**Error Analysis and Propagation of Error Lab**

By: Nathan Caron

Partner: Jerrod Collins-Andrews

Instructor: Wendy Laurin

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**Uncertainty**

The objective of this lab is to demonstrate the inherent error, or uncertainty, in measurements. Then see how those uncertainties propagate when used in equations and formulas. In our lab we demonstrated this by measuring and finding the areas of a circle and a square, and by measuring and finding the volume and surface area of a cylinder. We measured everything in cm.

**Data**

Using a clear 12 inch dollar store ruler, we measured the CD case and disc of Grace Potter & the Nocturnals- the lion, the beast, the beat. We also used the same ruler to measure the height and diameter of a cylinder, which in our case was a Melitta coffee can. My partner and I both calculated the case to have a length of 14.2 cm and a width of 12.4 cm. We estimated our error confidently to .1 of a cm. For the CD itself, we both came up with 12 cm even diameter, which we also estimated to be within .1 cm of the actual diameter. For the cylinder, we both came up with a height of 13.7 cm, and a diameter of 10 cm. Once again, we are confident we were within .1 cm of the actual measurements.

**Results**

In this lab our goal was to see how much area, surface area, and volume vary when there is some uncertainty in the measurements of length, width, diameter, and height. To accomplish this, we first used our measurements to find the area of the CD, the area of the case, the surface area of the coffee can, and the volume of the coffee can. We used the formula A = πr2 for area of a circle, and A = length x width for area of a rectangle (for our case). We used the formulas SA = 2πr2 + 2πrh and V = πr2h for the surface area and volume of the coffee can. Since my partner and I separately got the same results for every measurement, and we both felt we were very accurate, we decided that we were within .1 of a cm on every measurement.

Our CD had a diameter of 12 cm, which using r = d/2 gives us a radius of 6 cm. So using the area of a circle, we had A = π(6 cm)2 = 36π cm2 = 113.1 cm2. When multiplying or diving with 2 measurements (r x r), the error (represented as lower case s) is represented as: . Capital S stands for the area in this case, or 113.1 cm2. Lower case letters a and b represent our estimated uncertainty, or in this case both .1 cm. The capital letters A and B represent our measurements that are being multiplied, which is our radius, 6 cm. So our calculation looks like: . When calculated out, our error comes to ± 2.7 cm2. So our CD’s area is 113.1 cm2 ± 2.7 cm2.

The CD case had a length of 14.2 cm, and a width of 12.4 cm. Using the equation for area, A = length x width = 14.2 cm x 12.4 cm = 176.1 cm2. We are going to use the same equation for uncertainty that we did with the CD, so S is going to be 176.1 cm2. For a and b we are going to use .1 cm again. Capital A in this case is our length, 14.2 cm, and capital B is our width, 12.4 cm. When you plug those numbers in and solve for s, you get ± 1.9 cm2. That makes our CD case’s area 176.1 cm2 ± 1.9 cm2.

Our Melitta coffee can is a cylinder. Our measurements were 13.7 cm height and 10 cm diameter, both accurate within .1 cm. Our radius was d/2 = 10/2 = 5 cm. We needed 2 equations for this object, the equation for surface area, and the equation for volume. The surface area equation is: SA = 2πr2 + 2πrh = 2π(5 cm)2 + 2π(5 cm)(13.7 cm) = 186 π cm2 = 587.5 cm2. Since this equation has addition and multiplication, to find the error we must first find the errors in the multiplication instances of 2πr2 and 2πrh. Then we will need those 2 values of error and use them in the addition equation: . When we use the multiplication equation for error on 2πr2, we get ± 4.4 cm2. Using the same equation on 2πrh we get ± 9.2 cm2. Now we can use the addition equation for error, which comes out to ± 10.2 cm2. So our total surface area for the coffee can comes out to 587.5 cm2 ± 10.2 cm2.

The final calculation that was made was for the volume of the coffee can (cylinder). To get the volume we use V = πr2h = π (5 cm)2 (13.7 cm) = 342.5π cm3 = 1076 cm3. Once again we must use the multiplication equation for error, only this time we must add c2/C2 after b2/B2. Once again using .1 cm for all of our measurement errors, our error, or s, comes to ± 31.4 cm3. Our final volume for the coffee can comes to 1076 cm3 ± 31.4 cm3.

**Conclusions**

In conclusion, I feel the objective to analyze error was a success. Even by being off by as little as one tenth of a cm per measurement can alter your area or volume by quite a bit. Even with such small error, when multiplying 3 measurements our error was in the range of ± 31.4 cm3. The factors that can affect your error can include the device you’re measuring with, the shape of the object you’re measuring, and how accurately you are at positioning the measuring device, such as when measuring the diameter of the coffee can. The only change I could see that would further minimize error would be to get more accurate measuring devices. The errors that did occur were unavoidable and they were there to prove to us how much a small error in measuring can drastically alter results. Overall for me it was a successful lab, there’s nothing else I can think of that could be done to improve the lab.

**Calculations**

Here are the calculations written out:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Area | Surface Area | Volume |
| CD | 113.1 cm2 ± 2.7 cm2 | N/A | N/A |
| CD case | 176.1 cm2 ± 1.9 cm2 | N/A | N/A |
| Coffee Can | N/A | 587.5 cm2 ± 10.2 cm2 | 1076 cm3 ± 31.4 cm3 |