Graphing Lab, Steel Bearings

Graphs, Linear Regression, Comparison with Expected Values

PHYS 104L

1 Goal

The goal of this week's lab is to check your understanding and skills regarding the collection of data, creation of graphs, finding the equation of a best fit line, and comparing results with expected values.

2 Introduction

In this lab, we will again be testing the definition of volumetric mass density and how it is related to the mass and volume of objects. As we saw a few weeks ago,

$$\text{Density} = \frac{Mass}{Volume}$$

We could use this definition to solve for the mass of an object as

$$\text{Mass} = \text{Density} * \text{Volume}$$

We see that if we use materials of the same substance, such that the density of the material stays the same, the larger the volume of space an object occupies, the larger we would expect the mass to be.

Procedure

1.) You should have, at your table, a container with 14 different sized steel ball bearings. The bearings are all made of AISI 52100 Chromium Steel with a known volumetric mass density of 7.81 grams/cm^3. Use your Vernier Caliper to measure the diameter of each ball bearing and use the mass balance to measure the mass. Record these values in a table on your lab data sheet.

Calculations

1.) Open an Excel spreadsheet and setup a table with one row for each steel ball bearing. For the first two columns, list the measured diameter and the measured mass. For convenience, enter the data such that the rows go by increasing mass from top to bottom.

2.) Create a third column where you calculate the radius of the ball and a fourth column where you calculate the volume of the ball using the appropriate formula. Create a fifth column where you calculate the Radius cubed (R^3) and a sixth column where you calculate the diameter cubed (d^3). Fill in these values for all 14 ball bearings. (Remember, Excel can do all those calculations for you fairly quickly.) Print a copy of this spreadsheet and attach it to your report.

3.) Create a graph of Mass vs Volume using the data for all 14 steel bearings. Label the graph appropriately. Perform a linear regression analysis to determine the slope and y-intercept of the best fit line. Identify expected values for the slope and y-intercept and list separate four-line summaries for the slope and y-intercept listing the Result, Range, Expected Value and check for Agreement. On your data sheet, show your work and reasoning for determining the expected values for the slope and y-intercept for this graph. Be sure and pay attention to units! Print a copy of this graph, and the other graphs, with the linear regression results and four line summaries to include in your lab report.

4.) Repeat step 3 for a graph of Mass vs R^3. On your data sheet, show your work and reasoning for determining the expected values for the slope and y-intercept for this graph too.

5.) Repeat step 3 for a graph of Mass vs d^3. On your data sheet, again, show your work and reasoning for determining the expected values for the slope and y-intercept of this graph.

Lab Questions

1.) Should you expect all three graphs to be linear? Should you expect all three graphs to have the same slopes? Explain why or why not.

2.) Did your expected y-intercept values agree with your experimental result for the 3 different graphs? If any of them did not agree, can you offer an explanation as to why?

3.) Did your expected slope values agree with your experimental result for the 3 different graphs? If any of them did not agree, can you offer an explanation as to why?

4.) If you used a set of Acrylic balls (acrylic has a mass density of 1.20 gram/cm^3) with the same diameters as you used in this lab, would you expect the slope of the resulting Mass vs Volume graph to increase, decrease, or stay the same? Explain your reasoning.

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Data Sheet / Report

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Ball Diameter (cm)	Mass (grams)

Sample Calculations for Radius and Volume:

Show your work and reasoning for determining the expected slope and y-intercept values for your graph of Mass vs Volume:

Show your work and reasoning for determining the expected slope and y-intercept values for your graph of Mass vs R^3:

Show your work and reasoning for determining the expected slope and y-intercept values for your graph of Mass vs d^3: