platform in the Wadden Sea). The GKSS Research Center is very particular about the accuracy of the devices they include in the MERMAID system.

For example, when the phosphate measuring module was used many times on the same water sample, the results were so consistent that they varied from each other by only a few parts per billion. Also, the scientists compared their automatic measuring devices with the most modern "gold standard" method of conducting each of the chemical analyses and found that the results were essentially identical.

1. From the above paragraphs, explain in your own words how the GKSS Research Center is addressing the issues of measurement reliability, bias, and validity in their MERMAID systems.

MAKE YOUR OWN MEASUREMENTS

In this lab, you will use the "ruler" provided at the bottom of this page to measure the length of your statistics textbook. Team with a group of other students in your lab and decide on how you will make your measurements.



Cut along the dotted line to remove the "ruler." Write down your measurement to the nearest tenth of a unit (e.g., 6.3 or 12.7). Be sure that you don't influence your group members by telling them the value that you found or what measurement anyone else obtained until all of the measures have been made.

Record all of the values below. Your instructor will ask you to write these values on the board. Be prepared to describe in lab how the students in your group made their measurements. Also be prepared to discuss what possible sources of bias you saw in the procedure.

Our measurements _____ _____ _____ _____ _____

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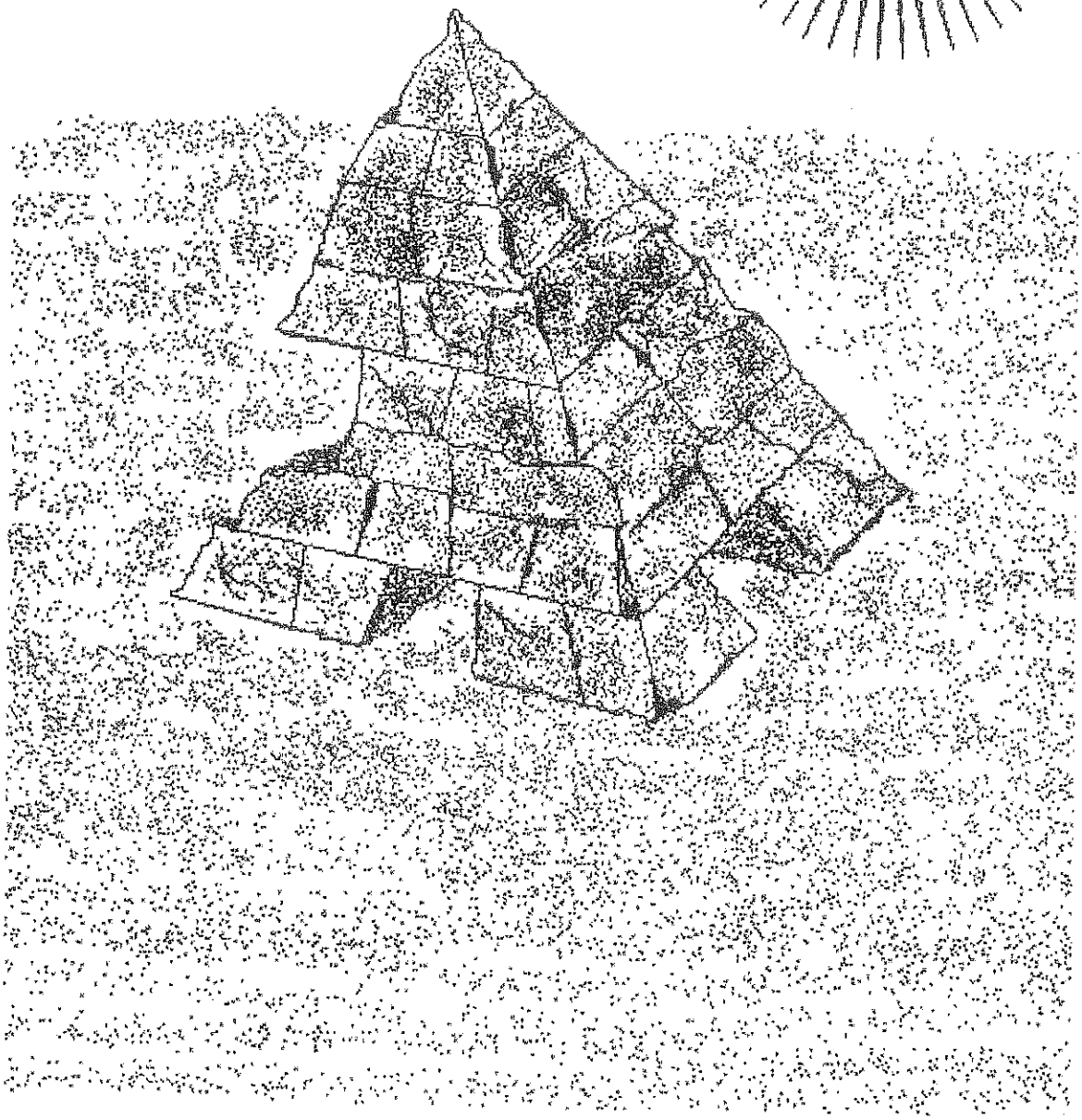
0 1 2 3 4 5 6 7

If the Pharoah's architect had used the ruler from Statistics class . . . .



IN THE LAB

Measurements are variable – they will come out a bit differently each time they are made. How different they are is seen in the *reliability* of the measuring instrument. Also, sometimes the procedure used makes systematic errors that affect the outcome in the same direction no matter how many times the measurement is made. These systematic errors are reflected in the *bias* of the measuring process. We are going to examine the reliability and possible bias of the measurements obtained by the students who measured the textbook using the crude "ruler."

2. Record the measurements made by the rest of your class. Carefully keep all the measurements from each group together.

3. Are there any groups that have very different measurements than the rest of the class? Could these have occurred from using a different procedure in carrying out the measurements? Explain.

4. What do you think about the reliability of measurements your class made? Is there a large amount of variability? Are the measurements of some groups more reliable than others? Explain.

5. If every measurement in the class were made by lining the ruler up with the side of the page rather than with the 0 mark, would this affect the reliability of the measurements? Would it affect the bias of the measurements?

6. The length of the textbook has been measured using an architect's ruler, and the value obtained will be given to you by your instructor. How close are the individual measurements obtained by your classmates to this value? Are any of the values clear outliers? How close is the average of the measurements to the value given by your instructor? Was the average closer to this value when the outliers were removed? Comment.

7. Are the measurements made using the crude ruler *valid*? Explain.