MEK4600: Assignment 1

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1 Analysis of Experimental data

For this assignment you will be working with a series of data collected from a mass flow meter (Endress & Hauser Promass 63) in the Hydrodynamics lab. The datafiles and technical specifications of the flow meter can be found online at http://www.uio.no/studier/emner/matnat/math/MEK4600/v13/undervisningsmateriale/.

The goal of this assignment is to apply some of the techniques that have been covered on actual data. The data shown here was collected in February 2007 as part of an experiment on particle-turbulence interaction in multiphase pipe flow. During the data collection runs the mass flow meter was sampled at 10 Hz and the data saved to an ascii text file. The parameters of the runs and their filenames are given below in table 1. The accuracy of the flow meter for measuring mass flow rate, density, and temperature is given on page 28 of the manual.

For this assignment you will be handing in a report written in LaTeX. For further information consult either [1] or [2]. The report should have a brief abstract, an introduction where background material is presented, a short section describing the experiment, a section presenting the results, and a conclusion and bibliography if needed. If any supplemental files (mfiles, scripts, LabView VIs) are used please include them in appendicies. When writing the report please touch on the following aspects:

1. Please state the best estimates and their uncertainties for the mass flow rate, volumetric flow rate, bulk velocity, kinematic viscosity, and Reynolds numbers for the three cases.

2. How did you compute the viscosity? How much variability do you think this contributes to the estimate of the Reynolds number?

3. Are any of the data points outliers? If so how did you determine what was an outlier? How much do these outliers (if any) affect the mean quantities obtained?

4. Compare the bext estimate of the flowmeter with the stated accuracy from the manual.

5. Discuss any possible sources of error and how they could be reduced.

File Name	Pump Speed (Hz)	Fluid Density (kg/m^3)	Fluid Temperature (°C)
run25_mfr.txt	20	994	25.0
run30_mfr.txt	30	994	24.6
run35_mfr.txt	50	994	27.1

Table 1: Experimental parameters for a series of recordings from the mass flow meter. The flow was water and was seeded with 950 μm diameter polystyrene particles. The average volume fraction of the particles was $O(10^{-3})$. All data was collected at 10 Hz.

2 Reading for this week

The assignment covers the following sections of [3]. Please read and be familiar with the covered concepts and this is what is expected to be covered in this assignment.

1. Chapter 1, Preliminary description of error analysis
   (a) Section 1.5, Estimating uncertainties when reading scales
   (b) Section 1.6, Estimating uncertainties in repeatable measurements
2. Chapter 2, How to report and use uncertainties
   (a) Section 2.1, Best estimate ± uncertainty
   (b) Section 2.2, Significant figures
   (c) Section 2.3, Discrepancy
   (d) Section 2.7, Fractional uncertainties
   (e) Section 2.8, Significant figures and fractional uncertainties
   (f) Section 2.9, Multiplying two measured numbers
3. Chapter 3, Propagation of uncertanities
   (a) Section 3.1, Uncertainties in direct measurements
   (b) Section 3.2, Sums and differences; products and quotients
   (c) Section 3.3, Independent uncertainties in a sum
   (d) Section 3.4, More about independent uncertainties
   (e) Section 3.5, Arbitrary function of one variable
   (f) Section 3.6, Propagation step by step
   (g) Section 3.9, General formula for error propagation
4. Chapter 4, Statistical analysis of random uncertainties
   (a) Section 4.1, Random and systematic errors
   (b) Section 4.2, The mean and standard deviation
   (c) Section 4.3, The standard deviation as the uncertainty in a single measurement
   (d) Section 4.4, The standard deviation of the mean

5. Chapter 6, Rejection of data
    (a) Section 6.1, The problem of rejecting data
    (b) Section 6.2, Chauvenet's criterion

References

[1] The not so short guide to $\LaTeX 2_\varepsilon$, http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf

[2] Mittelbach, F. and Goosens, M. 2004 The LaTeX Companion: Tools and techniques for computer typesetting. Addison Wesley

[3] Taylor, J.R. 1982 An introduction to error analysis: the study of uncertainties in physical measurements. University Science Books