Unit 0: A Template for AME 332 Laboratory Reports

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January 30, 2002

Abstract

The abstract is the most important part of the report and should be carefully written. There must be only one abstract in the report; i.e. do not write separate abstracts for the individual experiments within the unit. The first sentence should summarize the entire experiment, as specifically as possible. The abstract should focus on results, including key quantitative results, e.g. a Reynolds number of 2310 ± 14.3 was observed for transition in the Reynolds' experiment. It should be written in a cold-blooded, clinical, and fact-laden style. Avoid use of first and second person, as well as to referring to yourself in the third person. Passive voice is acceptable; however, it is advisable to make the fluid phenomena the actor as much as possible in using the active voice, e.g. "The adverse pressure gradient induced the flow to separate." Both the abstract and report should not be a narrative of what you did, but should report on how the fluid behaved and explain why it behaved as it did. Look at some journal papers to see how abstracts are usually written. The reports must be concise and to the point. The objective is not to fill pages, but describe briefly what fluid mechanics you have learned from the experiment. The page limit on each unit report is **SIX**, and this limit along with the format outlined in this template must be strictly adhered to. Note that each experiment within the unit must be described in a separate section of the report as shown in the template. The page limit excludes this title and abstract page and the declaration page which must be attached at the end of the report without fail.

1 Title of first experiment in the unit

1.1 Introduction

In the introduction a statement of the problem must be given with an overview. You can give some details and general background on the experiment. *Do not*, however give a narrative description of the specific procedure for the laboratory. Focus here on more general issues and the underlying flow physics. Be concise. Avoid figures in this section. You do not have to repeat what is already mentioned in the handouts; you can reference what is there. Do not simply quote from books. References can be cited anywhere in the report as shown here, [1].

1.2 Experimental Method

You should include this section only to describe important and sometimes necessary deviations from standard laboratory procedure. In most reports, this section should be omitted, at least for AME 332, because of space limitations. In professional practice, however, a proper description of experimental method is important.

1.3 Results

This section will have your observations and results. You should also write the formulas that you may have used to do your calculations, even if they are mentioned in the handouts. For example the thrust generated by the propeller in Unit 5a is given by Eq. (1):

$$T = (p_2 - p_1)\,A, \tag{1}$$

where T is the thrust, p_1 is the pressure at the inlet, p_2 is the pressure at the outlet, and A is the cross-sectional area. Describe every variable used in the formulas and equations. You should incorporate punctuation into your equations as appropriate.

Plot data as points and then fit a curve through them to show a trend. Sometimes it is convenient to use a least square fit for your graph, at other times you can use a smooth curve drawn in a drawing program such as IslandDraw. Joining the data points with straight lines is bad practice; however, they must be clearly marked on the graph. In any case, do not submit hand-drawn figures. Fig. 1 is a plot of thrust, T, generated by a jet as a function of flow rate, Q, in Unit 5b. The symbols $*$ represent the data points obtained during the experiment while the solid curve is a least square fit of a second order polynomial to the data points. The least square fit was done using the POLYFIT function in MATLAB. The graphs must be labeled as exemplified in Fig. 1. Axes must be labeled properly with correct units. If there is more than one curve on the same plot, each curve must be labeled correctly using a legend box. Curve fits should be reported explicitly in either the figure itself, the caption, or the main text. Be careful to include units in the curve fits in the style shown in the figure heading.

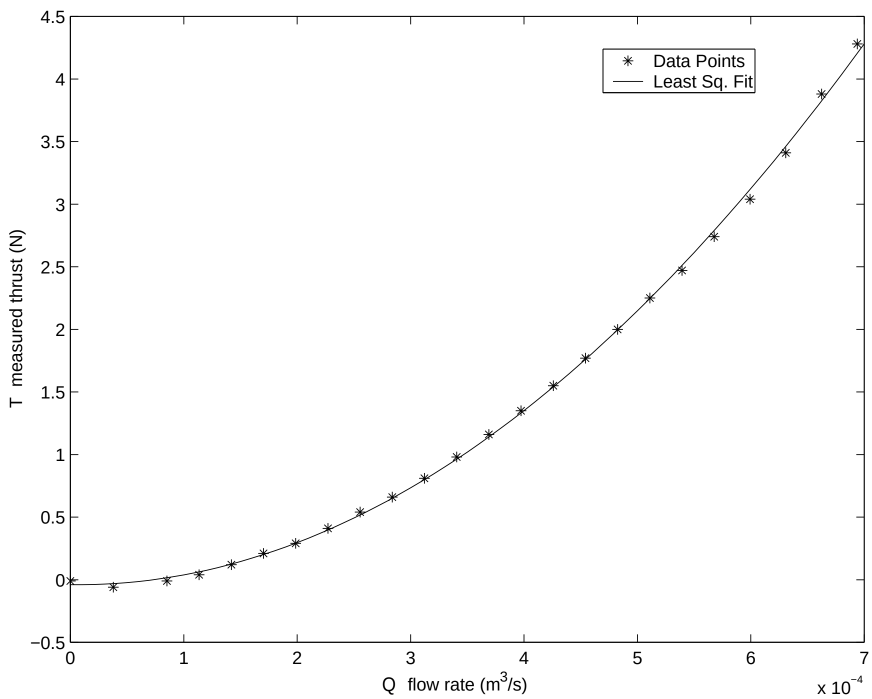

Figure 1: Jet: Thrust *vs.* flow rate. Curve fit of data: $T = \left(8.99 \times 10^6 \ \frac{N\ s^2}{m^6}\right) Q^2 - \left(1.19 \times 10^2 \ \frac{N\ s}{m^3}\right) Q - (3.94 \times 10^{-2}\ N)$.

Fig. 2 is another graph shown as an example. The first part is a plot for the free surface of water in solid-body rotation in Unit 1b. Note that Fig. 2 has both a least squares curve fit of the raw data plotted as well as a curve which came from an independent theoretical prediction. This approach can be very valuable in checking how well the theory fits the data. If appropriate, you should use semi-log or log-log plots, as they can reveal the trends much better for some data. Also powerful is a plot showing the *difference* between the theoretical predictions and the experimental observations as a function of some independent variable, *e.g.* the right half of Fig. 2.

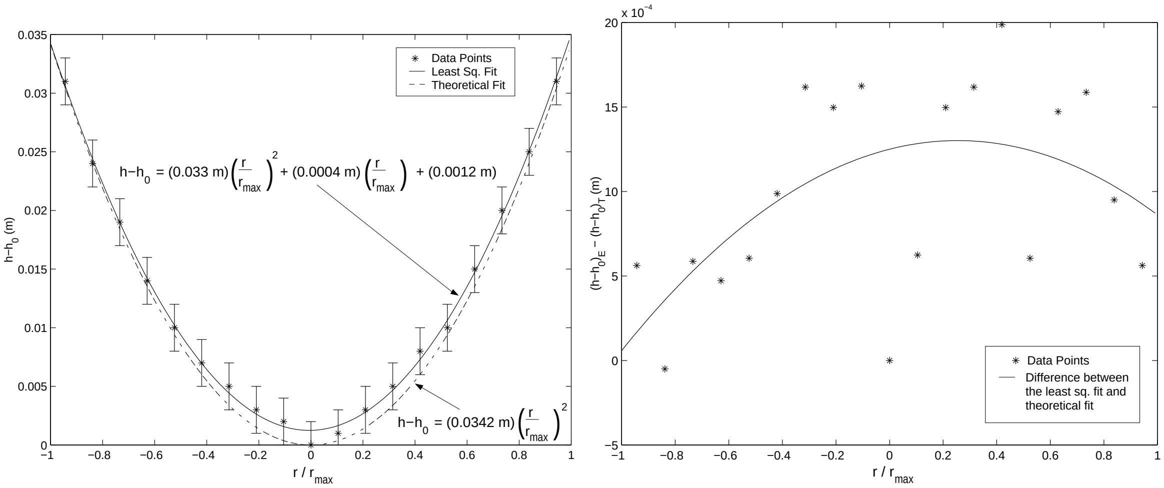

Figure 2: Free surface height *vs.* radial position; difference between theoretical prediction of free surface height and observed height.

A reasonable amount of data should be recorded during the experiment to show meaningful results. Bear in mind that more data points are usually required when the curvature of a curve is large. In nearly all cases, it is better to plot the data than to put it in a table. That way it is easier to see any trends in the data. There is no need to include raw data such as voltage readings you read from the meter. Convert to physically meaningful quantities before plotting. Be careful with units in your calculations. You have to be consistent with the units. For example in Fig. 1 it is not correct to plot thrust in Newtons against flow rate in Gallons per Minute. Use of SI or MKS units is strongly recommended.

Graphs must be large enough for the lettering to be legible. Graphs and figures must be embedded within the text and not attached at the end of the reports.

It is recommended that you decide what readings to take before starting the experiment. Make sure you go through the instructions and apparatus of the experiment carefully. Reading the theory in advance might give you an insight into what results to expect. Comparison between the experimental data and theoretical estimates is recommended. You may also include any qualitative observation you made during the experiment in this section.

1.4 Discussion

- An itemized discussion section is required as shown here.
- The comments should reflect your understanding of the experiment and subject matter. It should inform the reader of what was learned about fluid mechanics from the experiments.
- Creativity in interpreting the results (what do the data mean?) will be rewarded.
- Compare your experimental observations and those found in literature such as your text book [1], or other sources, perhaps from the archival literature [2]. Use the format provided in the reference section for books and articles. Be careful to give a full citation.
- Qualitative or quantitative analyses of the errors can be included here.
- Other factors that will be considered are: English (grammar, spelling, please spell check your text, technical use of language), adequate experimentation (minimum effort = minimum grade), accuracy of the results (sloppy measurements not acceptable).
- Do not use a smaller font to cram more text in your report. A font size of 12 points is required. Do not try to increase the size of the report to six pages by including irrelevant material. The *quality* of your comments and discussion is more important. A report of less than six pages is perfectly acceptable and points will not be taken off solely for that.

2 Title of second experiment in the unit

2.1 Introduction

Many introductions will be made here.

2.2 Experimental Method

This section is optional.

2.3 Results

Lots of results will go here. Here are some examples of equations. Equations can be embedded in the text like this: $y = mx + b$. Equations can be separated from the text like this:

$$y = ax^2 + bx + c,$$

or this

$$y = a \sin(\omega t) \,. \tag{2}$$

Here is an array of equations, which include many common mathematical symbols and operations

$$y = y_o \ln\left(\frac{t}{\tau}\right), \tag{3}$$

$$y = \int_0^x e^{-s^2}\, ds, \tag{4}$$

$$y = \frac{-b + \sqrt{b^2 - 4ac}}{2a}, \tag{5}$$

$$Q = \overline{V} A, \tag{6}$$

$$\nabla \cdot \mathbf{u} = 0, \qquad \text{mass} \tag{7}$$

$$\rho \frac{d\mathbf{u}}{dt} = -\nabla p + \mu \nabla^2 \mathbf{u} + \rho \mathbf{g}, \qquad \text{momenta} \tag{8}$$

$$\underbrace{\rho\left(\frac{\partial u_i}{\partial t} + u_i \frac{\partial u_j}{\partial x_i}\right)}_{\text{inertia}} = \underbrace{-\frac{\partial p}{\partial x_i} + \mu \frac{\partial^2 u_i}{\partial x_j^2}}_{\text{surface forces}} + \underbrace{\rho g_i}_{\text{body force}}, \tag{9}$$

$$Q = \int_A \mathbf{v} \cdot d\mathbf{A}, \tag{10}$$

x	y	z
0	1	2
4	5	6

$$\frac{u}{U} = \left(\frac{y}{\delta}\right)^{1/7}, \tag{11}$$

$$C_D = \frac{0.455}{(\log_{10} Re_L)^{2.58}} - \frac{1610}{Re_L}, \qquad 5 \times 10^5 < Re_L < 10^9, \tag{12}$$

$$c^2 = \left.\frac{\partial p}{\partial \rho}\right|_s \tag{13}$$

$$\text{curl} \times \text{grad}\phi = \nabla \times \nabla \phi = 0, \tag{14}$$

$$\boldsymbol{\Omega} = 5\,\frac{rad}{s}, \tag{15}$$

$$\mathcal{P}_{input} = \dot{m}\left[\frac{(V+\Delta V)^2}{2} - \frac{V^2}{2}\right], \tag{16}$$

$$\begin{pmatrix} 1 & 2 & 1 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} = \begin{pmatrix} 8 \\ 6 \\ 2 \end{pmatrix}, \tag{17}$$

$$\delta_{ij} = \begin{cases} 0, & i \neq j, \\ 1, & i = j \end{cases}, \tag{18}$$

$$\frac{\tilde{u}}{u_*} = 2.5 \ln \frac{y u_*}{\nu} + 5.0. \tag{19}$$

Here is a table

2.4 Discussion

Lots of discussion will appear here.

References

[1] Fox, R. W., and McDonald, A. T., 1998, *Introduction to fluid mechanics*, John Wiley and Sons, Inc., New York, pp. 234-236.

[2] Rockwell, D., 1998, "Vortex-body interactions," *Annual review of fluid mechanics*, Vol. 30, pp. 199-229.

Declaration

By signing this I declare the following:

- The experiment was performed and the data taken with [put co-worker's name here, if applicable]. I may have had discussions with others, but everything else reported here (like calculations, figures and text) is my own, unless explicitly indicated.
- All reasonable safety precautions were taken in the laboratory.
- Experiments were conducted in accordance with the laboratory rules:
  - There were two or more persons present in the laboratory during the experiments.
  - I have signed the laboratory register logging in and out.
  - The experimental equipment was left essentially as I found it. It was either in working order or any malfunction was reported to the staff. Tools used were returned to their places.

Signed

Sign your name here

Type your name here