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Physical Geology Lab – Measurement, Statistics, and Absolute Ages

Introduction.

Select one partner to work with on this lab. Put both of your names on the report that you turn in at the end of this Lab.

In this lab you will learn about the errors associated with measuring physical objects and how to apply simple statistical calculations to quantify these errors in a standardized way. You will also learn how to interpret published measurements of ages of rocks and their associated errors, and you will do some simple calculations to learn about the rates of major geologic processes.

Task 1: Measure the same object multiple times, and calculate the average and standard deviation.

You and your partner should each make 10 independent measurements of the length of one of the lab tables and record the measurements below. Use the "meter sticks" provided. Each measurement should be made completely independently; that is, make each measurement starting from scratch. Record the measurements to the nearest 0.5 millimeters (mm); your measurements may look something like this: 310.35 centimeters (cm), which is the same as 3.1035 meters (m).

Measurements of the length of Table Number ___:

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

_____ _____ _____ _____

The *mean* or average of a set of values is a commonly calculated value. It is calculated by adding the measured values and dividing by the number of measurements.

Calculate the mean (average) value for your set of measurements: _____

Check that your mean value is logical by carefully examining the table of measurement you made.

Write here the maximum _____ and minimum _____ of your measured table lengths.

Will the mean value always fall between the maximum and minimum measurements? _____

Will the mean value always fall exactly half way between the maximum and minimum measurements? _____

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Discussion of Standard Deviation (read carefully):

The meaning of Standard Deviation (S.D.) in scientific measurements is: After a set of measurements have been completed and the statistics calculated, if the experiment (measurement) is repeated again, the results will be within plus or minus 1 S.D. of the Mean 68% of the time (2 out of 3 measurements). This also means that 1 out of 3 repeat measurements will fall farther than 1 S.D. from the Mean. One S.D. is also called the "1-sigma" confidence interval.

Calculate the standard deviation of your set of table measurement values. _____ (Use the web site *http://easycalculation.com/statistics/standard-deviation.php*, or a similar tool.)

Write here the formula for calculating the Standard Deviation (if you find more than one version, use the one that has "N-1" in the denominator):

S.D.=

Multiplying the S.D. by 2 gives the "2-sigma" confidence interval, and 19 out of 20 additional measurements will fall within 2 S.D. of the Mean. What is the 2-sigma value of your pebble data?

_____

Multiplying the S.D. by 3 gives the "3-sigma" confidence interval, and 99 out of 100 additional measurements will fall within 3 S.D. of the Mean. What is the 3-sigma value of your table length data?

_____

A statistical measure called *variance* is sometimes used to compare different sets of measurements. Variance is the square of the standard deviation.

Calculate the variance of your set of measurements: _____

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Task 2: Measure multiple similar objects to determine the variability.

Measure the maximum dimension of 30 pebbles along a straight line on the floor of the hallway or the walkway outside the building. Stretch a string about a meter long on the surface to be measured, and tape the ends down securely.

Starting at one end of the string, measure the longest dimension of *the first 30 pebbles* you come to which touch the string. This should provide a fairly representative sample. Do not skip any pebbles which touch the string because doing so will make the set of selected pebbles not representative of what was assigned to be measured. Make the measurements to the nearest 0.5 mm. You should get values similar to these: 1.30 cm, 0.75 cm.

Neatly record your measurements here:

Use a web tool to calculate these statistical measures for your data set (and check to see if the results are reasonable):

Mean: _____

S.D. _____

Var. _____

Also give the Maximum value measured _____, and the

Minimum value measured _____.

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Task 3: Interpreting published values which include standard deviations.

The examples we will use are actual measurements of the "ages" of several different rocks using the method of radiometric (isotope) dating. Usually this is considered a highly precise and reproducible measurement process, even though many steps are involved.

#1. Look up the following article on the web, and find the "age" of the rock discussed. Geological ages are usually given in “thousands of years” [k.y. or Ka] "millions of years" [m.y. or Ma] or "billions of years" [b.y. or Gy or Ga].

http://en.wikipedia.org/wiki/Uranium-lead_dating

Age: _____

Also find the "error" quoted for this age: _____. For radiometric ages, the errors are usually quoted at the 2-sigma significance level; you should assume this, unless the author states the error is 1-sigma (1 S.D.).

Now, the **big question:** If the same rock sample were dated by the same radiometric techniques 20 more times in the same lab by the same people and methods, how many of the new measurements would fall within plus or minus 2-sigma (2 S.D.) of the original age value?

_____

#2. See the web article ***http://bulletin.geoscienceworld.org/cgi/content/abstract/102/7/961***, and answer the following questions.

Read this abstract all the way through. What is an abstract? _____

What year was the article published: _____

Who is the first author of the article: _____

What is the age of the Piper Gulch granodiorite (a type of granite), including the stated error:

_____

What is the age of the Bathtub Formation, including the stated error: _____

Are the errors 1-sigma or 2-sigma: _____

What is the Greek letter symbol used for "sigma": _____

Which of the two formations (Piper Gulch or Bathtub) is younger? _____

#3. Now you should be able to write a sentence explaining the meaning of the following "age" of a rock collected in southern New Mexico: *1,430 m.y. +/- 24 m.y. (2-sigma).*

Your carefully worded explanation:

What would be the "1-sigma" error for this example: _____

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Task 4: Calculation of distances the tectonic plates have moved.

Data: The textbook says that an average rate of horizontal movement of the tectonic plates is about 10 cm per year (4 inches per year). One km = 0.62 miles (look at your car's speedometer: how many miles per hour is 100 km/hr?). One million = one thousand thousand. One billion = one thousand million.

1. How many meters do the plates move in **500 years**?

   Meters? km? miles?

2. **10,000 years?**

   Meters? km? miles?

3. **1 million years?**

   Meters? km? miles?

4. **200 million years?** (when the early dinosaurs roamed Earth's surface)

   Meters? km? miles?

5. **2.5 billion years?** (when Earth's atmosphere first became rich in oxygen)

   Meters? km? miles?

6. **How far is it from the Equator to the North Pole?** (One-quarter of the circumference of Earth)

   km? miles?