



To: Students in Mechanical Engineering Classes with Report Writing Requirements  
From: Professor Peter Avitabile  
Date: 3 September 2003  
RE: Report Writing Tips & Guidelines & Common Mistakes Encountered

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Technical writing is a difficult, but very important task that must be mastered. There are two types of reports that are generally required in the Mechanical Engineering Curriculum:

- 1) the short memo report
- 2) the long formal report

Both of these have similar sections but are also very different in several regards. Before the report formats are outlined, there are several general aspects of writing and presentation that need to be presented. These are the use of references, equations, tables, plots, figures and common editorial mistakes made.

## **REFERENCES**

References are generally listed by Author, Publication, date (or other detailed information). The references are made in the main body of the text, starting with the number 1, and enclosed in brackets [ ]. Notice that in the example below that the first reference is made with the author's name whereas in the second case just the reference number is included in the text – both are acceptable variations.

As an example .....

As stated in Wheeler and Ganji [1], digital sampling must occur greater than twice the maximum frequency of interest when performing the FFT [2]. This is true for frequency domain representations of data. However, the sampling for collecting raw time data must be in excess of 10 to 20 times the maximum frequency of interest [3] when the data to be collected is only to be used for time representations.

and at the end of the report .....

### References

1. Wheeler, A.J. Ganji, A.R. "Introduction to Engineering Experimentation, 1<sup>st</sup> Edition, Prentice-Hall, New Jersey, ISBN 0-13-337411-4.
2. Cooley, J.W. & Tukey, J.W., "An Algorithm for Machine Computation of Complex Fourier Series", Math. of Comp., 1965, 19(90), pp 297-301.
3. Avitabile, P., "Basics of Spectrum Analysis/Measurements and the FFT Analyzer", UMASS Lowell Class Notes for ME 22.403, Spectrum Analysis 082702



## EQUATIONS

Equations should be prepared with an Equation Editor and should contain the proper use of superscripts and subscripts and matrix/vector notation as needed. In the text, the equations should be numbered, starting with the number 1, when referenced and enclosed in parentheses ( ). The equation itself should generally be on a separate line with the equation number to the right of the equation (and preferably right justified). Some examples of equations are shown below for reference.

$$\{y\} = [\{x\} \quad \{1\}] \begin{Bmatrix} a \\ b \end{Bmatrix} = [\text{coef}] \begin{Bmatrix} a \\ b \end{Bmatrix} \quad (1)$$

$$\text{SLOPE} = \frac{dy}{dx} = \frac{\Delta y}{\Delta x} = \frac{y_{i+1} - y_{i-1}}{x_{i+1} - x_{i-1}} \quad (2)$$

## TABLES

Tables are an orderly, organized presentation of data. The table will generally contain several columns of data that is organized with a label at the top of each column. Although not necessary, the table may contain borders and lines separating various parts of the data. A table label is always presented at the top of the table – not at the bottom. Tables are referenced in the main body of the document before the table is reached in the document. A sample table is shown below.

Table 1: Strain Gage Data Collected for Loading and Unloading Beam

Weight	Down mV	Up mV	Down uStrain	Up UStrain
47.8	4.5	7.3	42.37	68.74
147.8	13.0	16.5	122.41	155.37
247.8	22.0	25.6	207.16	241.05
347.8	31.1	34.7	292.84	326.74
447.8	40.1	43.8	377.59	412.43
547.8	49.3	48.4	464.22	455.74
647.8	58.2	58.5	548.02	550.85
747.8	67.2	67.5	632.77	635.59
847.8	76.2	76.5	717.51	720.34
947.8	85.2	85.2	802.26	802.26

## PLOTS & FIGURES

Plots and figures are an important part of presentation of material. In general, the plots should always completely stand-alone. That means that there should be a sufficient amount of material to completely describe the plot independent of the text in the document; the reader should be able to interpret most of the plot without having to read the text associated with the plot.

All plots must have axes labeled (with appropriate units when necessary). The plot needs to have a legend if multiple lines exist on the plot. The plot also must have a label to describe the plot. Since plots may be copied, it is important to be able to view the plot in black & white – even though it was originally prepared in color. The scales in the plots should consist of a reasonable numbering scheme. The data should be printed on a scale to best represent the data. The data should be the main focus of the plot and should use “white space” effectively. A sample plot showing proper format is presented below for reference. (Note that the plot below does not satisfy the B&W requirement.) Do not make sloppy plots – this is a sure way to lose valuable points on reports. (Appendix A contains a set of plots that have been submitted in previous years that clearly show poorly constructed plots – plots of this type are guaranteed to cause loss of points on project reports.)

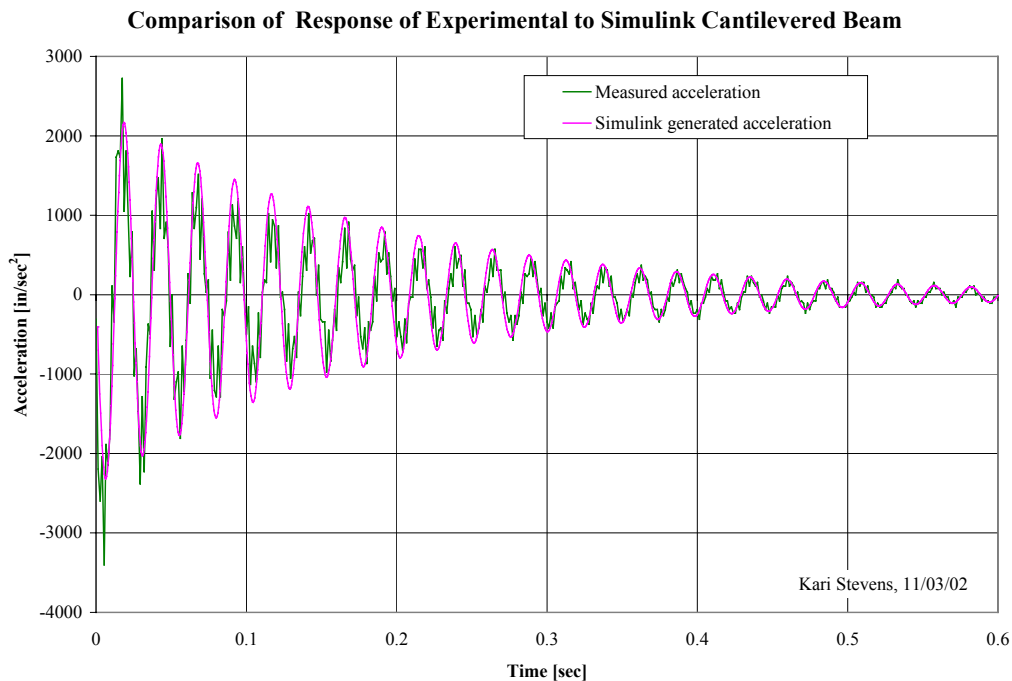


Figure 1: Comparison of Analytically Derived Cantilever Response and Laboratory Measured Response



## **EDITORIAL BLUNDERS**

There are many common editorial blunders that are typically made in writing reports that need to be avoided. Appendix B contains a list of some of the common blunders. (This list is a compilation of editorial mistakes from several sources and there may be similar statements in various sections.)

## **REPORT FORMATS**

While there may be some variation (due to individual or course preference), the basic parts of a short memo report and a long formal report are identified below. Each of the different sections are described in the following sections.

### Short Memo Report

Introduction  
Discussion of Procedures or Methods Used  
Results Obtained and Analysis Performed  
Summary/Conclusions/Recommendations  
References  
Appendices

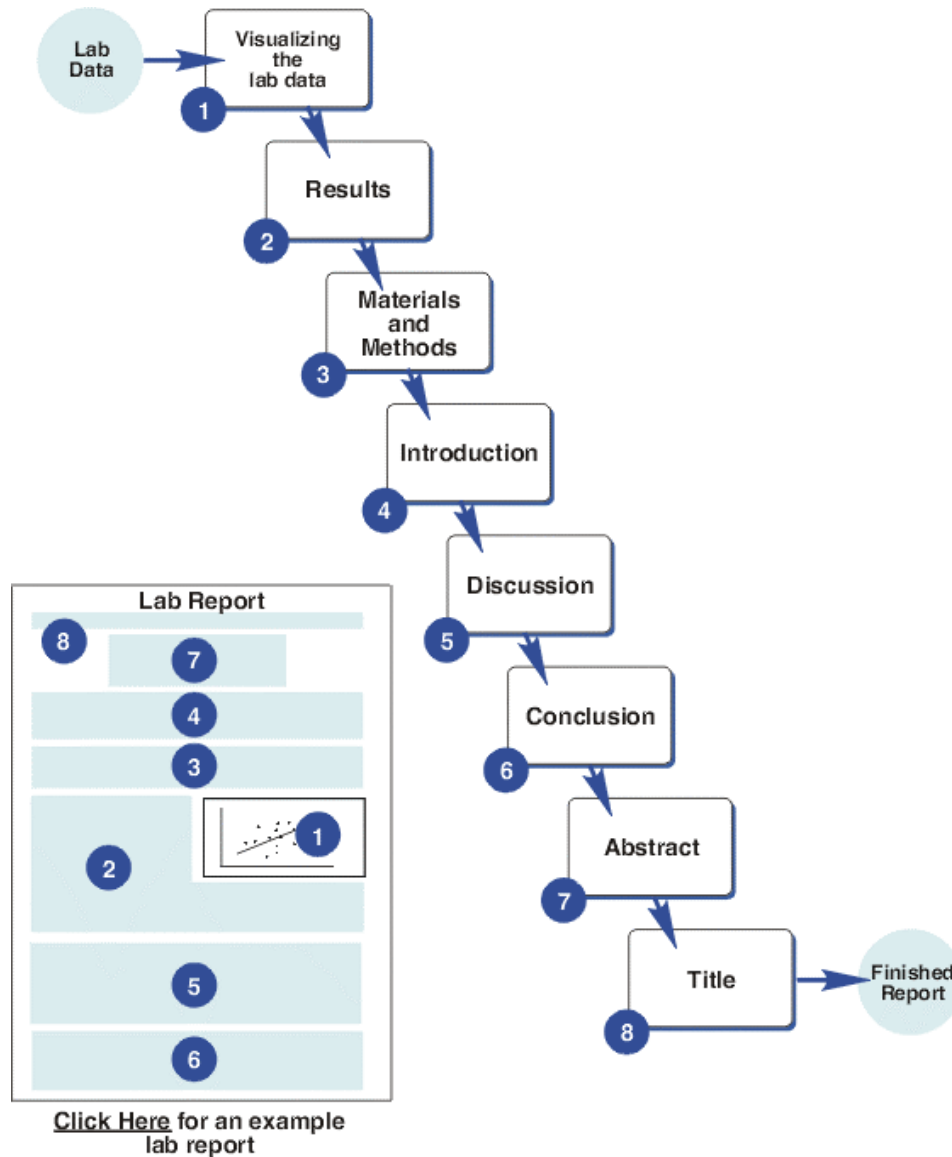
### Long Formal Report

Abstract  
Table of Contents  
Introduction  
Theory/Literature Review  
Discussion of Procedures or Methods Used  
Results Obtained and Analysis Performed  
Summary/Conclusions/Recommendations  
References  
Appendices

An important item to realize is that a reader will typically not read your document in the order in which the topics are presented above. For instance, a long format report might be read in the following order.

First, the Abstract will be read. The reader wants to determine if the subject matter is of interest. Second, if the reader is interested, the next section to be read might be the Summary or Conclusions. The reader is likely trying to determine if this is something new and of interest or something that the reader is familiar with. Third, if the reader is interested, either the Introduction or Theory section will be reviewed next. The reader is now interested and is starting to determine additional information in greater depth. If the reader is still interested, then the balance of the report will be read. But note that the reader may not ever look at the appendices. The appendices will be reviewed if there is detail that is not clearly described in the report or if there are omissions or other anomalies that the reader needs to clarify.

Now realizing how a reader may review a report, the actual development of the report is quite different (and in most cases is the reverse order of how the report is actually read. While a report can be generated in any order, there is an advantage to developing the report as shown in the schematic below. This enables the logical flow of how data is collected, processed and formulated into the laboratory report. While the diagram was obtained from [www.ncsu.edu/labwrite](http://www.ncsu.edu/labwrite) which had an excellent description of the development of a laboratory report, that web site may not exist any longer.





## **BRIEF DESCRIPTION OF REPORT SECTIONS**

The following sections give a very brief description of each section typically found in a report. (NOTE: In this first edition only a very brief description is given. This will be expanded in future revisions of this document to give more detailed information.)

### Abstract

The abstract is a summary of the entire project or experiment. The purpose is to provide readers with a quick condensation, highlighting the important points. This allows the reader to decide if the particular report is worth reading at the present time. Note that specific results are not reported in the abstract nor are there any reference to specific references in this section.

### Table of Contents

The table of contents lists the various sections of the report in logical order. This section also contains a list of all figures and tables in the report.

### Introduction

The introduction is a section that presents the problem at hand. What is the purpose of the analysis or experiment. Many times the introduction presents what others have done in the area of concern, what has and has not worked well; references to previous work is appropriate in this section. The introduction leads the reader up to the point of the current work that is being considered to improve, correct or rectify approaches taken by others.

### Theory/Literature Review

This section identifies the methodology upon which the analysis or experiment is based. This may identify the work of others as well as newly developed techniques, approaches or theories.

### Discussion of Procedures/Methods Used

The procedures and/or methods used contains exactly that. This section should briefly describe the approach taken. There should not be detailed extreme depth in procedures used or analyses performed. Long excessive detail will generally bore the reader. This type of detail is best provided in an appendix. Only the important features of the procedure or method used need be described.



### Results Obtained and Analyses Performed

This section identifies the actual results obtained or analyses performed. Again, excessive detail should be placed in an appendix. Only the important information necessary for the reader to understand, in general, what has been observed is necessary. The details, if needed, can be viewed in the appendix.

### Summary/Conclusions/Recommendations

This section may be just the summary or just the conclusions or just the recommendations or combinations thereof. It depends on the particular report and the end goal of the report. However, this section(s) must answer questions that were posed in the introduction. While summary and conclusion statements are typical in most reports, the recommendations is a critical part of many reports. The recommendations help the reader to determine what, if anything, should be done in the future to improve on the procedures or methods used. Another important item is that the Summary/Conclusion should never introduce information that has not been presented in the body of the report.

### References/Bibliography

The references and/or bibliography should be complete and follow proper literary formats. The references need to all be referenced from the main body of the report.

### Appendices

The appendices contain logically grouped sections that contain significant detail so the reader can probe further into the data or analyses performed. The appendices may also contain large sets of tabular data, detailed computer output results, detailed procedures utilized, etc.

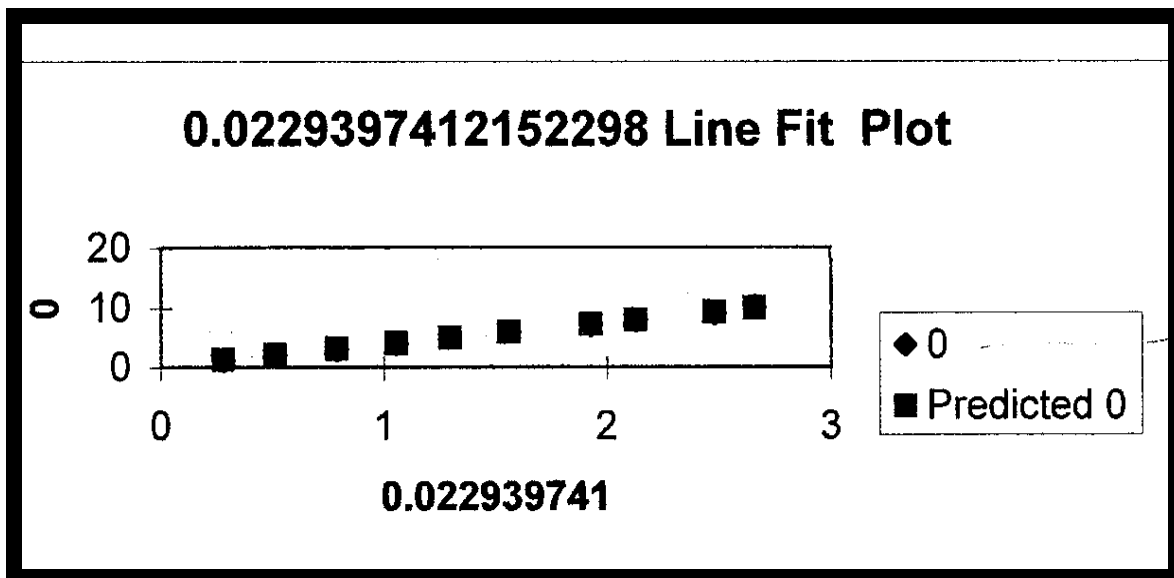
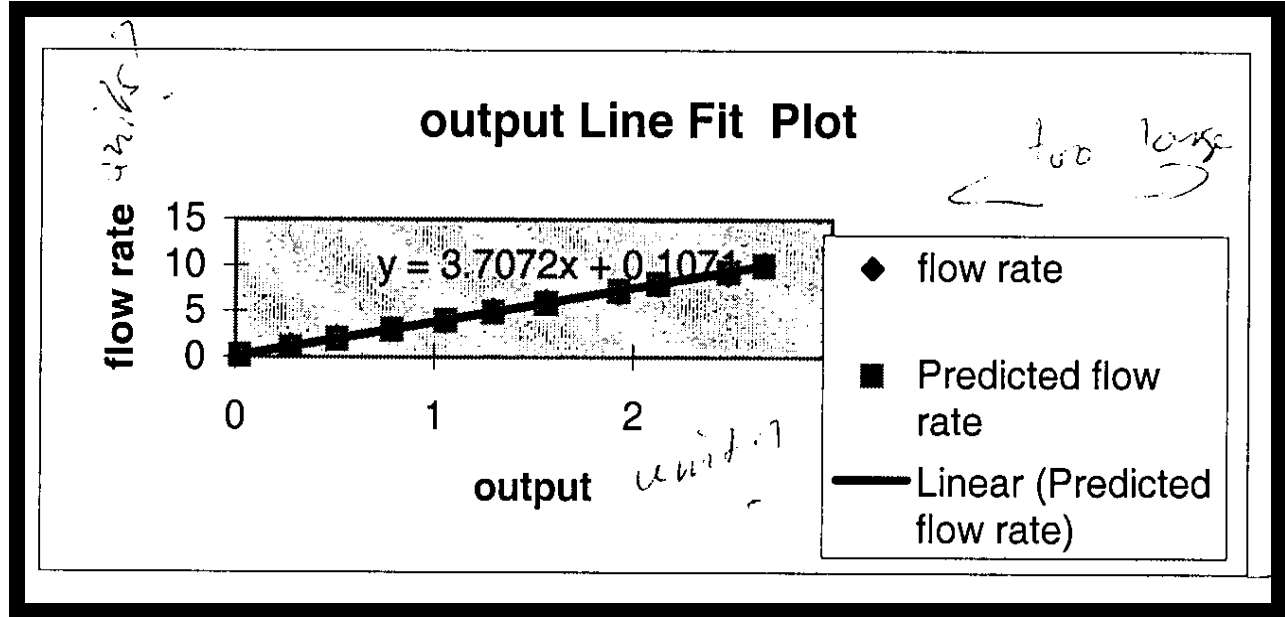


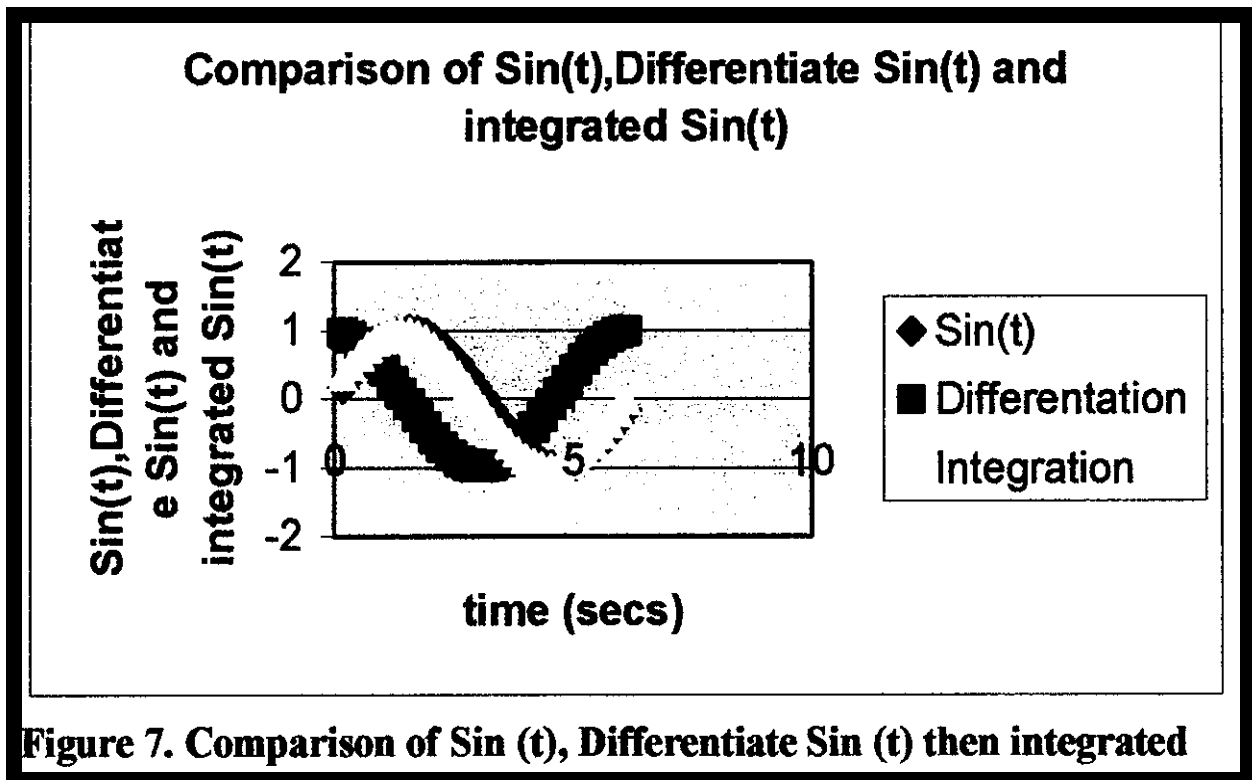
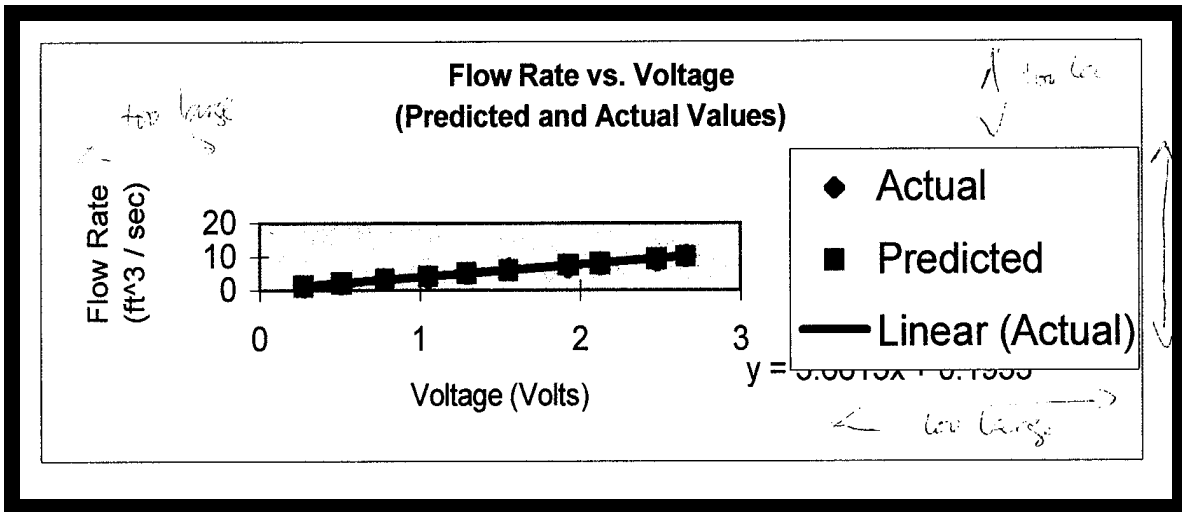
## APPENDIX A

### SOME POORLY CONSTRUCTED PLOTS

(from previous classes)







**Figure 7. Comparison of Sin (t), Differentiate Sin (t) then integrated**



## APPENDIX B

### LIST OF SOME COMMON EDITORIAL BLUNDERS AND HELPFUL INFORMATION

(from various sources)



## Things not to do in a Technical memo or report

- Do not use 1<sup>st</sup> person (I, we, me, us) – use a passive tense
- Do not run sentences on and on – more shorter sentences are better
- Do not use 100 words when 10 will do
- Do not use “This” as the subject of a sentence
- Do not editorialize or insert opinions
- Do not use “since” when you mean “because”. “Since” implies temporal dependence.
- Do not end a sentence with a hanging preposition
- Figures and tables should not appear on a page before they are referenced in the text of the report, i.e. do not put figure on page 6 and not talk about it until page 7 or later. Figure can be discussed on page 7 and not show up until the next page or later, but preferably the next page at the latest.
- Do not use contractions—e.g. can’t and don’t
- Never start a sentence with a variable
- Do not use it’s (= it is) when you mean the possessive of it (= its)

## Things to do in a Technical memo or report

- Keep your discussion brief and to the point.
- Number figures consecutively, e.g. Fig. 1, Fig.2, and so on (the same is true for references)
- Any figure that you include in your report should be cited in the body of the report. If you do not discuss the figure, then why is it in your report?
- Use short clear sentences
- Tell what “This” is, e.g. “This graph”
- Know the meaning of the words that you use – precision and accuracy are not the same thing
- Use a comma between the two sentences in a compound sentence
- Use a comma at the end of an introductory prepositional phrase
- Hyphenate compound modifiers, e.g. two 30-KN load cells vs. 30 KN load cells
- Use a table to summarize data. Burying a lot of results amongst a paragraph is confusing. A table lays it all in plain sight.
- Label graphs appropriately, make them a reasonable size and do not use bastard scales
- Use a leading zero in numbers—e.g. **0.1234** as opposed to simply **.1234**
- Number references and refer to them by number in the body of the report
- Cite references and give appropriate credit where it is warranted
- Include page numbers
- The word “data” is plural, so it takes a plural verb—e.g. “the data are in agreement”
- Avoid using “in order to”—it is wordy
- Use superscripts and subscripts as needed—e.g.  $10^3$  – not  $10^3$ , or  $A_x$  – not  $Ax$
- Either indent new paragraphs or skip a line without indenting, but do not do both
- Do leave a space between a dimension and its units – e.g. 10 ft – not 10ft.
- Figures are always cited at the bottom of the figure whereas tables are cited at the top



### Common Editorial Mistakes (excerpted/edited from Los Alamos Dynamics Summer School)

- Make sure all tables, figures and references are referred to in the main text. These figures should be placed after the paragraph where they are first mentioned
- Do not start a sentence with "This" and then omit the subject.
  - EXAMPLE:
    - "This can be the result of energy dissipation within the material." should read:
    - "This observed response can be the result of energy dissipation within the material."
- Figures must reproduce in black and white.
- Proper use of "Since" and "Because". Since should refer to time, e.g., "Since the founding of our nation..."
- Misuse of since: "Since the mode shapes corresponding to this frequency indicated that Mass 2 experienced the greatest motion, ..." in this example 'Since' should be replaced with 'Because'.
- All graphs must have their axes labeled and the units identified.
- The word "data" is plural. "The data that was collected..." should read, "The data that were collected..."
- Repetitive use of the same word or word form in a sentence. "The floor plates were modeled with shell elements with material properties of aluminum." should read, "The floor plates were modeled with shell elements using aluminum material properties."
- Keep sentence structure as simple as possible. If possible avoid using hyphens, semi-colons and parentheses.
- Consistent number of significant digits. In the following table, mode 1 resonant frequency is reported to 3 significant digits, while the higher resonant frequencies are reported to 5 significant digits. This implies that the higher resonant frequencies can be estimated with much greater accuracy. Note that it may require a detailed statistical analysis to determine just how many significant digits can accurately be reported.

# Memorandum

**To:** 22.296 Students  
**From:** Julie Chen  
**Date:** Fall 2001  
**Re:** Full Lab Report Format

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In this course there will be two types of lab reports – a full report and a short memo report. Each group is responsible for submitting a single report. The very last report of the semester will be an individual report. Therefore, while it is often efficient for one person to “specialize” in the Excel plots, it is important that each person in the group be familiar with all aspects of the report – background, figures, plots, analysis, etc.

The following should be used a guideline for the full lab reports. There are many ways to format a technical report. However, the general content is the same in all cases. For this course, please follow the format specified here. The report should have a memo heading as seen above, with all members of the group contributing to the report and the “lead” engineer identified, along with the title of the lab report. The “lead” engineer is responsible for reviewing the report in its final form. This responsibility should be shared equally among the group members throughout the semester.

The report should contain each of the following sections, numbered, and in order.

## **1.0 Introduction**

This section should briefly explain to the reader the purpose of the report and should briefly outline the content of the rest of the report. For example, for the hardness report, the introduction should briefly explain what hardness is (the details should be provided in the Background or Brief Review... section), why it is important, and what is contained in the report. Below is a short example:

Hardness is a measure of how resistant the surface of a material is to localized plastic deformation. The hardness of a material can affect how resistant it is to wear, how easy it is to machine, and often can also be directly related to strength. This report presents the results of an experiment involving Rockwell and Brinell hardness tests on various types of materials – steel, aluminum, and plastic (Delrin). A comparison is made of the two common hardness techniques; in addition, an evaluation is made of the applicability of an expression used to relate Brinell hardness to strength for steel.

## 2.0 Brief review of literature and theory

This section should explain any qualitative definitions or descriptions of the mechanism or theory being studied. Any equations used to analyze the data should be presented and explained in this section. Label all equations with equation numbers and use this to refer to them in the text -- i.e., In Equation 2, the relationship between strength and Brinell number is linear. In general, this section should contain *your interpretation* of the relevant sections from the lab handout (i.e., this should be *in your own words....DO NOT simply copy sections of the lab handout into your lab report*)

## 3.0 Detailed description of experimental procedure

This section should clearly describe the equipment used, the specimens tested (e.g., material, dimensions), and the procedure.

For example, for the hardness lab, this section should include the type of machine used (e.g., Instron/Wilson Rockwell Hardness Tester Model 3456), the type of indenter and minor/major loads, and the types of specimens (steel block, aluminum block, Delrin (plastic) block). The procedure can either be a step-by-step description or in paragraph form, but it should be relatively detailed.

For example, for the Brinell hardness tests, the procedure should read something like this:

### 3.1 Brinell Hardness Test

For the Brinell hardness tests, the block was placed in the tester and was raised until it just touched the surface of the 10mm spherical indenter. Care was taken to locate the indenter away from the edges and away from any other indentations. The load was set on the machine to 500 lb by adjusting the air pressure valve. Once the load on the dial gauge was stable, the black knob on the left side of the machine was pulled out, causing the load to be applied to the material. After about 15 seconds, the knob is pushed back in and the block is lowered. Measurements were taken of the diameter of the indentation using a set of calipers. Three separate indentations were made on the same block for each type of material.

### 3.2 Rockwell Hardness Test

## 4.0 Observations

This section should include any observations made of the specimen, material behavior, test procedure, etc. during the experiment.

In the Rockwell hardness tests, there appeared to be some sensitivity to which side of the block was tested. Measurements taken on the same side and near the same location were in good agreement with each other. However, measurements taken on different sides of the block seemed to exhibit greater differences. As the plastic material was significantly softer

than the steel, the scale was switched to the superficial Rockwell 15T scale (see section 3.0). At this lower major load (15 kg), the depth of penetration appeared to be approximately the same as for the steel at a major load of 100 kg. In general, the Rockwell test took slightly longer than the Brinell test, but did not require an additional measurement and calculation step.

## 5.0 Analysis of experimental results (application of theory)

This section should include all of the data collected in tabular form, tables summarizing the calculations, and plots showing trends. Plots should have clear labels for the x and y axes, including UNITS! Also, think about how many significant figures are appropriate. Explain how the results were obtained. Think about the best way to present the data so that it relates to the discussion (e.g., x-y plot, bar chart). Make sure your results make sense!

Table 1. Tensile Strengths of Wires

Specimen	Max. Load (lb)	Ult Strength (ksi)
A	100	23
B	45	43

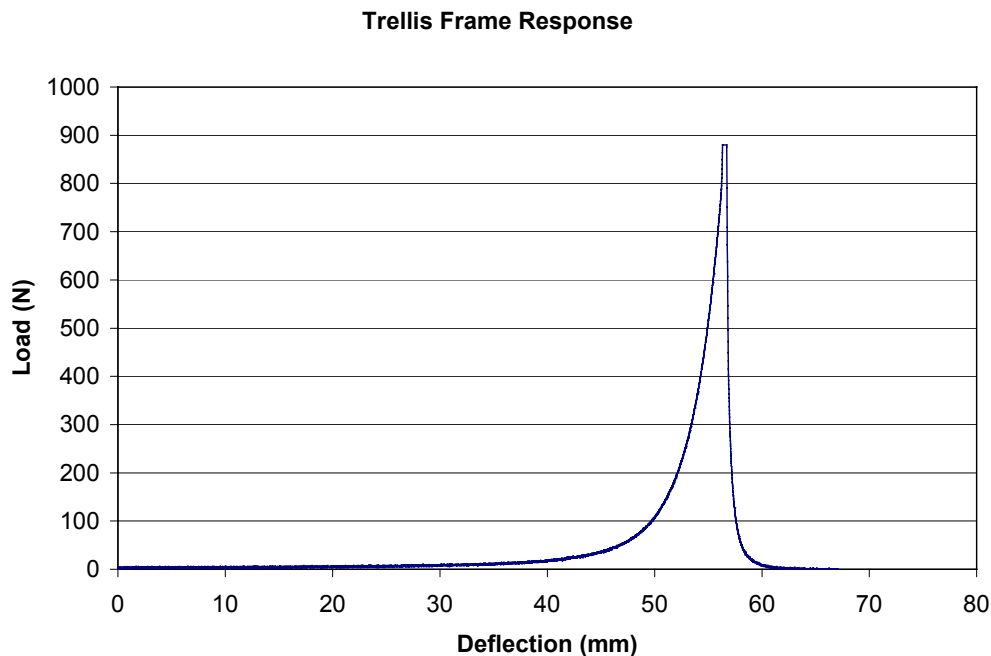


Figure 1. Load-Deflection Response of Plain-Weave Fabric in Shear at Room Temperature.

Be sure to label all tables and figures. The figure labels should be descriptive of the purpose of the plot, not simply a repetition of the axis labels. For example, the figure label shown for Figure 1 is much more descriptive than simply “Load-Deflection Curve”. Also, all tables and figures should be referred to directly in the text.

For example:



In Figure 1, the values for the Brinell hardness numbers were determined by using the diameters measured (see Table 1) and Equation 1.

## **6.0 Answers to questions posed**

Show equations used to determine answers. Try to explain your reasoning as clearly as possible. Think about why these questions have been posed – i.e., what is the important point being made?

## **7.0 Discussion of applicability of theory, experimental approach (this section may be combined as part of Section 5.0, but make it clear that you are doing so)**

This section should be where comprehension of what happened in the lab is demonstrated. As such, it is one of the most important sections of the report. Be sure to directly address what each of the plots shows. It is also a good idea to address the major points that the post-lab questions are trying to make, as well as addressing the “objectives” listed in the lab handout. One good guideline is to make sure you refer directly to each of the figures in the report. For example,

In Figure 2, a comparison is made between the strength predicted by Equation 2 based on the Brinell hardness values of the steel, aluminum, and Delrin. As can be seen from the plot, this equation provides a good fit for steel, but is off by 10% for the aluminum and more than 30% for the Delrin. Thus, Equation 2 should not be used for materials other than steel.

In Figure 1, we see that the Brinell number does not increase linearly with increasing indentation diameter for a given material tested using the Brinell tester. This is expected, as in Equation 1 the diameter and Brinell number are not linearly related. Similarly, the indentation load and indentation diameter also do not seem to be linearly related. While the exact relationship between these two is not covered in this report, this is not unexpected; an increase in indentation diameter when the ball is first penetrating the material requires much less deformation of material than when the penetration of the indenter ball is closer to a hemisphere (see sketch in Figure 4).

## **8.0 Conclusions and recommendations**

This section should briefly summarize the key points of the report. For example,

In this experiment, two different methods for hardness testing were examined – Rockwell and Brinell. The Rockwell test has the advantage of a wide range of scales that can be selected according to the expected hardness range of the material. In addition, the Rockwell test directly generates the desired “hardness number”, while the Brinell involves additional measurement and calculation. For the Brinell test, however, an expression has been developed for steel, directly relating Brinell number and strength. The results from this experiment indicate that this equation should not be used for other materials.

The hardness test is a quick and relatively simple method for comparing the surface properties of various materials. However, caution must be exercised when attempting to convert the hardness number to strength and when testing to reduce the effect of surface conditions on the number obtained.

Recommendations for improving the lab: Accuracy of the diameter measurement was limited by the need to “eyeball” a measurement with the calipers. It would be helpful to have a more accurate way to measure the indentation diameter.

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Other notes about technical reports:

- In general, technical reports are written in the passive voice, rather than using “I” or “we”.
- It is often useful to refer to a plot or information from another source (e.g., textbook, lab handout, other reference). This is fine to include in your lab report, but you must give credit to the original source. Use references in this case.

The relationship between the Rockwell B and Brinell numbers for Steel is shown in Figure 4 [2].

At end of report....

#### REFERENCES

- [1] Chapman, M., Materials Science, J.Wiley & Sons, New York, 1997.
- [2] ASTM Standards, E140, “Hardness values for metals”
- [3] Sonderburg, C., “Measurement of Hardness of Plastics,” *Journal of Polymer Science*, Vol. 10, No.2, pp.102-110, 1996.

Date: 23 October 2000

To: Patrick Drane

Cc: Professor J. Sherwood, Professor P. Avitabile

From: Joe Student

RE: Lab #SAMPLE -- Introduction to MATLAB and MATHCAD

## Overview

The purpose of this memo is to report the results from Lab #SAMPLE. Some simple equations from Chapter 4 of Design of Machinery, 2<sup>nd</sup> Ed, by R.L.Norton [1] are evaluated using MATLAB [2], MATHCAD [3] and hand calculations.

## Discussion

Chapter 4 of Ref. 1 identifies several equations regarding the analysis of four bar linkages. In particular, the relative angle of  $\theta_3$  (angle of coupler with respect to the x-axis), based on given values of  $\theta_2$  (angle of crank relative to the x-axis), is to be computed. Figure 1 shows the linkage for reference (Figure 4-6 on page 154 of Design of Machinery, 2<sup>nd</sup> Ed, by R.L.Norton).

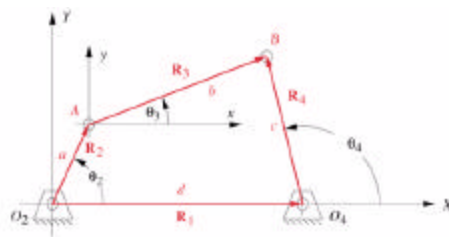


FIGURE 4-6  
Position vector loop for a fourbar linkage

Figure 1 – Linkage Configuration

Equation 4.13 from Ref. 1 is given as:

$$\theta_{3(1,2)} = 2 \arctan \left( \frac{-E \pm \sqrt{E^2 - 4DF}}{2D} \right) \quad (1)$$

where D, E and F as well as other related terms are defined by Equations 4.8a, 4.11b, and 4.12 in Ref.1. Additional notation for these equations is shown in Figure 1.

Background material regarding the use of MATLAB and MATHCAD is contained in Ref. 4 and 5, respectively. These two documents contain descriptions on the use of these two software packages. Both MATLAB and MATHCAD are used to compute equation (1); these results are compared to hand calculations.



The calculations performed using MATLAB are contained in Appendix A included with this memo report. Likewise, the calculations performed using MATHCAD are contained in Appendix B. The detailed hand calculations that were performed are contained in Appendix C. The calculations were performed for input  $\theta_2$  with values of  $0^0$ ,  $45^0$  and  $90^0$ . Due to the nature of the solution in Equation (1), only one of the roots was used for the evaluation of  $\theta_3$ . However, if other angles were to be considered, then additional logic would need to be included in the MATLAB and MATHCAD evaluations to handle the two potential roots that result. All the calculations yielded the same position information; this is summarized in Table 1.

Table 1 – Comparison of Results Four Bar Linkage (a=2, b=5, c=2, d=5)

	$\theta_2$	$\theta_3$
MATLAB	0	0
MATHCAD	45	0
Hand Calculations	90	0

### Conclusions

Results of the analysis required in Lab #SAMPLE were presented. The results of MATLAB and MATHCAD were compared to hand calculations performed. All techniques utilized had the same results, as anticipated, for this simple evaluation.

### References

- 1) Design of Machinery, New Media Edition, 2<sup>nd</sup> Ed, by R.L.Norton, ISBN 0-07-237960-X
- 2) MATLAB, Version 5.3, Math Works, Inc., Natick, Massachusetts
- 3) MATHCAD, Version 2000, Math Soft, Inc, Cambridge, Massachusetts
- 4) 22.321 MATLAB Software Usage, Rev 090900, notes provided in class
- 5) 22.321 MATHCAD Software Usage, Rev 090900, notes provided in class

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Authors Note (which is not part of this report)

The write-up presented above is not intended to be the complete memo report required in Assignment #1. This should be clearly noted because this demonstration assignment has been labeled as Lab #SAMPLE. This write-up is intended to present the style guide for what is expected in memo reports and is provided for reference only.



To: Professor Charmchi Date: 31 January 2001  
From: Professor Avitabile  
Subject: Sample Report – Evaluation of MATLAB Least Squares Best Fit of Data

**ABSTRACT**

Linear regression tools available in Microsoft’s Excel enable the determination of parameters that best describe a set of measured data. These tools greatly assist in the development of a mathematical model to describe physical phenomena measured in the laboratory. Linear algebra tools also provide the same analysis capabilities. The results of both of these techniques for a common set of data are investigated and compared.

**DISCUSSION**

Laboratory Exercise #1 involving Numerical Methods [1] was performed as one of the first laboratory assignments. That exercise used Microsoft’s Excel to process a set of data provided. The results of that laboratory was submitted in a brief report [2]; the details and results of that analysis are not provided herein. The linear regression analysis performed as part of that study yielded an approximation of the linear curve that best describes that data. The resulting equation that was obtained from Excel was

$$y = mx + b = 0.2693 * x - 0.0268 \tag{1}$$

In MATLAB, the same regression analysis can be performed using a linear algebra formulation. Recall that the basic equation describing the data can be written for several data point as

$$\begin{aligned} y_1 &= ax_1 + b \\ y_2 &= ax_2 + b \\ y_3 &= ax_3 + b \\ &\vdots \end{aligned} \tag{2}$$

which can be cast in matrix form as

$$\{y\} = \begin{bmatrix} \{x\} & \{1\} \end{bmatrix} \begin{Bmatrix} a \\ b \end{Bmatrix} = [coef] \begin{Bmatrix} a \\ b \end{Bmatrix} \tag{3}$$

The solution of this non-square matrix can be obtained by the premultiplying the transpose of the coefficient matrix to form a square matrix which can then be inverted using the standard inverse; this is commonly referred to as the pseudo-inverse

$$\begin{Bmatrix} a \\ b \end{Bmatrix} = \left[ [coef]^T [coef] \right]^{-1} [coef]^T \{y\} \tag{4}$$

This equation can be used to determine the parameters “a” and “b” ; these are the slope and y-intercept, respectively, for the equation of a straight line shown in equation (1).



## NUMERICAL EVALUATION

Using equation (4), a simple script file was developed for MATLAB. The data was obtained from [1] for data case used in the regression analysis labeled as “LAB-1A.XLS”. The detailed evaluation of the data for this least squares best fit is contained in Appendix A. From the MATLAB analysis, the parameters “a” and “b” were determined. Table 1 shows the comparison of the Excel and MATLAB results. Since the underlying equations are essentially the same, the results of Excel and MATLAB are not different, as expected. A plot of the fit along with the data collected is shown in Figure 1.

Table 1 – Comparison of Excel and MATLAB Best Fit Results

	Excel	MATLAB
Slope	0.2693	0.2693
Y- Intercept	-0.0268	-0.0268

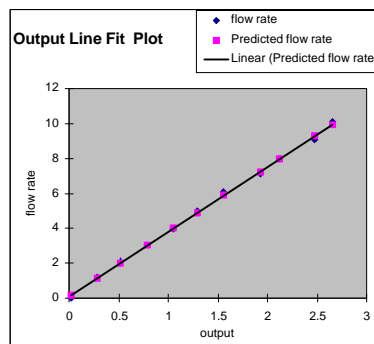


Figure 1 – Least Squares Fit of Flow Rate Data for Model XYZ  
(ED Note: this is sample data and is included for demonstration only)

## CONCLUSION

The results of the linear regression analysis using Excel were compared to the results using a linear algebra formulation using MATLAB. The results compared favorably. This enables an alternate method for assessing and evaluating data collected in the laboratory. This also serves as a check to assure that reasonable and accurate results are obtained from the analyses performed using Excel.

## REFERENCES

- 1 ME22.302 - Laboratory Exercise #1 – Numerical Methods – Spring 2001
- 2 Avitabile, P., Laboratory Report 22032-1 “Evaluation of Numerical Methods using Excel”, dated 31 January 2001



**APPENDIX A – Details of the Evaluation of the Data Set “LAB1A.XLS” using MATLAB**

In order to perform the least squares best fit of data using MATLAB, several steps are necessary in order to provide the data in the correct form. In MATLAB, enter the dependent variable {y} into a vector. Enter the independent variable {x} into a vector; also create another vector containing ones (1) for the number of equations to be solved. Create the coefficient matrix in MATLAB and solve the set of equations using MATLAB. The script to perform these steps (with the data from “LAB-1A.XLS”) is shown below

```

» x = [0;1.2;2.1;3.05;3.98;5;6.06;7.1;7.96;9.1;10.1]
» y = [0.022939741;0.278677185;0.511481518;0.786636653;1.054317421;1.294484182;
      1.558722641;1.925381211;2.126113434;2.477435113;2.657350328]
» one = [1;1;1;1;1;1;1;1;1;1]
» coef = [x one]
» out = inv (coef ' * coef ) * coef ' * y

```

The MATLAB output for {x}, {y}, [coef] and the solution is shown below

x =	y =	coef =	out =
0	0.0229	0 1.0000	0.2693
1.2000	0.2787	1.2000 1.0000	-0.0268
2.1000	0.5115	2.1000 1.0000	
3.0500	0.7866	3.0500 1.0000	
3.9800	1.0543	3.9800 1.0000	
5.0000	1.2945	5.0000 1.0000	
6.0600	1.5587	6.0600 1.0000	
7.1000	1.9254	7.1000 1.0000	
7.9600	2.1261	7.9600 1.0000	
9.1000	2.4774	9.1000 1.0000	
10.1000	2.6574	10.1000 1.0000	

The results of this analysis provide the parameters that describe the best straight line fit of the data provided. The resulting equation is

$$y = mx + b = 0.2693 * x - 0.0268 \tag{A-1}$$

AN OLDER DOCUMENT  
(NOT USED ANY LONGER)  
WITH SOME USEFUL  
INFORMATION

**University of Massachusetts Lowell**

**James B. Francis College of Engineering**



**GUIDELINES ON  
HOW TO WRITE TECHNICAL REPORTS**

**College of Engineering  
Writing Improvement Workshop  
Falmouth 203A (above bookstore)  
April 2001**



Some people rarely have to write anything....

Of course, this does not apply to you. You have chosen the life of a technical professional. Engineers, scientists, and technical specialists of every kind must convey the results of their thinking, their research, their *work* in writing.

The ability to convey your ideas clearly and convincingly has a direct influence on your career progress. At a more basic level, if your colleagues and superiors understand your ideas and are convinced of their soundness, those ideas will find support. Your proposals and plans will be adopted.

These guidelines won't make a great writer out of you, but they will help you present your technical work logically and effectively. The aim is to make the guidelines so useful you will keep them handy at your first job.

**THE MAIN PARTS OF A TECHNICAL REPORT** *← not this format,*  
Technical reports vary a bit, but the following format is typical in industry and government when addressing a *general audience*:

Frontmatter	*Title Page *Table of Contents *List of Tables *List of Figures
Body of Report	*ABSTRACT *INTRODUCTION Purpose and Scope Background EXPERIMENTAL APPROACH Equipment and Materials Procedure DISCUSSION OF RESULTS CONCLUSIONS AND RECOMMENDATIONS
Addenda	*BIBLIOGRAPHY *APPENDICES

\*Begin a new page

A much briefer, "memo" format, which is aimed at *highly informed readers*, is explained in Appendix A. We'll begin by looking at each part of the above, "long" format.

### TITLE PAGE

Include a *descriptive* title of the report, experiment name and number if appropriate, the author's name, the course title and section, the name of the professor or Teaching Assistant (TA), the date of the experiment, and the date your report is submitted.

### TABLE OF CONTENTS PAGE

In a comprehensive report the table of contents page looks like this:

TABLE OF CONTENTS	
List of Tables	Page iii
List of Figures	iv
Abstract	1
Introduction	2
Purpose and Scope	2
Background	2

## TABLE OF CONTENTS (Cont'd.)

Experimental Approach	5
Equipment and Materials	5
Procedure	6
Discussion of Results	8
Conclusions and Recommendations	12
Bibliography	14
Appendix A    Title of the Appendix	A-1
Appendix B    Title	B-1
Appendix C    Title	C-1

ii

You may use a topic numbering and lettering system if you think it will aid the reader. In shorter reports, however, all those letters or numbers just add clutter. Note that the frontmatter pages are numbered in lower case Roman numerals. If Appendix A has three pages, number them A-1, A-2, and A-3. Note: that there are no colons (:) after titles and subtitles.

### LIST OF TABLES AND LIST OF FIGURES

A *table* is simply information arranged in rows and columns. A *figure* is any kind of graphic display that is not a table. List the titles and page numbers of all the tables that appear in the *body* of your report (not in the appendices). Do the same on a separate page for the figures. If you have space on one page for both lists, *combine* the two and show the page in the table of contents as "List of Tables and Figures." Be sure to show the tables and figures separately on the page; don't mix them.

### ABSTRACT

The Abstract is a summary of the entire experiment or project. The purpose is to provide readers with a quick condensation, highlighting the important points and helping them to decide whether to read, skim, or skip the rest of the report.

A good abstract begins with a clear statement of the *technical objectives(s)* of the experiment: what you set out to prove or determine. Next come your *conclusions*: what, in fact, you did prove or determine. Also, it's usually a good idea to describe what the experiment consisted of, i.e., the *method* used to get your results. If the entire focus is on results obtained, the method may be downplayed or occasionally omitted. Here's an example of an abstract:

*This experiment examined the suitability of XYZ bolts in our standard and special high-performance assemblies. The bolts were subjected to tensile loads on a Tinius Olsen Tensile Testing Machine, and the breaking loads were analyzed by the gaussian distribution law. The data show that the bolts are suitable for use in our standard assemblies but not in our special high-performance assemblies.*

Remember the Abstract must *stand alone*, for it is often the only part of the report many readers will read. The Abstract appears on its own, separate page. Also, because the Abstract may be published separately from the report itself, the Abstract should not have references to other sections of the report or to figures or tables that appear elsewhere in the report.

### INTRODUCTION

This section tells the reader the basis of the experiment and gives helpful background information. Its two parts are labeled *Purpose and Scope* and *Background*.

#### Purpose and Scope

Combine these two topics because they are closely related. The *Purpose* statement tells the reader why you did the investigation. It explains why the work is important enough to investigate and what the specific *technical objectives* were.

## Purpose and Scope (Cont'd.)

**Note:** *Never mention the academic objectives* (e.g., to learn how to use an oscilloscope), but tell the reader the technical or economic reasons for doing the investigation. Most investigations have practical goals, for example, to improve a method or process, to identify optimal conditions, to improve process quality, to see if a design will meet performance specifications, to validate physical properties or behavior, to improve safety, to name just a few. Concentrate on these objectives. Once you have identified the technical objectives, the rest of the report tells how and whether or not you achieved them.

The **Scope** statement does two things for the reader. It defines the **boundaries** (or limits) of the investigation and it gives the **criteria** or standards on which your judgments were based. The scope statement narrows the problem and provides focus for the investigation. It also forms the basis for the conclusions. Here's an example of a Purpose and Scope statement with the scope information underlined:

*The advantages of transporting solids through a pipeline in the form of a water slurry are well known. However, these advantages are often offset by a lack of water for the pipeline and by the added cost incurred in separating and drying the solid material at the destination point. This study examined the feasibility of an alternative slurry system: the use of liquid carbon dioxide. The study examined the transport of two types of coal: an anthracite typical of the Pennsylvania region and a low-sulphur bituminous coal common to the Powder River Basin. Engineering data were developed from a pilot plant system, and delivered costs to various destinations were estimated.*

**Tip:** Notice that *past tense* was used when referring to the specific study. That's consistent; the experiment or study took place in the past.

## Background

This second part of the Introduction bridges the gap between the reader and the writer. Consider the knowledge a typical reader would have of your subject and ask, "What will my reader need to know to understand and accept the rest of the report?" For example, the Background section can:

- Help the reader understand the *theoretical principles* that underlie *this specific experiment*
- Familiarize the reader with the *history* of the problem
- Explain the *practical or scientific value* of the results derived
- Explain what is unusual or unique about the *methods* being used.

The important thing is to be certain that the Background section provides genuinely useful information that relates to *this* experiment. Too often, Background discussions (especially "Theory" discussions) read like filler material.

## EXPERIMENTAL APPROACH

This section discusses the *equipment and materials* used and the *procedure* followed to get the results.

In the *Equipment & Materials* section you should list (and, in most cases, describe) what you used to get your results. The key is to provide just the *right amount of detail* for the reader. For example, in some cases the reader may need to know the make and model number of a piece of equipment, and in other cases that information may be unimportant. Perhaps the reader needs to know the special characteristics or features of the equipment or materials. You must judge. Just remember: too much detail bores the reader and makes your report amateurish; not enough detail confuses and frustrates, and can even irritate the reader.

The *Equipment & Materials* section nearly always contains a schematic or diagram of the experimental setup. Make sure the diagram shows all the items mentioned in the text. The diagram also should have a *title* and *figure number*, be referred to in the text, and be located as close to the reference as possible (not in an appendix).

In discussing the *Procedure*, tell your reader what was done, not how to go about doing it. The procedure is not meant to be a set of instructions on how to recreate the experiment; its purpose is to explain how you arrived at your results. Use passive voice, e.g., "Pressure readings were recorded." Remember the earlier comments about level of detail. Omit all details not relevant to the results. The procedure may be written in paragraph form or as a list of numbered steps. Remember, the experiment took place in the past, so use *past tense*.

## DISCUSSION OF RESULTS

This section does two things: it *reports* your results and, at the same time, gives your *interpretation* of them. Begin this section by reporting your results in the form of tables or graphs if appropriate, then ask, "What do the results tell me about my objective(s)? Which tables or graphs relate to which objective? Do the results confirm theoretical expectations? If not, why not? How reliable are these data?" (Remember, insert each table or graph as close to the text reference as possible.)

The "discussion" should not be simply a long list of what went wrong with the experiment. Tell your reader what happened and give your analysis. Be careful not to go too far and get into conclusions; they come next.

## CONCLUSIONS AND RECOMMENDATIONS

Conclusions are the answers to the questions (or solutions to the problems) raised in the Purpose and Scope. The conclusions are your judgments, opinions, and interpretations of the results. Here's an example of conclusions:

*Changes in all three process conditions affect hardness but in different ways. Increasing the cure rate and immersion time improves hardness. Increasing the temperature improves hardness to a point, but at temperatures greater than 650 degrees F. hardness deteriorates.*

The *number* of conclusions must be the same as the number of *objectives* stated in the Purpose and Scope section. (For example, if you had two objectives, you should have two conclusions.) If the two don't agree, either you stated your objectives incorrectly or the conclusions don't focus clearly on the objectives.

Recommendations are what *courses of action* you advise the reader to take based on your conclusions. For example, if your experiment was intended to test mathematical models against actual experimental results, do you (based on your findings) recommend using the models? Under what conditions? Sometimes your recommendations must be negative; for example, "Based on the experimental results, *I do not* recommend using Ohm's Law to determine the resistance of an electrical component." You also may recommend changes in the equipment and/or procedure to get more accurate results when repeating the experiment. Be sure your recommendations are a logical follow-up to your conclusions.



## BIBLIOGRAPHY

Bibliographies contain citations of books, journal and magazine articles, conference papers, and other documents related to the subject of the report. Bibliographies can have two functions: (1) they can be used instead of footnotes or endnotes to document sources, or (2) they can serve as general lists of references as a guide to additional information on the subject, but uncited in the report. *In technical reports the bibliography, rather than footnotes or endnotes, is a widely accepted way to cite sources. (In such cases, all books in the bibliography must be cited in the text of the report.)* The Bibliography appears on its own, separate page.

## Bibliography (Cont'd.)

Arrange the list of documents alphabetically by author. If the author's name is unknown, use the title of the document to determine its position in the alphabetical arrangement. The format of the bibliography may vary from company to company and publisher to publisher. For your reports at UMass Lowell, use the following formats:

- |                           |   |
|---------------------------|---|
| Books                     | Anastasi, Thomas E., Jr., <u>Communicating for Results</u> , Menlo Park, CA: Cumming Publishing Company, Inc., 1972.  |
|                           | Rose, Arthur, and Rose, Elizabeth, ed., <u>The Condensed Chemical Dictionary</u> , 7th ed., New York: Reinhold Publishing Corp., 1966.  |
| Magazine Articles         | Tillman, John, "How High The Moon," <u>Science and Technology</u> , Vol. 35, June 1960, pp. 99-100.   |
| Journal Articles          | Brown, R.M., and Mueller, E.H., "On-Line Computers in Nuclear Research - - Part III," <u>Nucleonics</u> 25 (3), 48 (1967).  |
| Reports                   | Erickson, L., and Oakley, D., <u>An Explosively Driven Flap Closure for 18-Inch Pipe</u> , Livermore, CA: Lawrence Radiation Laboratory, 1986.  |
| Reports (Authors Unknown) | <u>World Markets for Polypropylene</u> , Cambridge, MA: Arthur D. Little, Inc., 1986.   |
| Conference Papers         | Teller, Edward, "Water Generation in Space," in <u>Conference on Nutrition in Space and Related Waste Problems</u> , NASA Special Publication #70, Washington, D.C.: U.S. Government Printing Office, 1964. |
| Theses                    | Massa, J.L., Theoretical and Experimental Studies of Ionization Exchange between the Ionosphere and Plasmasphere, Ph.D. Thesis, Ann Arbor, MI: University of Michigan, 1984                                 |

When you cite a source document in the text of the report, simply insert the *name* of the author and publication *date* in parentheses. If you need to refer to page numbers, insert them after the date. If the work has up to three authors, use the last name of each; if more than three authors, use the first author's surname and *et al.* (Latin for "and others"). These references normally are located at the end of the statement they document and inside the period; for example, "Within five years continuous-thrust spacecraft will be used for all space exploration (Jones et al. 1991, 37)."

## APPENDICES

Don't think of this section as "the appendix." It is not a suitcase into which is stuffed everything that was not used in the rest of the report. Appendices provide information to only a few readers who need to probe deeply into the details. Appendices **do** contain such things as computer printouts, tables of data that support the graphics used in the body of the report, sample calculations, raw data, complicated formulas and equations needed to support the conclusions but not necessary to understand them, and reprints from other documents. Appendices **do not** contain figures that show the apparatus, or tables that give the results; they belong in the body of the report.

Remember, each appendix is *optional* for the reader. Thus you must help the reader decide whether or not to read each appendix. Do this by giving each appendix a **letter and a title**, by listing each appendix and its title in the Table of Contents, and by **referring** to each appendix at the proper places in the body of your report.

Page numbers, figure numbers, and table numbers contain the letter of each appendix. If Appendix A has three pages, number them A-1, A-2, A-3. If Appendix B has two figures, number them B-1, B-2, etc.

## HANDLING TABLES AND FIGURES

What is the difference between tables and figures? A *table* is any display of information arranged in rows and columns. A *figure* is anything else (e.g., map, diagram, drawing, photo, schematic, graphic aid, and chart). Here are guidelines for handling tables:

- Refer to every table and figure in the text, and locate the table or figure as close as possible to the reference. Sample references include: “as shown in Figure 1, (See Table 1.), or simply (Table 1).” Capitalize the **T** in Tables and **F** in Figures. Spell out Figure; don’t use “Fig.”
- Give each table and figure a *descriptive title*. Table numbers and titles (headings) go *above* the tables. Figure numbers and titles go *below* the figures.
- In **table titles**, (headings) capitalize the first letter of the first word and all other words *except*: articles (a, an, the), conjunctions (and, as, but, if, or, nor) and prepositions (at, by, for, in, of, off, on, out, to, up). **Figure titles** are treated as sentences. Capitalize the first word in the figure title, but all other words except proper nouns are in lower case. Put a period at the end of each figure’s title.
- Tables and figures in the **appendices** contain the letter of the appendix, for example, Table A-1, Figure B-3.

## ABBREVIATIONS

- *Be consistent*. Don't use sq ft on one page and ft<sup>2</sup> on another.
- Always *use the singular form*, even if the value suggests the plural (e.g., 50 lb, not 50 lbs; 10 amp, not 10 amps).
- *Omit periods* after abbreviations (ft, ml, cm). The only exception is if the abbreviation is a word. Use in. for inches, for example.
- *Spell out* words that are *too short* to abbreviate (ohm, ton, mil).
- Make certain the reader *understands* the abbreviation; if there is any doubt, spell, out the term the first time you use it, followed by the abbreviation in parentheses.

## NUMBERS

The basic rule is to spell numbers below 10 and use numerals after that. The same applies to numerical order (seventh, but 27th). There are several exceptions to this rule, however:

- References to pages, Tables, and Figures are expressed in numerals (e.g., as shown in Figure 3).
- Numbers at the beginning of sentences are spelled. Try to rearrange the sentence to avoid this situation.
- Use numerals with abbreviated units of measurement (e.g., 8mm, 9 cu ft).
- When expressing a series of quantities, express them in numerals for uniformity. (For example, the farmer shot 23 quail, 16 sheep, and 2 traveling salesmen.)

Use commas with numbers of four digits or more in tables and with five digits or more in text.

In text, rounded-off values of six or seven digits are usually written, for example, 3 million copies, \$45 billion. Five-digit numbers, however, are either spelled entirely (ten thousand) or shown entirely as numerals (10,000). Never write 10 thousand.

When two numbers come together and one forms a compound adjective, spell the first one or the shorter one to avoid confusion (for example, four 12-foot boards or 200 eight-inch blocks).

## SOME TIPS ON WRITING WELL

First some practical suggestions:

1. *Don't wait until the last minute.* One of Murphy's truest laws is, "Things always take longer than you expect." If you postpone your report until the night before it's due, your report will read and look as if you did it the night before!
2. *Use a word processor.* Computers can help you organize your thoughts. They can find and correct misspelled words, give you access to an on-line thesaurus, and even check grammar and usage. Best of all, they save time when you polish and rewrite. Just remember, make two copies of your work on floppy disks.
3. *Study and follow the Guidelines.* Don't try to improvise.
4. *Before you start to write, do a little planning.* Begin by focusing on the *technical purpose* for doing the experiment. Jot down a few notes. What were you trying to prove or discover? What did you *actually* demonstrate? The key to a good report is the ability to put your work in *focus* for the reader. Notice the difference in focus in these two Titles and Purpose and Scope sections from the same experiment.

Example 1:

### *HEAT EXCHANGE*

#### *Purpose and Scope*

*The main purpose of this experiment was to prove that heat exchangers work. Heat exchangers work in many ways, but we were limited to two types. The first worked by having steam run parallel and counter current at the same time around the outside of a cold water pipe. The other type used steel plates and corrugated surfaces to exchange the steam's energy and the energy of the cold water. The experiment was limited to pressures between four and ten pounds per square inch. The flow rates for the steam and water were restricted between 20-41 and 265-295 ml/s respectively.*

Example 2:

### *COMPARING TWO TYPES OF STEAM-TO-WATER HEAT EXCHANGERS*

#### *Purpose and Scope*

*The exchange of heat between steam and water is probably the most widely practiced heat transfer operation in use. The main objective of this experiment was to determine and compare the thermal efficiency of two such types of heat exchanger: the traditional two-pipe exchanger and the newer Tranter Superchanger. Other objectives included comparing the overall advantages and disadvantages of each type.*

What's the point?

It's important before you even begin to write to ask the right questions. "Why would an engineer gather these data?" "Why was the work important enough to investigate?" "What are the specific *technical objectives* of the experiment?" Notice the presence or absence of *focus* even in the *titles* of the two examples above.

Technical objectives could include evaluating processes for efficiency (as above), or improving the quality, appearance, or strength of a part. Most investigations have practical goals, for example, to improve a method or process, to identify optimal conditions, to improve process quality, to validate physical properties or behavior, to improve safety, to name just a few.

## SOME TIPS ON WRITING WELL (Cont'd.)

5. *Write your first draft*, keeping the following in mind:

Consider your reader. Keep testing whether or not your reader can understand and follow your ideas based on your words on paper.

Write in simple, familiar words. Impress your reader with your *ideas*, not your vocabulary. Don't stop the flow of ideas by trying to edit as you write. First get it all on paper; put your draft aside for a time, then make a new beginning by polishing your work carefully.

6. *Polish for Clarity*. Your first goal is for your reader to understand what you have written. The fact that *you* understand the meaning behind the words is not only irrelevant, it can be a barrier to your working hard to reach your reader. Here are some examples of polishing for clarity:

### *Use specific, concrete terms*

Vague: The Superchanger was better than the double-pipe heat exchanger.  
Specific: The Superchanger's thermal efficiency was 60% higher than that of the double-pipe heat exchanger.

### *Place modifiers as close as possible to the terms they modify*

Ambiguous: After being stored at -30° F, the mechanic tested the battery's starting ability.  
Clear: After being stored at -30° F, the battery was tested for starting ability.

### *Identify the source of a statement.*

Unclear: It is believed that work stoppage can be avoided.  
Clearer: Both union and management believe a work stoppage can be avoided.

### *Be sure that references, (such as "this") are clear.*

Unclear: The team postponed its study of the security system at the nuclear plant. This was the subject of an uncomplimentary editorial in the local newspaper.  
Clear: The team stopped its study of the security system at the nuclear plant. The postponement was the subject of an uncomplimentary editorial in the local newspaper.

### *Define terms your reader may not understand*

Jargon: The program was stored in ROM.  
Clearer: The program was stored in Read Only Memory (ROM).

7. *Polish for Conciseness*. Conciseness means to express something clearly in the fewest possible words. Every word must work for you. Cut out deadwood. Here are a few examples:

Deadwood: In an emergency situation  
Concise: In an emergency

Deadwood: I talked to two different people about the problem.  
Concise: I talked to two people about the problem.

Deadwood: Enrollment will continue to increase in the future.  
Concise: Enrollment will continue to increase.



## SOME TIPS ON WRITING WELL (Cont'd.)

Deadwood:	I plan a career in the field of civil engineering.
Concise:	I plan a career in civil engineering.
Deadwood:	The report contains information of a technical nature.
Concise:	The report contains technical information.
Deadwood:	It is the purpose of this report to discuss the effects of computer technology on the design of microprocessors.
Concise:	This report discusses how computer technology has affected the design of microprocessors.
Deadwood:	Shipment of the test equipment took place in May.
Concise:	The test equipment was shipped in May.
Deadwood:	A new technique is now available. It consists of...
Concise:	A new technique consists of...

8. *Polish for correctness.* A report with errors in spelling, grammar, and punctuation suggests carelessness, which can harm the credibility of the entire report. Read your report over with great care. Test every word and sentence for correctness. Can you find the errors in the sentences below?

We only tested for thermal efficiency.  
The manifold lost it's head of steam.  
Because it controls the functioning of the equipment.  
Rupture occurred because of to much end load.  
After conducting several test runs, the equipment was purchased by the company.  
Always check your report for misspelled words

9. *Polish for completeness.* Completeness means providing the reader with all he or she needs to understand the report. You can provide that information in a variety of ways: parenthetical definitions, footnotes, glossaries, graphic aids, examples, analogies, background information, appendices, etc. The key is to *analyze your audience's understanding* of your subject and then to provide the *exact level of detail* that will satisfy your audience's needs. Work hard at this because too much detail will bore your audience, and too little will frustrate and annoy them. One key skill that good communicators always develop is the ability to *become* their audience as they write or speak.

### The Writing Improvement Workshop

The College of Engineering conducts a formal technical report writing program in which an engineering student submits one laboratory report for analysis each semester. A professional communicator reviews the report not just for the correctness of the writing, but also for the student's ability to grasp and enunciate the technical objectives and focus all parts of the report on those objectives. Each student meets his or her reviewer in a private conference to go over the comments and suggestions, to gain an understanding of what must be done to produce a report that meets industry standards. The procedures for reviewing technical reports are given in Appendix B. The basic guidelines used by reviewers in evaluating reports are presented in Appendix C.

**APPENDIX A** ← Use this format.

**Format for Memorandum (Short Form) Reports**

Not all reports should or can be adapted to the format described in the body of "Guidelines on How to Write Technical Reports." The sole reader may be the writer's immediate supervisor, who is thoroughly informed about the reason for collecting the data. The investigation itself may have been a very simple one, etc.

In such cases, a simpler report format is more appropriate than the lengthier one discussed earlier. One such **memo format** is as follows:

include cover sheet from syllabus. →

To: Instructor's Name  
From: Author  
Subject: A Descriptive Title

Date: \_\_\_\_\_  
Section: \_\_\_\_\_  
Partner(s): \_\_\_\_\_

use headings → **Summary**  
**Experimental Approach**  
use sub-headings → Equipment and Materials  
Procedure  
**Analysis of Results**  
**Attachments or Appendices (as needed)**

**Note that there is no cover page and no table of contents page.** Use the headings. **Don't** begin a new page for the Experimental Procedure or the Analysis of Results. **Number** all the pages. Do not insert the report in a special binder; simply staple the pages in the upper left corner.

Here's an explanation of the elements of the memo format:

**Subject**

*Pick your subject title with care; make it descriptive.* A well chosen subject heading can provide much useful information to the reader and save you the trouble of having to insert that information into the text. What is more important, it gives you an opportunity to grab the attention of the reader and avoid having your memo report end up in the reader's junk pile. For example:

**Instead of**  
Reynolds Number  
Kirchhoff's Laws  
Testing of XYZ Bolts

**Choose**  
Reynolds Number as a Predictor of Fluid Flow Type  
Verification of Kirchhoff's Laws  
Suitability of XYZ Bolts for High-stress Applications

**Summary**

The memorandum report should open with a short paragraph or two that summarizes the **purpose and scope** of the investigation, the **method** used to get the results, the **conclusions or findings** and any **recommendations** that might be called for. The Summary is similar to the Abstract used in the long form (page 2), except the Summary does not appear on a separate page.

Although this seems a great deal of information to provide, the Summary should take no more than a page of double-spaced text and often will require only three or four sentences. Here are some examples of summaries for memorandum reports:

**Example 1:**

*The analysis of how well the Reynolds number predicts the type of fluid flow in a channel has been completed. The analysis was based on a visual examination of the type of flow through a system consisting of water, a dye (dilute KMnO<sub>4</sub>) and a straight glass pipe fitted with a feed for the dye. The analysis showed that the Reynolds number is (or is not) a reliable predictor of the type of flow in the channel.*

## APPENDIX A: Format for Short Reports - Cont'd.

### Example 2:

*Here are the results of the load tests that you requested for the 18 XYZ bolts. They were obtained by subjecting the bolts to tensile loads on an Olney tensile machine and analyzing the breaking loads by the Gaussian distribution law. The data show that the bolts are suitable for use in our standard assemblies but not in our special high performance assemblies.*

### Example 3:

*The tensile tests on the sample of 18 XYZ bolts that you submitted last week show that the bolts will be suitable for our standard assemblies but not for our special high performance assemblies.*

*The conclusion is based on breaking load data that were obtained with an Olney Tensile Machine and then subjected to Gaussian distribution analysis. Because the sample may not have been representative, however, more tests should be conducted before a final decision is made.*

### Experimental Approach

Describe briefly your experimental approach. Identify the equipment and materials as appropriate and include a diagram of the experimental setup. If the procedure is too complicated to describe in about a page (using double-spaced text), include it and the diagram as an appendix or attachment to the memorandum report and simply refer the reader to the appendix or attachment.

### Analysis of Results

Next *present* your results *then discuss them*. Explain whether your results (as they relate to your objectives) agree with what you expected them to be based on your understanding of the underlying theory or technology. Show either the reason(s) for expecting certain results or the reason(s) for any disagreements between your results and what you expected. In addition comment on any ideas you might have for improving the experiment, for example, a better experimental setup or a change in the procedure that would simplify the work, give it a broader application, yield more accurate data, etc.

The discussion normally should not exceed about three pages of double-spaced text. In addition, show any *key tables* and *graphs* needed to present the data to back up your discussion and conclusions. (See page 6 of "Guidelines on How to Write Technical Reports" for more details about tables and figures.)

### Appendices or Attachments

Complete the report by attaching any *useful* appendix material as needed—the experimental procedure, sample calculations, derivation of an equation, description of a piece of equipment, etc. The same rules apply as in the long-form report. (See page 5 of the guidelines.)

Note: For ease of editing, print the text of your *first draft double-spaced*. Be sure to indent the first line of each new paragraph. The second draft can be single-spaced or double-spaced depending on what your instructor prefers. Thus, the amounts of space for the various parts of the report given above apply only to the first draft. Appendices or attachments are *always* single-spaced.

## APPENDIX B Writing Improvement Workshop Procedures for Reviewing Technical Reports

1. Each Semester you will be asked to submit one laboratory report to be evaluated for format, content, and clarity based on the foregoing guidelines. *The report must be your own original work.* Any text from other publications must be shown in quotation marks, and the author and publication must be referenced. Team or group reports are not accepted by the workshop.
2. *All reports must be computer printed* (or typed). The **first draft** text must be **double-spaced**; be sure to **indent** the first line of each new paragraph. The second draft, can be single-spaced or double-spaced, depending on what your instructor prefers. **Submit first drafts to your instructor, not to the Workshop. The Workshop does not accept first drafts from students.**
3. A Workshop reviewer will mark up your report, showing how it can be improved, and will notify you, through your instructor or TA, to *make an appointment to discuss your report.* You also should check the bulletin board outside Falmouth 203A or inquire at Falmouth 203A if you haven't been notified by two weeks after submitting your report.
4. The reviewer will post (on the bulletin board outside Fal 203A) a schedule of his or her availability so that you can select a time for your conference. **It is your responsibility to sign up for a conference and be there at the time you selected. Be sure you sign up with the right reviewer.** *If you have a scheduling problem, notify the Workshop Director in Fal 203A. If you miss your appointment, notify the Workshop Director as quickly as possible.*
5. In the conference your reviewer will discuss what needs to be done to improve your report, and will answer any questions you may have. Normally, no grade is yet assigned. If your initial work is judged to be of outstanding quality by industrial standards, you will not need to rewrite the report. If your initial report is less than that, *you must rewrite it* and resubmit it for a grade of "pass" or "fail."
6. Submit your rewrite plus the original report *no later than one week* (seven calendar days) after your conference with your reviewer. Return your original plus your rewrite to the Workshop Director in Fal 203A, or deposit them in the receptacle outside Falmouth 203A if the office is closed.
7. Your reviewer then evaluates the revised report and grades it "pass" or "fail." If the grade is "pass" the revised report and the original report are returned to the laboratory course instructor for technical review and a numerical grade of your *final draft*.
8. Failure on the second draft will normally result in a grade of zero for that laboratory experiment. *If there is sufficient time remaining in the semester*, however, the student will have the opportunity of a second conference and a third draft. Failure on the third draft will result in a grade of zero for the experiment. The Director of the Writing Workshop will review all third drafts.
9. If a required rewrite (second draft) is not submitted to the reviewer on time, a grade of "incomplete" will be assigned for that experiment. An "incomplete" can be resolved only by submitting the rewritten report to the Workshop Director *within one week of the original (missed) deadline.* The Director will review the rewritten report and assign a grade of "pass" or "fail." If the grade is "fail" no second rewrite will be permitted. If *no rewrite* has been submitted by one week after the deadline, a grade of "fail" will be assigned to the report.
10. The Director can be reached via e-mail at: **Leonard\_Meuse@uml.edu**, or by phone at **978/934-3380**.

Following is a list of corrections and recommendations that are made on many reports. Please look your report over. Do any of these problems apply to your report? Numbers in parentheses refer to page numbers in **GUIDELINES ON HOW TO WRITE TECHNICAL REPORTS**.

## FORMAT

- Headings need to be the same as in Guidelines. (p. A-1)
- Subject needs to be descriptive and informative. (p. A-1)
- Paragraphs must be indented if report is double spaced.
- Number the pages.

## TABLES AND FIGURES (p. 6)

- Each table and figure must have a number and a title.
- Refer to tables and figures by number.
- Capitalize the first letter of the words **Table** and **Figure** when referring to table/figure by number.
- Graphs are figures.
- Be consistent.
- Treat titles according to Guidelines.
- Something is **shown** in a figure, as opposed to the figure **being** something.
- Tables and figures show information about the experiment you did in the past.

## SUMMARY SECTION

- Technical objective is incorrect. See assignment handout.
- Technical objective is incomplete. See assignment handout.
- Summary is incomplete--it needs: (p. A-1)
 

technical objective	scope
method	results

## EXPERIMENTAL APPROACH (p. A-2 &amp; pp. 3, 4, )

- Describe what was done. DO NOT GIVE INSTRUCTIONS.
- Use past tense. Do not tell how it is done.
- Use passive voice. Describe what was done. ("The equipment was started," NOT "We started the equipment.")
- Do not include results in this section.
- Put calculations in an appendix.

## ANALYSIS OF RESULTS (p. A-2 &amp; p. 4 )

- Revise to focus on the assigned technical objective.
- Analyze the results. Do not just report the results.
- Procedure belongs in the Experimental Approach section, not in the Analysis of Results.
- Include tables and figures. referring to them to explain your results.
- Use past tense when discussing this experiment.
- Use present tense when discussing theory.
- Make it clear when the discussion is about theory and when it is about this experiment.

## APPENDICES (p. A-2, &amp; p. 5)

- Appendices must be organized by subject and divided into logical sections, not lumped into one "Appendix."
- Give each appendix an appropriate letter/number and a title.
- Number pages properly
- Give figures and tables appropriate letter/numbers and titles.
- When referring to a specific appendix, use a capital A for Appendix. (See Appendix C.)
- Refer to each appendix in the body of the report.

## OTHER

- USE SPELLCHECKER.
- Report lacks professional appearance.
- Language skills must improve significantly for the report to earn a passing grade.