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UNIVERSITY OF PORTLAND

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DONALD P. SHILEY

SCHOOL OF ENGINEERING

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WRITING

FOR

ENGINEERS

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FALL 2014

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Dear Student:

If you are like most engineering students, you probably imagine that success in your career will depend only on your technical competence. Nothing could be further from the truth. Your success will depend in equal measure on your technical competence and on your ability to communicate both orally and in writing. The best technical ideas are worthless if they are not communicated effectively to your peers and supervisors.

Unfortunately, effective technical communication is neither easy nor does it come naturally to most people. It can be taught, but you will learn it only if you are willing to put in the necessary effort.

The curricula in the School of Engineering have been designed, among other things, to emphasize communication skills. One of those skills is writing ability. The faculty's desire is to emphasize the importance of writing in all aspects of your education - to emphasize writing across the curriculum. Throughout your four years here you will be required to practice and improve on those skills, from your freshman engineering design project write-up to your senior design project report. I hope you take full advantage of the opportunity to practice your writing skills and to continually improve your abilities as you progress through your four years at the University of Portland.

Sincerely,

A handwritten signature in blue ink, appearing to read "Sharon A. Jones", with a long horizontal flourish extending to the right.

Sharon A. Jones, Ph.D., P.E., BCEE  
Dean of Engineering



# SECTION I - THE SCHOOL OF ENGINEERING WRITING PROGRAM

## I.A. Introduction

Concise and clear writing is an extremely important aspect of an engineer's education. Yet in the various engineering and computer science curricula at the University of Portland you will not find a technical writing course. Instead, writing is emphasized in a number of different courses. Why? Because the most effective learning is integrated with a variety of material. Also, as you progress through your four years here, you will continually develop and practice your writing skills. In addition, different courses (and different instructors) will emphasize different types of writing and, in some cases, different styles. And lastly, by incorporating writing in more than one course, faculty members hope to emphasize the importance of your ability to communicate in written form; you should continue to improve your writing skills as you move from one semester to the next.

## I.B. Goals

The goals of the School's writing program are:

- ❖ To help students recognize the importance of writing in the classroom and workplace.
- ❖ To promote a desire among students to correct their writing deficiencies and to improve their professional writing skills.
- ❖ To use writing as a way for students to learn and clarify thinking.
- ❖ To establish sufficient opportunities to practice and develop their writing skills.
- ❖ To provide appropriate writing instruction.
- ❖ To give appropriate advice, criticism, and correction to promote improvement through revision.

## I.C. Purpose of this Document

The purpose of this document is to give you a concise overview of faculty expectations. While writing style, organization and content often differ, depending on the intended audience, the intent of this document is to provide all students a uniform basis for their work while at the University. It is not intended to include all aspects of writing, nor all aspects of technical writing. It does not include details of grammar. In general, this document provides guidelines, along with some specific examples. Section VII lists a number of references from which you can gain further information. Two, in particular, are useful – *The Pocket Wadsworth Handbook* (Kirszner & Mandell, 2015) and *The Concise Handbook for Technical Writing* (Brusaw, Alred, & Olin, 1996).

## **I.D. Engineering Formats**

You will use a variety of formats in your laboratory and lecture courses, several of which are described in this document:

- ❖ Engineering reports
- ❖ Engineering letters
- ❖ Engineering memoranda
- ❖ Laboratory notebooks
- ❖ Engineering proposals

Course instructors may supplement the guidelines given below with additional requirements. For example, the instructor may specify that reports be single or double-spaced.

Most companies and agencies have their own writing and presentation formats, and it is unlikely that you will use the University's format in engineering practice. Regardless of the format adopted by a school or engineering organization, it is important you conform to the adopted format. In general, technical documents are written in the third person.

## **I.E. In the Broader Context**

The writing program in Engineering is only a part of a broader effort at UP to address your writing abilities. While the focus in engineering is on technical aspects of writing, proper grammar, punctuation, spelling, etc., are also essential. The faculty at UP have adopted campus-wide a writing manual (Kirszner and Mandell 2015). In addition, several websites provide valuable information. In particular, helpful writing exercises can be found at [writing.engr.psu.edu](http://writing.engr.psu.edu).

The University's Writing Center can also offer assistance. Student Writing Assistants from various disciplines on campus can provide feedback and offer suggestions. Appointments can be made on a group or individual basis. They can be reached at ex. 8002 and/or [writing@up.edu](mailto:writing@up.edu). The Writing Center is located in Franz 120.



## SECTION II - GENERAL TECHNICAL WRITING GUIDELINES

For most technical writing, certain conventions apply regardless of the type of document being prepared. For example, tables of data should be prepared in a certain way whether they are in a technical report or a memo. This section discusses those conventions as they apply to organization, tables, figures, equations, citations, reference and appendices. Your instructor may amend these guidelines for specific assignments.

Writing should be in paragraph form, not in outline form. You should observe accepted elements of style and editing, while keeping in mind the writing evaluation standards shown in Appendix A. Remember the content of a report must be complete and should observe the ABC's of technical writing (accuracy, brevity, clarity). Length alone is not an indication of a report's worth.

### II.A Organization

Logical and consistent organization of a report is essential. Main sections of a report should be denoted with headings, and, when appropriate, sub-headings should also be used. A consistent style should be used for headings and sub-headings throughout the report, with the style and/or numbering of headings differing from sub-headings so that the hierarchical level of each can be differentiated. This report uses a number/letter format, and has four levels of headings and sub-headings. See, for example, the fourth-level sub-headings under Section III.B.5.

Pages should be numbered, starting with the first page of text. All preface pages are usually numbered with lower case Roman numerals. For a lengthy or complex report, a table of contents is usually included.

### II.B. Units, Equations, and Calculations

Equations, numbers, and units are common in technical documents. Their use should be consistent and follow accepted standards. A few pointers are listed below:

- ❖ When written in the text, numbers ten or less should be written out.
- ❖ Give units with each parameter and number that you report.
- ❖ Use appropriate significant figures. Do not give more significant digits than can be justified by the accuracy of the applicable test or measurement. When appropriate, give an appropriate tolerance associated with the number.
- ❖ Whenever a formula is presented, clearly define each parameter and its units.
- ❖ When several equations are used, they should be numbered sequentially along the right-hand margin.
- ❖ It may not be necessary to show all of your calculations. Provide sample calculations, and place these sample calculations in an appendix. Sample calculations are particularly helpful for explaining a spreadsheet. See for example the fourth note under Table 1 in Section II.C.

- ❖ Except in the “laboratory notebook” format, do not place raw laboratory notes in the main body of a report. Include them as an appendix.

Shown below is an example of a properly formatted equation, in this case for the standard deviation of a linear measure:

$$Std. dev. = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{(n-1)}} \quad (1)$$

Where:      *Std. dev.* = standard deviation (cm),  
                  *i* = subscript for data points,  
                   $x_i$  = data point (cm),  
                   $\bar{x}$  = mean of the data (cm), and  
                  *n* = number of data points.

## II.C. Figures and Tables

Engineers are accustomed to using figures and tables to present information, and the use of these displays is greatly encouraged. The conventions for use of tables and figures in a document are similar, with a few subtle differences. However, before describing those similarities and differences, it is important to recognize what constitutes a table and what should be labeled as a figure. Tables are reserved for entries with rows and columns of numbers, while figures, in general, constitute everything else.

When tables or figures require landscape format, the table or figure should be oriented so that its bottom is aligned with the right-hand side of a portrait-formatted report.

Every table and figure should be labeled with: a number (for example, Table 3 or Figure 10) and a title (for example, “Axial Stress vs. Axial Strain of Annealed Copper”). When referring to a specific display, the words “table” and “figure” should be capitalized. The numbers should not be written out. Titles should be placed *below* figures and *above* tables. Tables as well as figures should be numbered consecutively, and a table or figure should closely follow its citation in the text. When a table or figure cannot fit on the current page following the citation, or when it requires a full page, it should be on the page immediately following the text’s first citation. Two methods are commonly used for citing figures and tables, as shown in the following examples:

“The measured compaction characteristics of the two soils are shown in Figure 1. This plot gives the relationship between the density of the soil. Soil A can be more easily compacted since it...”

“The compaction characteristics of the two soils are related to the density that can be achieved with a given initial water content (Fig.1). Soil A can be more easily compacted since it...”

Formal documents usually have lists of tables and figures following the table of contents.

Columns and rows in a table should be clearly labeled and show units. When appropriate, tables should describe how numbers in the columns were determined. This aspect is particularly important when spreadsheets are used to calculate values based on numbers in earlier columns of the table. Do not let row and column delineation lines detract from the presentation; they should add to its clarity and ease of use. An example of a well-formatted table is shown in Table 1.

**Table 1. Determination of a Stream's Unit Hydrograph for a One-hour Rainfall Event**

(1) Time (hrs.)	(2) Streamflow (ft. <sup>3</sup> /sec.)	(3) Baseflow (ft. <sup>3</sup> /sec.)	(4) Direct Streamflow (ft. <sup>3</sup> /sec.)	(5) Streamflow Volume (ft. <sup>3</sup> )	(6) Unit Hydrograph (ft. <sup>3</sup> /sec.)
1	110	110	0	0	0
2	110	110	0	0	0
3	122	122	0	198000	0
4	230	120	110	1026000	182
5	578	118	460	1782000	759
6	645	115	530	1530000	875
7	434	114	320	900000	528
8	293	113	180	486000	297
9	202	112	90	252000	149
10	160	110	50	111600	83
11	117	105	12	36000	20
12	98	90	8	14400	13
13	80	80	0	0	0

- Notes: 1. Columns (1) and (2) - data obtained from field measurements.  
 2. Col. (3) – Baseflow: assumed to be a straight line from 122 at 3 hrs. to 90 at 12 hrs.  
 3. Col. (4) = Col. (2) - Col. (3)

4. Col. (5) = Area under the direct streamflow curve, approximated using area of a trapezoid. Sample calculation for line 4:

$$Area = \left( \frac{h_1 + h_2}{2} \right) \times (base) = \left( \left( \frac{110 + 460}{2} \right) \text{ft.}^3 / \text{sec.} \right) \times (1 \text{ hour}) \times (3600 \text{ sec./hr.}) = 1026000 \text{ft.}^3$$

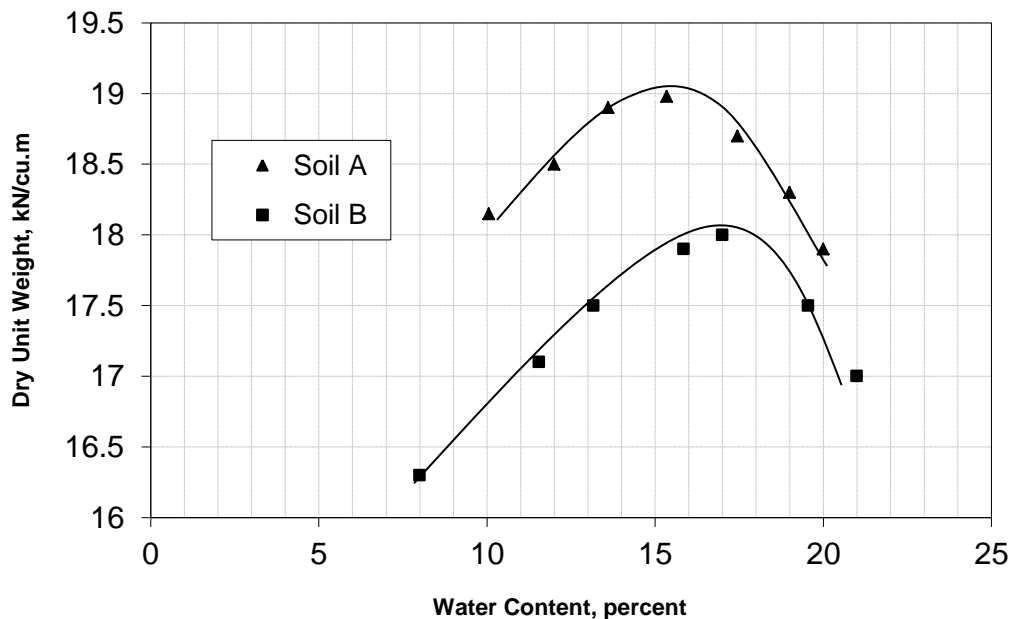
5. Total runoff determined by dividing total direct streamflow (sum of values in Col. 5) by area of drainage basin (4.5 sq. miles) and converting to inches.  
 6. Col. (6) = Col. (4)/(total runoff in inches).

A carefully designed and well-formatted figure can add tremendously to the message of a document. The figure should emphasize the topic and minimize incidental aspects, such as arrows, grid lines, etc. For graphs, charts and the like, it is important to select the most

appropriate depiction (line graph, bar chart, pie chart, etc.). Other important aspects include the following:

- ❖ Clearly label the axes of graphs and give the units within the axis labels.
- ❖ When appropriate, clearly show data points; do not just show the smoothed trend of the data.
- ❖ If a line is drawn through the data points, use a straight edge or smooth curve. Do not force the line through each data point but instead present the average trend of the data (as with “spline” curve-fitting options).
- ❖ Provide a legend if more than one data set is plotted on the same graph.

An example of a well-presented figure can be found in Figure 1.



**Figure 1. Compaction Test Results for Soils A and B**

When used effectively, figures and tables are an aid to, but not a substitute for, written text. As such, figures and tables should be cited in the text of a report, and their most important aspects should be discussed in writing. It is not sufficient to merely cite a figure without describing its salient aspects.

Appendix B shows several types of graphs that can be easily created using Microsoft Excel. Different types of graphs are appropriate for emphasizing different points. The appendix shows example graphs along with their appropriate uses.

## II.D. References and Citations

You must cite any references that you have used in preparing a report. These can include laboratory manuals, technical articles, textbooks, class handouts, testing standards, web pages, and personal communications. In general, common knowledge does not need to be documented. Ideas, concepts, and words of others, whether paraphrased or not, should be documented. "...it is a matter of both personal integrity and academic honesty to acknowledge others, especially when you use their words or ideas." (Maimon & Peritz, 2003, p.188)

The act of using words or ideas of someone else without giving them credit is called *plagiarism*. The following are examples of plagiarism:

- ❖ Including in a paper that you hand in, without citation, a paragraph that you found on the internet.
- ❖ Copying, without citation, part or all of another student's written report and submitting it as part of your report.
- ❖ Copying the answers to someone else's physics homework, and handing it in as your own.
- ❖ Discussing an answer to a question on a take-home exam with a classmate, and using that discussion to help you answer the question.

Different faculty members may have somewhat different standards for what constitutes plagiarism in the context of their particular courses. For example, some faculty members allow—or even encourage—students to work together on problem sets. If you have any questions about whether a particular action constitutes academic dishonesty in a particular course, ask the instructor.

Plagiarism is taken very seriously at University of Portland. The penalty for plagiarism can be as severe as *expulsion from the university*.

Citations in the text can be one of several forms, but should make it clear to the reader how to locate the complete reference in the document's list of cited material. Complete references, in the form of a reference list or bibliography, should provide enough information for the reader to retrieve the referenced document. Typically they follow the last part of the text, before the appendices. In technical documents, they are not generally included as footnotes.

A consistent and appropriate format for listing and citing the references should be used. You can find many examples in Kirsznner & Mandell (2015). Sufficient information must be provided so that someone can locate independently the referenced materials. Shown below is an example of the MLA referencing format, where the numbers are used as the citations in the text (either in parentheses, in square brackets, or as superscripts).

1. Sowers, George. *Introductory Soil Mechanics and Foundations: Geotechnical Engineering*. New York: Macmillan. 1979. Print.
2. American Society for Testing and Materials. *Annual Book of ASTM Standards, Section 1, Iron and Steel Products*. ASTM, 1988. Print.

3. Hirrel, Timothy. "How Not to Calibrate a Hydraulic Network Model." *Journal American Water Works Association*. 100.8 (2008): 70-81. Print.
4. Kuhn, M., Personal Interview. 28 June 2007.
5. Pennsylvanai State University. "Writing Guidelines for Engineering and Science Students." November 2010. Web. 25 July 2011 <<http://www.writing.engr.psu.edu/>>.

There are several different referencing styles. For example, this document uses the APA style, where the author and publication date are used for citations. It is important to remember to follow the appropriate convention for your particular document and to be consistent.

## **II.E. Appendices and Attachments**

Appendices (sometimes called attachments) are located at the end of a document and contain information that is relevant to the content of the report, but would be too cumbersome to include in the main section. Generally, appendices are at the end of reports, while attachments accompany letters and memos. Material in the main part of the report should include information that is directly pertinent to the topic at hand. If material is so cumbersome as to disrupt the flow of the text, it might best be included as an appendix. Appendices are usually grouped by topic and labeled with letters (A, B, C,...) or capital Roman numbers (I, II, III,...). Appendices should be cited sequentially in the text, matching the order that they appear at the end of the report.

## SECTION III - LABORATORY REPORTS

### III.A. Purpose

This report format emphasizes laboratory methodology and the computation, presentation, and discussion of laboratory results. In some cases, the laboratory results may be used for solving a specific engineering problem posed by the instructor.

### III.B. Format

Typically, formal laboratory reports include all of the elements discussed in the sections below. Short or informal laboratory reports omit the letter of transmittal, the table of contents, the executive summary, and the list of figures and tables. Individual instructors may have special guidelines for particular reports.

**III.B.1. Letter of Transmittal**—In some businesses, a letter of transmittal will usually accompany engineering reports, documents, and drawings. The sender and receiver of the report will usually keep copies of the transmittal letter in their files as a “receipt” or record that the report was actually sent and received.

As a minimum, the letter will give the title of the report and the number of copies that are being sent. In addition, a transmittal letter should include a brief description of the project scope, a description of your association with the project, and a concise summary of the results and conclusions or recommendations. It should also include a gracious offer to assist in interpreting the materials or in carrying out further projects. A letter of transmittal can generally be limited to one page. Although in business practice it is usually separate from the report (a “cover letter”), it is often placed inside your report behind the report’s cover. This placement will aid in gathering, grading, and distributing the reports.

**III.B.2. Title Page** – The title page includes the title of the experiment, test, or project; the course number, section, and name; the school and location; the name of your laboratory and instructor (Submitted to:); your name (Submitted by:); and the names of your laboratory partners (Laboratory work performed by:); the date(s) of the laboratory experiment, and the date the report will be submitted.

**III.B.3. Table of Contents** – For reports longer than 20 total pages or so, a table of contents is included that lists the various sections and appendices with their page numbers.

**III.B.4. List of Figures and Tables** – For reports with numerous tables and/or figures, a list of tables and a list of figures should be included that gives the label, title, and page number of each figure and table.

**III.B.5. Body of the Report** – A heading should precede each section of a report. Headings and sub-headings should have a consistent style throughout your report. The text of your report should include the following sections:

*III.B.5.a. Executive Summary* – This non-technical condensation of the report addresses a managerial or executive audience. It should include a brief description of the purpose, methods, and findings of your work.

*III.B.5.b. Introduction* – This section states the objective of your laboratory work (or project) and the engineering significance of the objective. It may also summarize the contents of the report.

*III.B.5.c. Background* – This section presents the context for your laboratory work. Although the following items may not be appropriate for every report, they could give you some ideas for this section:

- ❖ The governing engineering or scientific principles of the laboratory test.
- ❖ Engineering theory applicable to the experiment.
- ❖ Possible uses in engineering practice for the materials, models, or devices being tested.
- ❖ Possible uses for the laboratory results in engineering practice.
- ❖ Historical background of previous laboratory work related to your current work.
- ❖ Relationship between laboratory test and the engineering problem to which it will be applied.
- ❖ The background of the related engineering project to which the laboratory results will be applied. This could include the following:

The scope of work related to the project,  
A historical account of events leading to the current investigation,  
A general layout or description of the project, and  
A review of existing conditions relevant to the project.

*III.B.5.d. Laboratory Methodology* – This section divides into two subsections with subheadings:

- ❖ *Equipment and Materials.* Give concise specifications and descriptions of the experimental equipment and the materials, models, or devices tested, including, if appropriate, calibration dates.
- ❖ *Procedure.* Describe concisely the laboratory procedure. If your laboratory procedure is based on a published procedure, for example, ASTM or IEEE methods or laboratory notes, clearly cite the procedure and state any deviations from that procedure. For example, if you are using a laboratory manual, you should distinguish your actual procedure when it is different than the manual procedure. Except for simple tests, include a clear illustration of the test setup to help describe the procedure.

*III.B.5.e. Results and Discussion* – This part gives the main quantitative and/or qualitative results of your laboratory work. You should describe all significant observations and findings. For example, you should clearly describe any deficiencies or failures of the sample, model, or device that was tested. You should refer to and describe any figures, tables, and appendices that summarize your results. You should:

- ❖ Compare theoretical and experimental results. Clearly explain the assumptions behind the theoretical or accepted values. State any ways that your experimental



setup may not have met these assumptions or is otherwise deficient. Explain possible deficiencies in the theory.

- ❖ Discuss the use of your results in possible engineering situations.
- ❖ Discuss whether the observed behavior or failure of the material, model, or device was to be expected on theoretical grounds.
- ❖ Discuss the suitability of the material, equipment, or device that you tested for use in engineering situations.
- ❖ Discuss possible sources of error in your procedure and estimate their effect on the results. Give recommendations for improving the laboratory procedures or equipment.

*III.B.5.f. Conclusions and Recommendations* – This section directly answers the stated objectives of the laboratory work. Although the instructor will often provide specific items for discussion, the following ideas may be useful in writing your report. However, these ideas may not apply to all reports:

- ❖ Start or conclude the section with a clear statement of whether the objective was accomplished.
- ❖ Briefly explain results that “don’t look very good.”

Because they are so closely linked to the above analysis, many of your detailed conclusions and recommendations will be embedded in this section and need only be summarized in your final conclusions.

**III.B.6. Figures and Tables** – There are two recognized methods for presenting figures and tables. They can either be placed together at the end of the body of the report, or each figure and table can be placed separately immediately after it is first cited in the text. *\*Please refer to Figures and Tables Section II.C.*

**III.B.7. References** – See References (Section II.D.)

**III.B.8. Appendices** – Each appendix should be clearly labeled and must be cited in the body of the report. The appendices include the following:

- ❖ *Original data sheets.* Your raw laboratory notes and any lecture or handout notes, which should be dated and signed.
- ❖ *Sample calculations.* Include sample calculations for the results given in your report. You should clearly state your assumptions and explain each step taken in your calculations. Cite all equations, material properties, etc., properly.

## SECTION IV - ENGINEERING LETTERS, MEMOS, AND EMAILS

### IV.A. Purpose

The usual purpose of these formats is to forward information or answer an engineering problem posed by a client, consultant, or partner organization. In some cases, a letter can simply serve as an introduction to an attached report. In other cases a letter may be fairly extensive, and is referred to as a letter report. Engineering instructors will usually pose the situation and can give guidance on the technical contents of the letter and attachments.

A memo (or memorandum) is often used to transmit information within an organization, whereas a letter is used to transmit information to those outside an organization. The contents of memos and letters can be the same, although they have different formats.

You should be aware that email messages are frequently used in place of paper documents, particularly for internal communications. Email has the flexibility of acting as a very informal means of communication or a much more formal transmittal. Since email messages can be so easily composed and sent, extreme care should be taken in what is said. Remember that an email can easily be forwarded to multiple recipients. Care should also be taken to be sure that the message is indeed going to the proper person and not being broadcast to an entire organization (an easy mistake to make when hitting the wrong reply button). Any professional email communications should be treated as permanent documents. Recent use of email documents in court cases has attested to the ease with which electronic documents can be saved and retrieved.

### IV.B. Format

The content of most engineering letters can be organized into four main parts: *summary, background, discussion, and conclusions* (Blicq 1981). Depending on the intent and length of the letter, each part can be as short as a phrase or as long as several paragraphs. The four parts are described in more detail below.

**IV.B.1. Summary** – This brief description of the situation or problem, and your association with it, sums up the purpose of the letter. You should summarize your most important recommendations or observations. This part could be the opening sentence or paragraph of the letter.

**IV.B.2. Background** – This information “sets the scene” for the letter. It provides the context for what follows and gives a precise description of the purpose and scope of the letter (and sometimes a disclaimer of what is not within the scope). The following are examples of what might be included in the background sentences or paragraphs, although many may not apply to a particular letter:

- ❖ The purpose of the letter, project, site visit, analysis, investigation, or inspection.
- ❖ The scope of the work expected by the reader or client, and what has been excluded from this scope.

- ❖ A historical account of events that led to your investigation or the current situation; for example, previous investigation or evolution of the problem.
- ❖ A general layout or description of the project, for example, a machine layout, building site.
- ❖ A historical context of the current conditions that are relevant to the letter, for example, past engineering practices; evolution of technology, conventions, or codes; or performance of similar engineering works.
- ❖ A review of existing conditions relevant to the letter or project.
- ❖ The general engineering or scientific principles that apply to the situation and form a context for the problem.
- ❖ The dates of visits or meetings and who was present.

**IV.B.3. Discussion** – A presentation of what you found during your investigation is next. You can use this part of the letter to report items of importance and interest to the reader. This may include one or more of the following:

- ❖ A brief description of your methodology.
- ❖ Relevant findings and observations.
- ❖ A detailed description of the current conditions that you observed.
- ❖ Analysis results.
- ❖ Relevant evidence that you have uncovered.
- ❖ Your progress on a project.

Because they are so closely linked to the above analysis, many of your detailed conclusions and recommendations will be embedded in this section and need only be summarized in your final conclusions.

**IV.B.4. Conclusions** – This part of the letter presents what action is to be taken by you or the reader. This will often be a “recap” of the results or deficiencies identified in other parts of the letter. However, in a longer letter, this part is required to direct the actions of the reader, even if the text of this part echoes or refers to text in previous parts.

**IV.C. Courteous Closing** – These final few sentences typically create a courteous and cooperative tone (e.g., if you have any questions, do not hesitate to contact me), offer to assist in further projects or the interpretation of this one, or provide aids to further action (e.g., an extension number, best time to call, etc.).

In spite of the many details discussed above, the challenge in a letter is to clearly communicate all this information very concisely. Otherwise the letter becomes a formal report.

## SECTION V - LABORATORY NOTEBOOKS

### V.A. Purpose

A laboratory notebook (or engineering log) chronicles personal daily activities, observations, conversations, thoughts, and rough calculations. These engineering “work-entries” in your notebook are an “official” source of information for your engineering designs, reports, and potential patent or legal actions. As such, the primary audience of your notebook is yourself, although your peers, supervisors, sales persons, lawyers, and others may eventually use the information you have recorded. It is primarily a means of recording (in one place) information that you will later need to use, although it may also become a valuable source of evidence in any legal actions. The notebook can also be a great help with such mundane tasks as filling out a “time card” for billing purposes at the end of the week or recording telephone numbers for future reference.

If required by your instructor, you will use a laboratory notebook in your laboratory or senior design projects. You should typically use a single notebook for the entire senior design project or laboratory course sequence.

### V.B. Format

Your notebook should be a bound notebook with numbered pages. You should record all entries in ink. You should date and initial each new entry in your notebook. Use an unambiguous format for recording the date, for example, 9 May 2003 or May 9, 2003 instead of 5/9/03. You should never tear pages out of your notebook. If you add pages, date them and make a note of the addition on a regular notebook page. Mark out unused space so there is no blank space. Observe the following principles as you fill your notebook:

- ❖ Make all entries legible. A sloppy notebook is of no use to anyone, including yourself. Years later, you may want to look back at your work for insights and your comparisons with theory.
- ❖ Do not take data one day and copy it into your notebook later. This only creates problems when you forget or mistakenly record information. The notebook is the only place to record your laboratory information, telephone contacts, etc.
- ❖ Do not erase information; just cross it out. The crossed out information may help in future interpretations.
- ❖ Record everything in your laboratory notebook. Use the five W’s as a reference: who, what, when, where, why (and how).
- ❖ Include a title page to indicate new directions in the recorded laboratory work. For example, when you start a new experiment set, include a page to describe what you will be doing.
- ❖ Include where you are working and with whom the work is being performed. All important circumstantial information should at least be noted in the notebook. Describe any special circumstances about where the work is being performed.

- ❖ All information important to the work performed should be included in the notebook. Include your measurements, calculations, comparisons, etc. as part of the notebook. Do not skimp. It is not easy to go back in time and get the information you need.
- ❖ Do not record work connected to the laboratory or project on “scratch paper.” Use your notebook as the scratch paper and do everything in it, including preliminary calculations.
- ❖ Appropriately label all graphics. When including sketches of instrument displays or test setups, be sure to include all relevant labels. Identify the equipment used, how it was set up, and its operating condition. Be sure to label all graphs with the information necessary to extract the information you need.
- ❖ Include your observations (not just the data) during an experiment. Your observations are what converts a “cookbook” experiment into learning experience. Record what you discover.
- ❖ Include conclusions and insights “revealed” to you. The notebook is not just for recording data and observations but also your evaluation of the work. Include, at the end of each experimental session, an evaluation of what you found, including insights and comparisons with theory.
- ❖ Include occasional summary pages to summarize your work and insights. A good time to do this is at the end of a laboratory session, before your memory of the laboratory work fades.
- ❖ In the case of work for which a patent may be sought, have a colleague sign and date as a witness.

## SECTION VI - ENGINEERING PROPOSALS

### VI.A. Purpose

An engineering proposal is a formal “offer” to perform engineering services for a potential client. The proposal presents your qualifications and a plan of action for a specific project. Three common scenarios of engineering proposals are as follows:

- 1) The client solicits a specific request for engineering firms to submit proposals for a project (request for Proposals or RFP). Upon receiving proposals from you and your competition, the client will evaluate your qualifications and plan. Although the cost to the client is certainly a concern, proposals for engineering services are treated differently than quotations or bids for products or construction, in which the lowest bidder will usually receive the contract. Most clients recognize that the expense of good engineering services will be repaid several fold in reducing the lifetime cost of a quality product.
- 2) The engineer presents a proposal to his/her management for the design of a new product conceived and initiated by the engineer. The purpose of the proposal is to sell management on supporting the project.
- 3) Unsolicited research proposals are submitted without being specifically requested by the client and often without a particular end use in mind. The engineer submits a proposal for performing engineering research services that will be of eventual benefit to the client. The client is usually a government agency or industry organization.

Scenarios (1) and (3) set up an external or formal proposal described below. Scenario (2) can be set up as an internal or informal proposal or as a formal proposal. Your engineering instructor’s scenario will help you determine which format, formal or informal, is most appropriate.

### VI.B. Format

Typically, your proposals should include the following parts. Brusaw et al. (1996) also presents descriptions and examples of these parts of a proposal.

**VI.B.1. Title Page** – The title page includes the title of the proposal or project; the name of your instructor (Submitted to); the names of our partners (Partners); the course number, section, and name; the school and location; and the date.

**VI.B.2. Table of Contents** – A table of contents should be included with proposals longer than 20 pages.

**VI.B.3. Summary** – You should summarize in a single paragraph the purpose of the client’s project or, in the case of an unsolicited proposal, the need for the proposed research; your proposed program; your qualifications; and your budget.

**VI.B.4. Introduction** – Clearly state the purpose of the client’s project. Give background information related to the project, and define the scope of the work that you will be expected to perform (see the ideas given for the Background section of the Engineering Letter format, Sect. IV.B.2). For unsolicited proposals, such as scenarios (2) and (3) above, you should provide the motivation for the client to undertake your proposed program or product design.

**VI.B.5. Proposed Program** – Describe the approach that you plan to take in carrying out your work. You should be specific so that the client will recognize that you have carefully anticipated the required work and can begin completing the tasks without delay. If you plan to collaborate with another engineer or firm, you should clearly describe this arrangement. The client may also be interested in the availability of your staff to work on his/her project in the event that you are awarded the engineering contract. You should inform the client of the time required to perform the proposed work.

**VI.B.6. Qualifications, Experiences, and Facilities** – Give the qualifications of all staff personnel working on the project. Whenever possible, give summaries of similar projects with which you have been involved. If appropriate, give the names of former clients as references. In presenting your qualifications, you should heed the professional obligations given in the *Code of Ethics* of the National Society of Professional Engineers: “Engineers shall avoid . . . statements containing an opinion as to the quality of the engineers’ services or statements intended or likely to attract clients by the use of showmanship, puffery, or self-laudation, including the use of slogans, jingles, or sensational language or format.”

If the proposed work requires special equipment or facilities, show that you have sufficient capability to undertake the work.

**VI.B.7. Budget** – Give a summary of the estimated cost to the client. The budget should be itemized into broad categories appropriate for the project.

**VI.B.8. Appendices** – Include a proposed time schedule of the activities associated with your engineering work. Depending on the project, you can also include the results of any related laboratory or preliminary design work. Note that internal proposals may need to specify internal costs, usually personnel time on the project, estimated in hours or work-days, and the use of specific company equipment, support staff, or supplies.

## SECTION VII - BIBLIOGRAPHY

### Cited References

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Brusaw, C. T., Alfred, G. J. & Oliu, W.E. (1996). *The Concise Handbook for Technical Writing*. New York: St. Martin's Press.

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Pennsylvania State University. (2010). *Writing Guidelines for Engineering and Science Students*. Retrieved 25 July 2011 from. <http://www.writing.engr.psu.edu/>

### Technical Writing References

Schall, J. (2002). *Style for Students: Effective Technical Writing in the Information Age*. Eden Prairie, MN: Outernet Publishing.

Smith, J. G., & Vesilind, P.A. (1996). *Report Writing for Environmental Engineers and Scientists*. Woodsville, NH: Lakeshore Press.

Tufte, E. R. (2001). *The Visual Display of Quantitative Information, 2<sup>nd</sup>. Ed.* Cheshire, CT: Graphics Press.

### General Writing Reference

Strunk, W. & White, E.B. (2000). *The Elements of Style*. New York: MacMillan.

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## APPENDIX A

### WRITING EVALUATION STANDARDS

#### Content and Development

- ❖ Accurate, complete, and clear content with adequate development (i.e., of procedures, results, concepts).
- ❖ Effective and correct use of illustrations.
- ❖ Effective and correct use of references.

#### Organization

- ❖ Correct use of appropriate format.
- ❖ Appropriate headings.
- ❖ Logical flow of ideas in order of presentation (i.e., background, discussion, conclusions, recommendations).

#### Style

- ❖ Appropriate for audience and purpose.
- ❖ Concise wording.
- ❖ Effective and readable sentences.
- ❖ Appropriate word choice.

#### Editing

- ❖ Complete sentences.
- ❖ Standard English usage (i.e. clear pronoun reference, correct subject-verb agreement, standard inflections for verbs).
- ❖ Correct mechanics for written English (i.e. capitalization, punctuation of sentences, paragraphing, spelling).
- ❖ Manuscript neatness and appropriately assigned formatting (i.e. margins, indentions, neat corrections, standard use of numbers and abbreviations, pagination, overall appearance and presentation).

## APPENDIX B

### EXAMPLES OF GRAPHS

Using Microsoft Excel, graphs can easily be created from tables of data. However, the type of graph should be selected to emphasize the point being addressed; for example, differences between data sets, or a trend line.

- ❖ Column and bar graphs best represent the differences between data sets, where the relationship between or among the data sets may not be the important point.
- ❖ Scatter plots are best used where data points consist of pairs of values. They are best used to display trends. Excel allows you to determine a line of best fit using linear regression analysis. The result will show the linear equation, along with the coefficient of determination,  $r^2$  (a measure of the goodness of fit; or how well the line fits the data points).
- ❖ Pie charts are valuable for showing the relative proportions of the total attributed to an attribute.

Note that many of the standard graphs available in Excel may not be appropriate for the types of presentations made by engineers and computer scientists. Also, many of the colors available to distinguish different aspects of a graph may not show up well as differences when printed in black and white.

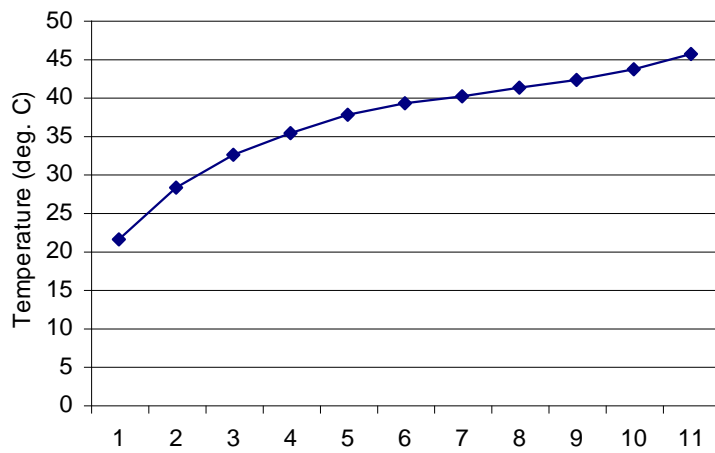
The following sections provide examples of how graphs can be used and misused.

#### Example One

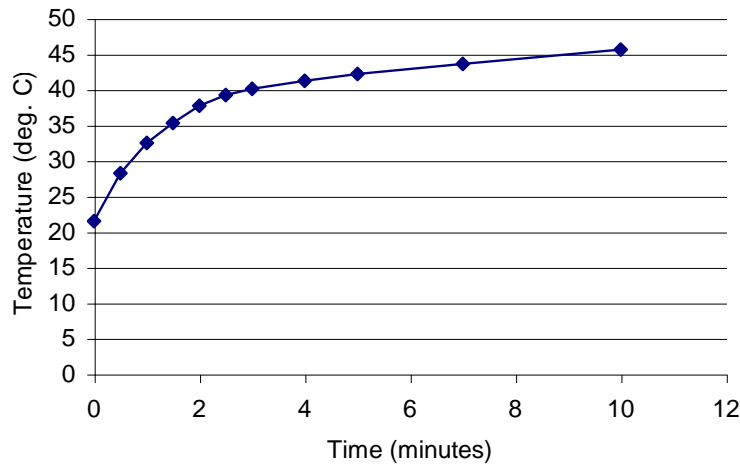
Table B-1 shows an Excel array of numbers, which has been plotted in Figures B-1 and B-2. Clearly the table communicates the values more precisely, and with a sense of the level of significant figures. However, a figure can provide a better feeling for the relationship among data points. Figure B-1 was created with an Excel line graph. It is an incorrect representation since the horizontal axis does not contain intervals that are consistent with the independent variable. In addition, there is no label for the horizontal axis. Figure B-2 was created with an Excel xy scatter plot, depicting the dependent vs. the independent variable. Note that the second plot shows the trend of the data accurately.

**Table B-1. Relationship between Time and Temperature for Experiment 1**

<u>Time (min.)</u>	<u>Temperature (C)</u>
0	21.5
0.5	28.2
1	32.5
1.5	35.3
2	37.7
2.5	39.2
3	40.1
4	41.2
5	42.2
7	43.6
10	45.6



**Figure B-1. Poor Example of Plotted Data Using an Excel Line Graph**



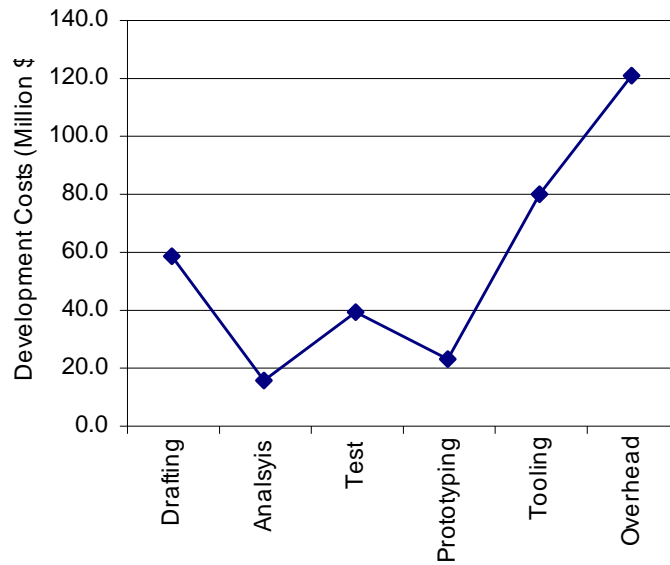
**Figure B-2. Example of a Properly Plotted Data Set Using an XY Graph**

### Example Two

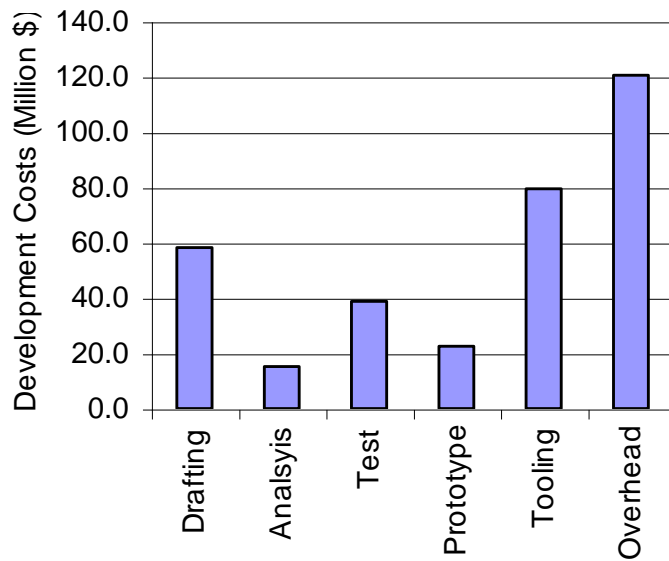
The data points shown in Table B-2 are illustrated in three different ways in Figures B-3 – B-5. Figure B-2 does not depict the data in a meaningful way since there is not necessarily a connection between the development costs of the various components of the project. Therefore, the lines connecting the points are inappropriate. Figure B-4 represents the data better. The pie chart shown in Figure B-5 illustrates an effective way to show the portions of the total that each of the components represents. Note that in pie charts, the largest portion usually “starts” at the 12-o’clock position, with successively smaller portions following as one moves in a clockwise direction.

**Table B-2. Cost of Project Development**

<u>Category</u>	<u>Development Cost (\$M)</u>
Drafting	58.2
Analysis	15.2
Test	38.8
Prototyping	22.6
Tooling	79.5
Overhead	120.5

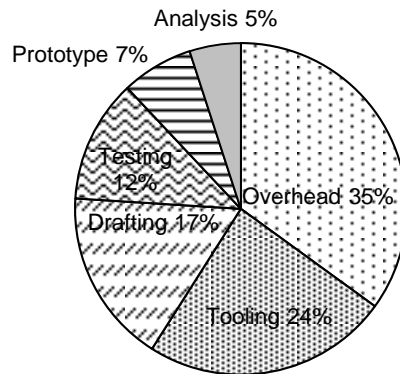


**Figure B-3. Improper Representation of Data**



**Figure B-4. Appropriate Representation of the Data**

### Total Developments Costs



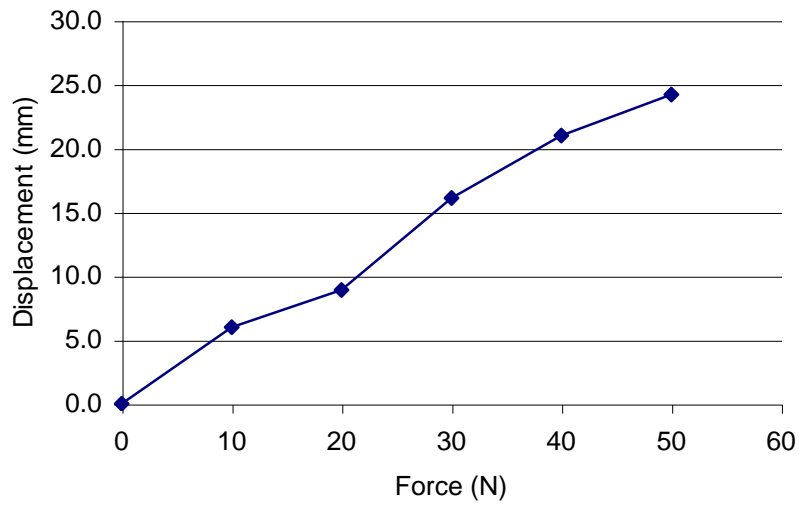
**Figure B-5. Pie Chart Representation of the Data**

### Example Three

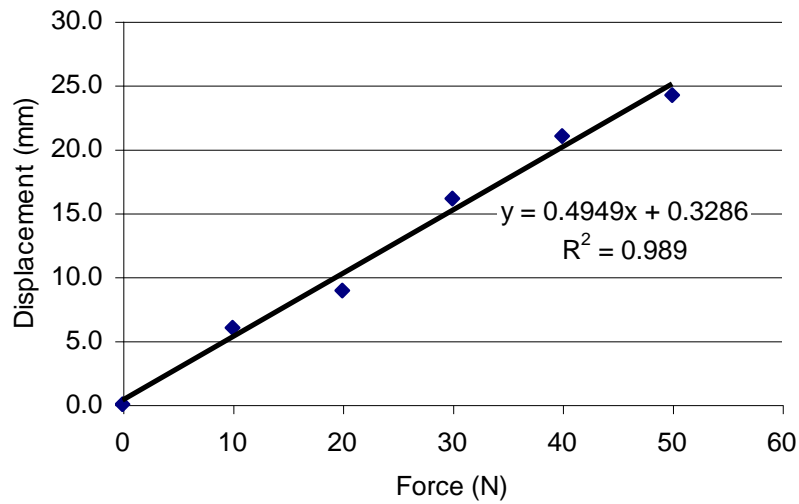
Figures B-6 and B-7 illustrate two ways of plotting the data from Table B-3. Both are xy scatter plots and the data points are plotted the same way. However, the lines in the first figure may not convey the trend that the author wished. The trend shown in the second figure shows a linear regression effectively representing the linear, not zig-zag trend.

Table B-3. Relationship of Force and Displacement.

<u>Force (N)</u>	<u>Displacement (mm)</u>
0	0.0
10	6.0
20	8.9
30	16.1
40	21.0
50	24.2



**Figure B-7. Improper Plot of Data**



**Figure B-8. Proper Representation of Data showing Linear Trend**