Measurements statistics and significant digits

ASSIGN BUSTER

Have you ever wondered why the package of MMs you just bought never seems to have enough of your favorite color? Why is it that you always seem to get the package of mostly brown M&Ms? Is the number of the different colors of M&Ms in a package really different from one package to the next, or does the Mars Company do something to insure that each package gets the correct number of each color of M&M?

Purpose or objective of the experiment: After this lab, students will be able to see concrete examples of uncertainty in measurement. Students will be able to:

Gain experience in making measurements of mass, volume, and temperature.

Get an introduction to the concepts of accuracy and precision as they apply to measurements and the application of significant digits and scientific notation.

Gain a base to the concepts of random error and experimental uncertainty.

Gain experience in determining mean, median, mode, and range.

Use T-Test and Chi Square to analyze statistics

Research question / hypothesis:

Research Question:

How accurate can you measure?

Is the number of the different colors of M&Ms in a package really different from one package to the next?

Hypothesis:

If we measure an object, then the accuracy depends on the instrument, because the manufacturer of the instrument calibrated that instrument to certain accuracy.

If I count the M&Ms that are in the bag, then the number of M&Ms of each color depends on the percentage given, because each bag has different amounts of different colors of the M&Ms.

Pre-laboratory /preparatory questions (remember to cite all sources using APA, make sure all your answers are in complete sentences):

If you are using a graduated cylinder whose smallest division is 0. 1 mL, to what degree of precision should you report liquid volumes? Express your answer in the form of ±0. 01 mL

A stack of five CDs is 1. 6 cm tall. What is the average thickness of each disk? To the nearest whole number, how many disks will be in a stack 10 cm tall? 31 disks.

5/1. 6= 3. 125 3. 125*10 = 31. 25

What is a meniscus; what role does it play in the correct reading of liquid volumes?

Meniscus is the liquid that is applied into a container also known as the curve that is near the surface of a liquid.

-Convex meniscus: when the molecules are more attached to each other than to the container witch means that the middle is curved upward.

-Concave meniscus: when the molecules are less attached to each other that to the container that means that the middle is curved downward.

Discuss in a paragraph, each of the following terms, and explain how you would determine them:

Mean is the average, is the sum of all the numbers divided by the amount of number you have on the equation.

Example: 10+11+12= 33

The you have to divide it by its number and it would be = 11

The Median is the number that is in the middle of the equation.

Example: 3, 9, 15, 17, 44 (smallest to largest)

The Median is: 15 (The number in the middle)

Mode

Mode is when a number is repeated more than once in an operation if there isn’t then there is no mode.

Example: 10, 11, 12, 12, 13, 14,

12 is the number that is repeated so that’s why 12 is the mode

Range

The difference of the smallest and biggest number on a list.

Example: 50, 60, 20, 10 the biggest number is 60 and the smallest number is 10

60 – 10 = 50

Significant digits (discuss significant digits in mathematical computations)

Significant digits are digit other than zero (1, 2, 3, 4…etc.)

Example: 60 has 2 significant digits.

3. 50 has 3 significant digits.

9. 10 has 2 significant digits.

104 has 3 significant digits.

Scientific notation

Scientific notation is a shorter way to write larger numbers . It is a method to write numbers in decimals between 1 and 10 multiplied by a power of 10. (the point must go after the first digit)

Example: 102 = 100, so 700 = 7 Ã- 102

Ã- 102 is “ Scientific Notation”

T-Test

It examines weather two samples are different, and is used when the differences of two samples are unknown.

For example: it can be used to compare the average goal that soccer player A and soccer player B has.

Chi-Square

The chi-squared distribution with k degrees of freedom is the distribution of a sum of the squares of k independent standard normal random variables.

One way that we could determine if the Mars Co. is true to its word is to sample a package of M&Ms and do a type of statistical test known as a “ goodness of fit” test. This type of statistical test allow us to determine if any differences between our observed measurements (counts of colors from our M&M sample) and our expected (what the Mars Co. claims) are simply due to chance or some other reason. For example, if the Mars company’s sorters are not doing a very good job of putting the correct number of M&M’s in each package. We call the goodness of fit test we will be using a Chi Square (X2) Analysis.

We will be calculating a statistical value and using a table to determine the probability that any difference between observed data and expected data is due to chance alone.

We begin by stating the null hypothesis. A null hypothesis is the prediction that something is not present, that a treatment will have no effect, or that there is no difference between treatment and control. Another way of saying this is the hypothesis that an observed pattern of data and an expected pattern are effectively the same, differing only by chance, not because they are truly different.

What is our null hypothesis for this experiment? The amount of each color of M&Ms in each bag are different and it doesn’t have to do with the percentage given by the Mars Co.

To test this hypothesis we will need to calculate the X2 statistic, which is calculated in the following way:

X2 = Sum of (o-e)2

e

where o is the observed (actual count) and e is the expected number for each color category. The main thing to note about this formula is that, when all else is equal, the value of X2 increases as the difference between the observed and expected values increase.

You should investigate on the Internet and complete all the blanks in the following chart.

Celsius

Kelvin

Fahrenheit

What is the boiling point of water?

100°

373. 15 K

212°

What is the freezing point of water?

0°

273. 15 K

32°

What is the normal body temperature?

36°

309. 15 K

96. 8°

Complete the chart

– 40°

233. 15

-32. 8

-273. 15

0

-459. 67

-174. 444

447. 594447. 594

– 346

Theoretical Framework (discuss accuracy in measurements, significant digits, scientific notation, T-Test, and Chi Square. Also discuss other statistical evaluation methods):

Materials (in report make sure you list size of graduated cylinders and beakers):

Special rulers (1-4)

Graduated cylinders (3) with different capacities

Triple-beam balance

Beakers (5), different sizes

Tap water

Thermometer, -20°C to 110°C (2)

Thermometer, -40°C to 52°C (4)

Tap water

Hot plate or Bunsen burner

Bag of M&M candy

Procedure (in your final report, you must list your procedure as a paragraph written in past tense)::

Part A

Measure the length and width of your book with each of the four special

Convert all measurements to centimeters (if necessary)

Using all your measurements, calculate the perimeter (in cm) and area (in cm2) of the cover of your book. Record in Data Table A

Part B

In the laboratory, there are three graduated cylinders. Each has a different volume of water. Record the nominal capacity, the volume of liquid in each cylinder and the uncertainty for that cylinder in Data Table B

Part C

At the triple-beam-balances, there are three jars with different amounts of an unknown substance in each.

Each student determines the average mass of each jar (weigh the jars two times – place the scale of the balance at zero between measurements) and record your results in Data Table C.

Part D

In the laboratory, there are two beakers with water and two beakers with water and salt solution. The beakers are at different temperatures.

Determine the temperature in Celsius and Kelvin for each using the -20°C to 110°C and the -40°C to 52°C thermometers and record on Data Table D.

Part E

Wash your hands and your desk. You will be handling food that you may want to munch on later.

Lay out a large sheet of paper or paper towel-you'll be sorting M&Ms on this.

Determine the mass of the unopened bag of M&Ms and record

Open up a bag of M&Ms.

DO NOT EAT ANY OF THE M&Ms (for now!) (in the spirit of the beginning school year, you may eat them when we complete this lab)

Separate the M&Ms into color categories and count the number of each color of M&M you have.

Record your counts in Data Chart F

Determine T-test between your sample and that of other students (do at least 3)

Determine the Chi square value for your data.

Now you must determine the probability that the difference between the observed and expected values occurred simply by chance. The procedure is to compare the calculated value of the chi-square to the appropriate value in the table below. First, examine the table. Note the term " degrees of freedom". For this statistical test the degrees of freedom equal the number of classes (i. e. color categories) minus one: degrees of freedom = number of categories -1

In your M&M experiment, what is the number of degrees of freedom? 5

The reason why it is important to consider degrees of freedom is that you calculate the value of the chi-square statistic as the sum of the squared

deviations for all classes. You must take into account the natural increase in the value of chi-square with an increase in classes.

Scan across the row corresponding to your degrees of freedom. Values of the chi-square appear below for several different probabilities, ranging from 0. 90 on the left to 0. 01 on the right. Note that the chi-square increases as the probability decreases. If your exact chi-square value is not listed in the table, then estimate the probability.

Notice that a chi-square value as large as 1. 61 would be expected by chance in 90% of the cases, whereas one as large as 15. 09 would only be expected by chance in 1% of the cases. Stated another way, it is more likely that you'll get a little deviation from the expected (thus a lower Chi-Square value) than a large deviation from the expected. The column that we need to concern ourselves with is the one under " 0. 05". Scientists, in general, are willing to say that if their probability of getting the observed deviation from the expected results by chance is greater than 0. 05 (5%), then we can accept the null hypothesis. In other words, there is really no difference in actual ratios. Any differences we see between what Mars claims and what is actually in a bag of M&Ms just happened by chance sampling error. Five percent! That is not much, but it is good enough for a scientist.

If however, the probability of getting the observed deviation from the expected results by chance is less than 0. 05 (5%) then we should reject the null hypothesis. In other words, for our study, the null hypothesis states that there is a significant difference in M&M color ratios between actual store-bought bags of M&Ms and what the Mars Co. claims are the actual ratios.

Stated another way…any differences we see between what Mars claims and what is actually in a bag of M&Ms did not just happen by chance sampling error.

The following information should be in your conclusion.

Based on your individual sample, should you accept or reject the null hypothesis? Why? . I don’t accept he null hypothesis because what I observed was that the deviation is greater than 0. 05 (5%).

If you rejected your null hypothesis, what might be some explanations for your outcome?

this means that the calculation of the Mars Cos company is incorrect.

Now that you completed this chi-square test for your data, do it for the entire class, as if we had one huge bag of M&Ms. Use the information reported on the overhead, complete Data Chart G.

You should also discuss the following in your conclusion.

Based on the class data, should you accept or reject the null hypothesis? Why ? Based on the class data, I accepted the null hypothesis because the observed deviation is less than 0. 05(5%)

If you rejected the null hypothesis based on the class data, what might be some of the explanations for your outcome?

If you accepted the null hypothesis, how do you explain it-particularly if you rejected the null based on individual group data? What is the purpose of collecting data from the entire group? It is because the percentage of each bag is different, some colors are greater than the percentage and some are smaller, but the total percentage of all the bags of M&Ms makes it closer to the percentage given by the company.

Determine the mean, median, and mode, as well as the range, of M&Ms by color. Mean: 1 median: 3 mode: 5 (blue and orange) range: 4

Wash your hands and all equipment after working with chemicals and prior to leaving the laboratory.

Analysis and Conclusions (answer in complete sentences and paragraphs):

Which ruler gives you the most precise, and the least precise, measure of the perimeter and area of the cover of your laboratory notebook? Why does this occur?

Ruler 4 gives the most precise measure because it is the most complex one.

It is common to get different volume readings from each container in Part B.

What explanation can you offer for an apparent decrease in volume?

The units of each container are different, the apparent decrease in units is because the beakers don’t not have smaller or bigger units.

What explanation can you offer for an apparent increase in volume? The units of each container are different, the apparent decrease in units is because the beaker does not have smaller or bigger units.

Which container in part B gave you the most precise reading of the actual volume of water it held? Justify your choice

Container 3 gives me the most precise volume of water because it has smaller units of measure.

Scientists call errors or variations from expected results that do not result from carelessness or incorrect procedure random experimental errors. Experimental errors are no one’s fault, they are unavoidable, and one must consider them any time we evaluate the results of an experiment. Suggest two sources of random experimental errors that might cause different results in Part C of the Procedure.

Sometimes instruments have a differences when measuring, the triple-beam-balances might have some differences even when measuring the same thing because it could have a fabric problem.

It could be the liquid inside the container that might have evaporated a little bit in the process, making their weight change or it could be a slight mistake of the person who was applying the liquid into the container.

What effect does salt have on the temperature of an ice-water mixture?

The salt lowers the temperature of an ice-water mixture.

In Part E of the experiment, why do you think that your percent totals differed from the totals of the other groups in the class?

Because each M&M bag has a different amount of different colors of M&Ms.

Write at least a 200-word summary of this experiment, discussing the research questions, hypotheses, procedures employed, summary of observations, and analysis and conclusion (answering the research question).

Plants, human biology, earth among other type of science where what came to mind when thought of a science class up until the moment we started taking this course. In such a little time we have learned that science and numbers, or better yet math, come hand in hand. Knowing how to calculate properly when doing experiments is vital for the outcome of such. In studying M&M company’s number. We learned how to calculate things like the mean, median, mode and range and the meaning behind them. We where thought how to calculate this numbers but never studied the meaning behind them until know.

After gathering all the information needed it is fundamental to organize them in order to have a clear view of the purpose behind the experiments. We learned to organize our information gathered into graphs and tables. In doing so you learn that its not that difficult to read the information presented by them. In the other hand what I struggled the most with was identifying which containers had salt until the professor thought us how to. At the end of this experiment the most valuable information I learned was that experiments have to be done multiple time in order to get a concise conclusion. In this

M&M project analyzing the percentage of the amount of M&M in the bag I learned lots of things. In this experiment I finally understood how to identify the mean, median, mode and the range of a list of numbers

Comments:

References (list all references used, in correct APA style):

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