PHY 122 LAB : Density (linearized plot)

Introduction

In this lab we will determine the density of clay by weighing a set of hand-made spheres. We fit a model function for mass vs. diameter using a linearized plot and a log-log plot. The aim is to understand how scientists "model" physical effects. This means that they simple guess what the formula describing some effect might be, then try to fit measurements to this formula. Here we assume you can "guess" (or derive) how density depends on diameter and mass for a simple case.

A famous example of modeling is the Wright brothers wind-tunnel experiments in 1904, to find the best shape for an aircraft wing. They modeled the dependence of lift force on toy wings in a wind-tunnel, on wing area, wind speed and angle of attack, then fitted measurements to a guessed formula which was dimensionally correct. In this way they discovered an aerodynamic law, still used today. This says that the lift force goes as the square of the speed, so aircraft going twice as fast get four times as much lift force, and hence don't need such big wings.

Note that "theory" (eg Einstein's) is different from "modeling". Theory depends on physical insight, contains truth which depends our understanding of the world, and is predictive over a very wide range of conditions, while mode[1]ling means guessing a law to fit data, often over a limited range.

Model equations must be dimensionally correct, and this can provide powerful hints as to the form of the dependence.

The second aim of this experiment is to introduce you to Logarithmic plots, which are widely used in science.

Procedure

Make a clay sphere about 1cm diameter and measure its diameter with the vernier calipers. Take 6 independent readings (roll the ball, change partners, etc) to establish uncertainty from the SDM of these readings. Be sure each lab partner takes caliper readings. Weigh the sphere and wiggle the gram slider to estimate errors. Repeat for a series of balls, from nominal diameters 1-7 cm.

Analysis

1. Working in GA, find the density of clay from a linearized plot (not log-log plot, which we do below) of mass and diameter (M,D) data. (eg plot some power of diameter against mass and find the slope to give the density). You should deduce your own model function for this experiment, based on general knowledge of the

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relationships betweeen volume, mass and density to find this power and the relationship between the slope and the density. A linear fit to the data will provide the error in the slope; you must then use the rules you've learnt for the propagation or errors to find the error in density from the error in slope..

2. Self-checks: Does your value for density seem reasonable, within say a factor of 2 ? Look up the density of materials you know are lighter/heavier; which sink or float - what can we conclude from that ?
3. Now we will assume we don't know how volume depends on radius, so we will write $V = a\ r^n$, where a is a constant, and find n from a Log-log in GA: A pure power law can be linearized using log-log axes (note “ln” is base-e and “log” is base-10 -either will work, with ln giving somewhat better “resolution”, but being tougher on the brain to interpolate) Calculate ln(D) and ln(M) and plot these transformed variables in GA. Do this by DATA \ NEW COLUMN\ CALCULATED. Then select these new columns for the plot. Find the exponent (and its uncertainty) in the power law from the slope of the log-log plot. Does this fit with your model function?
4. Log-log by hand: Plot your data by hand on log-log paper (supplied in lab). This is now base-10. Find the exponent of the assumed power law from the slope of the line.

Report

Make a single summary table of all results. You need not tabulate all measurements here, if your original data are reasonably neat.

PAB &JCHS.

Prelab Quiz PHY122 Lab

Name___________________________ Section time/day_____________________

1. Make a log-log plot of the data below using Graphical Analysis or Excel. In Excel, this is done with XY-scatter plot, then change both axes to log scale.

2. Find the value and units of the constants A and n from the slope and intercept of your log-log plot, assuming the functional relation $y(x)=Ax^n$. Ignore errors.

x(apples)	y(oranges)
1	3.00E+00
2	7.50E-01
4	1.88E-01
8	4.69E-02
16	1.17E-02
32	2.93E-03
64	7.32E-04
128	1.83E-04
256	4.58E-05