“The horror of the moment,” the King went on. “I shall never forget.”

“You will, though,” the Queen said, ‘if you don’t make a memorandum of it.”

*Alice’s Adventures in Wonderland*, Lewis Carroll, 1945.
1. Rules for good technical writing
2. Technical memo format
3. Technical report format
AME20213 – Spring 2010 - Technical Memo/Report Grading Sheet

Laboratory Exercise No.: ______

Memo/Report Author(s): _______________________________________________________

The technical document MUST follow the format described in the text that is specified for this exercise. Further, it must conform to the guidelines given in the text on writing technical memoranda, number and unit formats, and graphical presentation.

Each area below will be graded as unsatisfactory (score = 1), satisfactory (score = 2), or excellent (score = 3). These areas are somewhat subjective and may vary slightly between TAs. To help guide you, the items listed below each area must be followed to receive a satisfactory grade. Satisfactory means that your document conforms to all or almost all requirements. Unsatisfactory signifies a document that in deficient in several requirements – a document that we would be embarrassed to show a prospective employer during an interview. Excellent means exceptional – way above the requirements – a document that impresses us and one that you would be proud to include with your resume in seeking a job. Past grading experience in this class has shown that few documents meet the grade of excellent (less than five in a semester). All excellent grades would give a total score of 24.
Specific Technical Writing Considerations:

- All Variables/Symbols Identified in Text
- All Variable’s Units Presented (in Correct Format)
- Numerical Results Presented in Proper Format
- Correct Number of Significant Digits Used
- All Figures/Tables Explained in Text
- Figures and Tables Correctly Presented Including
  - Labeled Axes, Proper Captions, and Clear Markers
- References in Proper Format and Correctly Referenced in Body of Text
- Correct Spelling and Grammar
- Uncertainties for Every Measured and Predicted Value

Quality of Writing:

- Proper Format, Organization, and Content
- Quality of Writing Including Ability to Communicate Clearly Ideas, Sound Reasoning, Results, and Technical Details

Technical Content:

- Appropriate Plots (Presence and Quality of Description)
- Uncertainty Calculations
- Quantitative Comparison of Measured and Theoretical Values

Quality of Technical Understanding:

- Scientifically Viable Conclusions/Discussion
- Comprehension of Purpose of Laboratory Exercise
- Comprehension of Physical Principles Governing the Experiment and Measurement
For an Application Question, *excellent* corresponds to all correct answers.

**Application Question #1:** Score = ____

**Application Question #2:** Score = ____

**Application Question #3:** Score = ____

**Application Question #4:** Score = ____

**TOTAL SCORE:** ____/24

**NOTE:** See class web site/Laboratory Exercises for example *satisfactory* and *excellent* technical memos and *excellent* technical report.
Writing Technical Memoranda (12.2.2)

- Write technical memoranda in the third person.

- Use the past tense throughout technical memoranda.

- Limit the length of sentences. Break long sentences up into shorter ones. Scientists and engineers tend to write long sentences.

- Segment ideas into paragraphs such that the reader is led through the presentation in a smooth and effortless fashion.

- Type all memoranda. Choose a word processing software package and learn how to use it effectively. This will help to produce a professionally presented document which usually includes text, figures, tables and equations.
Writing Technical Memoranda (12.2.2)

- Proofread and check for spelling errors. It often helps to have someone else do the proofreading.

- Provide a plausible explanation based upon scientific principles whenever predictions and measurements differ. Uncertainties or mistakes are not acceptable reasons. Support any explanation by some simple calculations.

- Report the average value with its uncertainty whenever reporting results based upon multiple measurements. Avoid simply listing all the measured values.

- Use correct English. Do not confuse commonly used words such as “its” and “it’s”. The former is possessive; the later is a contraction. Other examples include “affect” and “effect”, “farther” and “further”, “ensure” and “insure”, “because” and “since”, “approximately” and “about”, and “decrease” and “drop”.
Writing Technical Memoranda (12.2.2)

1. Every variable and symbol, either measured or analytical, must be identified.

2. Every variable’s units must be presented.

3. The proper number of significant figures must be used with all numbers.

4. Uncertainties must be given for every measured and predicted variable. Nominal values must be included. The assumed confidence level must be stated. Often it is easiest to present uncertainties in a table and include supporting calculations in an appendix.

5. The physical concepts behind a model must be explained. Do not just present the model’s equations.
# Systems of Units

## Table 11.1 Five systems of units (adapted from [2] and [3])

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>meter (m)</td>
<td>centimeter (cm)</td>
<td>foot (ft)</td>
<td>foot (ft)</td>
<td>foot (ft)</td>
</tr>
<tr>
<td>Time</td>
<td>second (s)</td>
<td>second (s)</td>
<td>second (s)</td>
<td>second (s)</td>
<td>second (s)</td>
</tr>
<tr>
<td>Mass</td>
<td>kilogram (kg)</td>
<td>gram (g)</td>
<td>pound-mass (lbn)</td>
<td>pound-mass (lbn)</td>
<td>slug</td>
</tr>
<tr>
<td>Force</td>
<td>newton (N)</td>
<td>dyne</td>
<td>pound-force (lbf)</td>
<td>poundal</td>
<td>pound-force (lbf)</td>
</tr>
<tr>
<td>gc</td>
<td>$1 \frac{\text{kg} \cdot \text{m}}{\text{N} \cdot \text{s}^2}$</td>
<td>$1 \frac{\text{g} \cdot \text{cm}}{\text{dyne} \cdot \text{s}^2}$</td>
<td>$32.174 \frac{\text{lbn} \cdot \text{ft}}{\text{lbf} \cdot \text{s}^2}$</td>
<td>$1 \frac{\text{lbn} \cdot \text{ft}}{\text{poundal} \cdot \text{s}^2}$</td>
<td>$1 \frac{\text{slug} \cdot \text{ft}}{\text{lbf} \cdot \text{s}^2}$</td>
</tr>
</tbody>
</table>
Some Interesting Units

• Guess the common units for the following

Amount of seed to sow an acre of ground

Distance from head to wrist

Distance an arrow would fly

Distance walked on foot in 1 hour

Distance a shout would carry

Distance seen when squatting beneath a horse

Distance you can see to the horizon in miles
Rules of Significant Figures

- **The most-significant digit** (msd) is the leftmost, nonzero digit.

- **The least-significant digit** (lsd) is the rightmost, nonzero* digit.
  
  *IF there is a decimal point, then the lsd also includes zero.

- **The number of significant figures** equals the number of figures between and including the least-significant digit and the most-significant digit.

How many significant figures are there in each of the following?

- 10.5800
- 105800
- 10.58
- 010580.
Rules for Number Round Off

• To round off a number, truncate the number to its desired length and make the remainder a decimal fraction

• If the fraction > ½, round up the number’s lsd
• If the fraction < ½, leave the number’s lsd as is
• If the fraction = ½, round up the lsd IF it is odd
How Many Significant Figures?

027.08450

MSD? LSD?

Number of significant figures =

Rounded off to 5 significant figures =
6. Do not use relative words, such as “good,” “reasonable,” “acceptable,” “significant,” etc., when describing an agreement between values. Quantitative statements must be made when making a comparison, such as “x differed from y by z %.”

7. Each figure or table included must be referred to and discussed in the text. Do not say “calibration data is shown in Figure 1” or “results are presented in figures 1 through 6” and then never discuss what is shown in each figure.

8. Equations must be punctuated with commas or periods, as if they were part of a sentence. Do not let them dangle in space.

9. A “0” must be included in the front of the decimal point if no other number is present. The decimal point can be missed by the reader when the “0” is absent.

10. All pages must be numbered consecutively except the cover sheet.
Number and Unit Formats (12.2.3)

- Use SI units. Give the equivalent values in other units in parentheses following the SI unit values only if necessary.

- Avoid using unacceptable abbreviations such as sec for second, cc for cubic centimeter, l for liter, ppm for parts per million. For example, express 7 ppm as 7 µL/L.

- Include units for each number when using composite expressions, such as those involving areas, volumes and ranges. Volume, for example, would be written as 2 m x 3 m x 5 m. The correct expression for a range of values would be 23 L/s to 45 L/s. Use the word “to” instead of a dash when expressing a range. For example, write 5 to 10 rather than 5-10.
Number and Unit Formats (12.2.3)

- Use Arabic numerals and symbols for units, such as “the mass was 15 kg.” Keep a space between the numeral and the symbol. This is even true for percentages, which should be expressed as x % and not as x%.

- Italicize quantity symbols, such as $l$, $V$ and $t$ for length, volume and time, respectively.

- Put unit symbols in Roman type. Subscripts and superscripts may be in either Roman or italic type.

- When there are more than four digits in a number on either side of the decimal marker, use spaces instead of commas to separate numbers into groups of three, counting in both directions from the decimal marker, such as 3.141 592 654.
Number and Unit Formats (12.2.3)

- Express all logarithms using log, with their bases as subscripts, such as \( \log_e(x) \) and \( \log_{10}(x) \). Do not use \( \ln(x) \) for the natural logarithm.

- Use decimal prefixes with a number’s units, keeping its numerical value between 0.1 and 1000, such as 1.05 MJ instead of either 1.05 \( \times 10^6 \) J or 1.05E6 J.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Prefix</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{24}$</td>
<td>yotta</td>
<td>Y</td>
</tr>
<tr>
<td>$10^{21}$</td>
<td>zeta</td>
<td>Z</td>
</tr>
<tr>
<td>$10^{18}$</td>
<td>exa</td>
<td>E</td>
</tr>
<tr>
<td>$10^{15}$</td>
<td>peta</td>
<td>P</td>
</tr>
<tr>
<td>$10^{12}$</td>
<td>tera</td>
<td>T</td>
</tr>
<tr>
<td>$10^{9}$</td>
<td>giga</td>
<td>G</td>
</tr>
<tr>
<td>$10^{6}$</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>$10^{3}$</td>
<td>kilo</td>
<td>k</td>
</tr>
<tr>
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<td>hecto</td>
<td>h</td>
</tr>
<tr>
<td>$10^{1}$</td>
<td>deka</td>
<td>da</td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>deci</td>
<td>d</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>centi</td>
<td>c</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>micro</td>
<td>$\mu$</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>nano</td>
<td>n</td>
</tr>
<tr>
<td>$10^{-12}$</td>
<td>pico</td>
<td>p</td>
</tr>
<tr>
<td>$10^{-15}$</td>
<td>femto</td>
<td>f</td>
</tr>
<tr>
<td>$10^{-18}$</td>
<td>atto</td>
<td>a</td>
</tr>
<tr>
<td>$10^{-21}$</td>
<td>zepto</td>
<td>z</td>
</tr>
<tr>
<td>$10^{-24}$</td>
<td>yocto</td>
<td>y</td>
</tr>
</tbody>
</table>

Table 2.3: Prefixes for Units
Format Mistakes “Quiz”

• Identify any format errors in the following.
  • 2 – 3 m/sec
  • 42%
  • Body temperature, T, equals 98.6°F.
  • 1 x 10^{-4} J
  • One ft. equals 12 in. exactly.
  • 25,233°
  • 4000 ppm
Graphical Presentation (12.3.4)

- A title or caption must be present.

- Both the abscissa and ordinate must be labeled with the name of the quantity plotted and its units in brackets or parentheses.

- Tick marks should be used on each side of both axes. Internal tick marks are preferable.

- All curves must be labeled either on the plot using arrow indicators or in the plot’s legend when more than one curve is plotted.

- Analytical results must be plotted as a solid curve. Do not use symbols.
Graphical Presentation (12.3.4)

- Numerical results must be plotted as a dashed or dotted curve. Do not use symbols.

- Experimental results must be denoted with symbols and error bars, using the same symbol for a given data set.

- Any curve representing an estimate must be presented with ± confidence limit curves evaluated at P % confidence.
Graphical Presentation (12.3.4)

Figure 7.1
The Technical Memo (12.3)

The format of a technical memo is similar to that commonly used in industry and at national laboratories. It is a concise, formal presentation of your findings on a particular technical issue. It is not a comprehensive explanation of the theoretical or experimental methods that you have used, but rather a summary highlighting the results that you have obtained. Typically, the body of a technical memo should not exceed 2 to 3 pages in length, excluding any supporting material that usually is placed in appendices. The suggested format is described below.
The Technical Memo (12.3)

Date: 1/18/05

To: Professor P.F. Dunn

From: I.M.A. Student

Subject: Rocket Thrust Measurement

Summary: This should be one paragraph that summarizes the important results and states the significant conclusions. When writing this section, assume that this may be the only part of the technical memo that actually is read. Thus, it needs to be self-contained and not refer to any other written section, graphs and tables, that are contained in the body of the memo. Key results must be presented. Values of important experimental parameter ranges must be included. If theory also is presented, a quantitative statement about agreement or disagreement with the experimental results needs to be made.
Findings: This part covers in more detail what was summarized above. Enough information must be provided such that an engineer at your level could critically evaluate the approach and methods, and understand how you arrived at the results and conclusions, without your providing any information beyond what is written. Only the most important figures and tables need to be included here. Supporting material such as additional plots, program listings or flow charts can be included as attachments (appendices) to the memo. All figures and tables must be numbered and referred to properly in the text. Include only the material that you consider necessary to support the conclusions. Never present results, especially in figures and tables, that you do not specifically discuss in this section. Do not attach volumes of computer-generated output without any explanation. The reader is impressed not by the volume of data collected but by the value of it.
The Technical Memo (12.3)

References: References must be numbered in consecutive order. Do not include any references that are not cited in the memo. The following reference format conforms to that specified by The Chicago Manual of Style??:


This includes the last names and first and middle initials of all of the authors, the year of publication, the title of the article, the abbreviated title of the journal (italicized), the volume number, and inclusive page numbers of the article.


The book title is italicized.
The Technical Memo (12.3)

Appendices: These addenda contain supplementary material, such as detailed derivations or calculations. They are not meant to contain a record of everything that was done on the memo’s subject. Include only what is needed to support material presented in the body of the memo. Do not place the results here and then refer to them from the memo.

• For this class, appendices (such as uncertainty calculations) need not be typed. The can be hand-written, provided they are neat and legible.
The Technical Report (12.4)

1. **Title Sheet**: List the class and its number, report title and number, your name, all group members’ names and the date. This is the cover sheet of the report. It is not numbered.

2. **Abstract**: The primary purpose of the abstract is to provide the reader with a brief and sufficient summary of the project and its results. It is to be short (no more than approximately 100 words) and informative. It must indicate clearly the nature and range of the results contained in the report. The abstract must stand alone. No citing of numbered references, symbols, etc., must be made unless they are understood without any reference to the report. The easiest procedure is to write the abstract summarizing the entire body of the report *after* the report has been written.
3. **Table of Contents:** Each of the subsequent sections should be listed with their corresponding pages in the report.

4. **List of Symbols (Nomenclature):** English symbols are first listed in alphabetical order, then Greek symbols in alphabetical order. Be sure to describe adequately your nomenclature, for example, not just "viscosity" but either "absolute (dynamic) viscosity" or "kinematic viscosity." Also note that in some cases the mere descriptive name of the symbol is not sufficient. For example, when listing coordinates be sure to specify the coordinates' directions with respect to some reference point. Also, when describing nondimensional numbers, specify their definitions in terms of the other symbols listed. The best procedure in gathering the nomenclature is to construct the list of symbols after the body of the report has been written.
5. **Introduction:** This section introduces the reader to the nature of the problem under investigation. It explains the history and relevance of such an experiment and its application. Previously published papers relevant to the experiment should be cited here. The general objectives of the experiment should be stated. Do not simply summarize the experimental objectives. Provide a guide for the reader as to what will follow in the report.
6. **Approach:** This section sometimes is referred to as *methods* or *procedure.* It needs to describe briefly the experimental, analytical and numerical methods used to arrive at the results. There must be sufficient detail to permit a critical evaluation of the methods used and replication of the results by another party. It is not necessary, however, to give full descriptions of all of the methods that are described in detail elsewhere, for example, how a particular numerical integration scheme works step-by-step. Uncertainty estimates for all parameters and procedures used to arrive at the results must be provided. Usually, it is preferable to present these estimates in a table. A block diagram or flow chart of the steps in the approach can be very helpful to the reader. Alternatively, a step-by-step approach can be put in narrative form. A flow chart should be included for each computer program used. A listing of each program should be presented in an appendix and documented with sufficient comments such that it can be followed easily by the reader.
The Technical Report (12.4)

7. **Results:** The results of your experiment are presented here, usually facilitated by graphs, figures and tables. The findings of the experiment are presented but neither discussed nor evaluated in this section. Keep in mind that you want to be concise when presenting the results. Put results in graphical form whenever possible. Sample calculations can be put in an appendix. When the results cover several aspects of the project, subdivide this section such that each part deals with one major aspect. The results of an uncertainty analysis must be provided. Detailed, supporting calculations should be presented in an appendix. Mention specifically what is contained in *each* figure and table. Do *not* say, for example, that “the results are shown in figures 1 through 6,” and then fail to explain what is presented in each figure.
8. **Discussion**: This section should include a discussion and evaluation of the results obtained and their relation to other pertinent studies, if any. The findings of your experiment are interpreted in this section. Express your scientifically justified opinion in this section about the facts that were presented in the previous section. Remember the distinction between fact and opinion. Point out the limitations of how you approached the experiment and how you would improve on your approach. Be constructively critical. Describe what you have learned from the experiment.

9. **Conclusions**: Briefly conclude the major findings of your experiment. Do not introduce anything new or continue to discuss the results.

10. **References**: These follow the same guidelines as for the technical memo.

11. **Appendices**: These follow the same guidelines as for the technical memo.