

John Smart
Physics I Lab

Lab Partners: Jack Smart & Felix de Cat

Lab #1: Measurement Uncertainties

Experiment date: 30/01/2020

Instructor: Dr. Mac

Introduction:

The purpose of this lab is to gain experience using uncertainties and to understand what these uncertainties tell us about our measured values and the experiment. We will do this by measuring the mass and the diameter of a steel sphere. Using the equations,

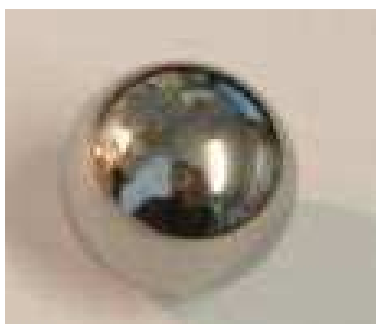
$$\rho = m/V$$

$$V = (4\pi r^3)/3 = (\pi/6)d^3,$$

calculations for the density of the sphere will be performed. Where ρ is the density in (kg/m^3), m is the mass in (kg) and V is the volume of the sphere in (m^3). The d and r stand for the diameter and the radius of the sphere respectfully both in (m). We will also be calculating the uncertainty in the diameter in order to find the uncertainty in the volume then finally in the density. Finally, the experimental value of ρ will be compared to the theoretical density of $7.8 \cdot 10^3 \text{ kg}/\text{m}^3$.

Procedure:

In the first part of the lab we will use a vernier caliper to measure the diameter of the steel ball ten different times. Then we use this value to calculate and find the uncertainty in the volume. In order to find the density we will need the mass of the sphere. Using a scale, with an error of .1%, the mass of the sphere will be measured.



Steel Ball



Vernier Caliper

Data:

Attached at the end of lab report.

Sample Calculation:

Volume using vernier caliper:

$$V = (\pi/6)*d^3 = (\pi/6)* (1.81\text{cm} \pm 0.01)^3 \quad (\text{cm})^3$$

$$V = 3.10 \text{ cm}^3 \pm 1.6\%$$

Density with uncertainty using vernier caliper:

$$\rho = m/V = (.0278 \text{ kg} \pm .1\%) / (3.10 \text{ cm}^3 \pm 1.6\%)$$

$$\rho = 8.97 * 10^3 \pm 144 \text{ (kg/m}^3\text{)}$$

Number of sigma away from accepted value:

$$N = (\text{calculated} - \text{accepted}) / \text{uncertainty} = (8970 - 7800)/144 = 8.1, \text{ within } 8\sigma.$$

Conclusion:

This lab helped us learn how to make measurements using a caliper and how to use measurement uncertainties to find the density of the steel ball and compare it with the accepted value of $7.8 \times 10^3 \text{ kg/m}^3$. Using these uncertainties we can find out whether our measurements were accurate, precise, and realistic. In our trials we found the average diameter of the ball to be 1.81 cm and the uncertainty in the diameter was .01cm using the vernier caliper. We took the average value because our measurements were random. These values were calculated using excel. With these values we found the volume of the ball to be 3.10 cm^3 with a percent error of 1.6 percent. The final calculation of density turned out to be 8970 kg/m^3 with a percent error of 1.6 percent. The calculated density for the steel ball ended up being within 8 sigma of the actual value, giving us not a realistic measurement. The value with the vernier caliper was probably a more accurate measurement than a meter stick for example, but just because the device is more accurate or precise does not mean that the measurement will be a good one, because our value for the caliper was within 8σ away. The sources of error in this experiment were either the caliper was not calibrated correctly or the measurement was not near the center of the ball.

Data

Vernier Caliper

Date: 30/01/2020

Partners: Jack Smart

Felix de Cat



diameter (cm)	$x - \bar{x}$ (cm)	$(x - \bar{x})^2$ (cm ²)
1.81	0.00	0.0000
1.82	0.01	0.0001
1.83	0.02	0.0004
1.80	-0.01	0.0001
1.81	0.00	0.0000
1.79	-0.02	0.0004
1.81	0.00	0.0000
1.80	-0.01	0.0001
1.82	0.01	0.0001
1.81	0.00	0.0000

Sum (cm): 18.1

Average (cm): 1.81

Sum (cm²): 0.0012

RMS (cm): 0.01095445

Standard deviation (cm): 0.011547

Mass (kg): 0.0278

Mass uncertainty: 0.1%