B. REPORTS

The purpose of technical writing is to convey information as efficiently as possible. Technical reports generally are not read for the sake of entertainment, but for the purpose of obtaining information. Technical writing is not colorful, and nor does it use exaggeration. Technical writing is well organized; significant findings are not hidden at the end as a surprise to the reader. It is best to give the reader the important conclusions as soon as the reader has learned enough to appreciate them. The rest of the paper should then be written to justify and amplify the conclusions. In order to simplify the writing process, an efficient way to begin organizing a report is to write down the important conclusions of the report. Next, fill in the other information that the reader will have to be told to understand the conclusions. Written and oral communication abilities are some of the most important skills that you should obtain at MTU; honing those skills is the primary objective of the lab reports in this class.

B1. ORGANIZATION

Organization is an essential element of good writing that contributes to readability. Four levels of organization must be considered in every written report: the whole-report level, the section level, the paragraph level, and the sentence level. You will have no options on the whole-report organization; there is a required format that you are to follow (either the memo format or the lab report format) as is explained below in this handout. Each section of your report has a function; you must organize the material in that section such that it achieves that function, reads smoothly, and is as short as practicable. Each section is likely to consist of one or more paragraphs; in cases of multiple paragraphs, these must be strung together such that there is a logical sequence of topics.

Paragraph structure is, perhaps, the most often neglected element of organization. However, paragraph structure is as important as sentence structure. A paragraph typically has **one theme**; generally, this theme is identified in the opening sentence of the paragraph. Generally, either the **first or the final sentence** of a paragraph gives the conclusion or the message that the reader is intended to remember about that topic. The sentences in between the opening and closing lines must develop the theme (identified in the first sentence) and lead the readers to the conclusion. Paragraphs should consist of **at least three sentences**, but should not be so long that the reader cannot remember the beginning or the sequence of ideas.

Sentence structure in technical writing can become very awkward unless care is used. Sometimes sentences become too long. Usually a long sentence can be broken into two or more short sentences. One way of insuring that your writing is readable is to read aloud what you have written. This technique often will reveal grammatical errors and the need for punctuation as well. Another common problem in sentence formation is the sentence fragment. Every sentence must have a subject and a verb within the body. The technique of reading out loud also will help to locate incomplete sentences.

In this class and some subsequent classes, you will use either a "short" or a "long" report format. The short format is that of a memo; the primary purpose of the memo is to convey the results and conclusions. Memos are the common, every-day method of communication of factual information in the work place. The longer report format

typically is used at the conclusion of an engineering or scientific project. You will be told for which lab exercises you are to use the memo and the long format.

B1a. Memo format

A memo is a 1-2 page communication. Although brevity is important, grammar and syntax are not to be sacrificed. Apart from the Header, the sections of the memo are not usually given title lines; each section will comprise one or more paragraphs. The memo report will have the following sections:

1. Header

On separate lines are given the date (Date:), the intended recipient (To:), the authors names (From:), the subject (Re:), and names of people to whom copies are sent (cc:).

2. Purpose

Briefly state why we are concerned with the topic and what the objective of the lab exercise is.

3. Conclusions

Rather than having an abstract or executive summary, the memo gives the important outcome near the top. Often the reader will go no further than this section, and thus it is important that the conclusions be easily found.

4. Procedure

In a memo, space is not taken to explain the entire procedures that are followed. A very brief (one statement) description may be given that **cites the methods** that were followed. If any deviations from the written methods occurred, these should be mentioned.

5. Discussion

Highlight the meaning and significance of the results. The results themselves are presented in tabular or graphical format.

B1b. Full report format

There are several slight variations on the standard format for a lab report, but all are similar. A lab report may vary from two to fifty or more pages in length. The tight organization of the report allows the reader to easily find all information that is necessary to interpret the results. The format that you will follow is summarized below.

1. Title page

   This should include the date, lab title, and authors' names and signatures.

2. Abstract

   An abstract is a brief summary (one or two paragraphs) of the entire lab. It should identify the reason for interest, the objectives, the approach, the key results, and the conclusions.

3. Introduction

   This section gives background information that helps the reader to understand the importance of the work. The objectives of the project also are stated in this section. Complete sentences rather than a tabulation of partial sentences are required.

4. Methods

   A brief summary is given of the methods and materials that were used. This section should have enough detail or citations to enable a reader to repeat the procedures. Imperative voice is not used.

5. Results

   The numerical results are presented in figures or tables together with text that explains what is given in the figures or tables.

6. Discussion
7. Conclusions
8. Appendices

   Large tables of data, repetitive figures, or explanations of detailed calculations are given in appendices.

B2. VOICE, TENSE, AND NUMBER: THE SCIENTIFIC STYLE

Reports should be written in the active voice, or on occasion in the passive voice. The imperative voice should be avoided. It may be acceptable in cookbooks (e.g., "Mix one cup of sugar with the flour and blend.") or in operating instructions (e.g., "Turn the knob counterclockwise until the pilot light glows."), but it is not acceptable in technical reports. For example:

1. Active Voice (BEST)—

   "The dissolved lead concentration was 10 nanomolar", or "The vapor pressure of benzene was 93 mm Hg."

2. Passive Voice (OK)—

   "The water was frozen in plastic trays.", or "The solution was analyzed for total metal content."

3. Imperative Voice (WORST)—

   "Dissolve 3 grams of iron in 100 ml of HNO_3", or "Use the refractive index to determine the concentration of isopropanol."

The past or the perfect tenses are usually the most natural. Occasionally the present tense can be used, particularly for stating enduring truths. Frequent shifting of tenses can leave the reader confused.

Almost all technical writing is done in the third person. The pronouns **you**, **I**, **we**, etc. are avoided. While a few people feel they make technical writing less stilted, most people regard their use as pompous. One thesis advisor suggested that her student avoid using **I** and **we** in writing until he had won a Nobel prize.

One common mistake is the use of pronouns like **it**, **they** or **them** when it is not clear to what they refer. Also the over-generalized references like "It is known that....",

"They believe the reason...." (when **they** isn't clear) should be avoided. Even "Most engineers regard..." is not good unless the statement is documented.

B3. CONCISENESS:

Reports should be as concise as is consistent with being complete and unambiguous. Most readers are busy people. They do not want to be burdened with thicker reports than necessary. Concise writing requires some assumption about the level of the reader. For the purposes of this course, the reader is the graduate student in charge of the lab or the instructor. Imagine these people to be your bosses in an environmental engineering consulting firm. In describing laboratory procedures, it is not necessary to go into detail about every step unless nonstandard techniques were used. Avoiding excessive verbiage requires practice and usually revision of the first draft. Some examples of how writing can be condensed follow.

1. Original

"First 7.9 pounds of copper were weighed out and transferred into a crucible. Then 2.1 pounds of aluminum were weighed and added to the crucible. Next the crucible was placed into the furnace and heated until it was determined that the metal was molten. The metal was then stirred and superheated to 1150°C. Finally the molten alloy was poured into an ingot mold..."

Rewritten

"A 10 pound ingot of a copper-21% aluminum alloy was prepared from metal by melting in a clay-graphite crucible in a gas-fired furnace. Stirring and superheating to 1150°C insured homogeneity and sufficient fluidity for casting..."

2. Original

"Exactly 9.8 grams of potassium thiocyanate were weighed out and put into a 1 liter flask. Then, distilled water was added to the mark. The solution was mixed until all of the potassium thiocyanate was dissolved. Three 25 ml samples of a known silver nitrate solution were measured and placed into conical shaped flasks. To each, 100 ml of distilled water was added. About 5 ml of concentrated nitric acid and 5 ml of iron (III) ammonium sulfate indicator were then added. Small amounts of the potassium thiocyanate solution were added to each until a red-brown color was observed. The amount of the potassium thiocyanate in the solution was then calculated from the amount of silver nitrate that reacted to achieve the color. The concentration of potassium thiocyanate was determined to be 0.1 M with a standard deviation of $\pm$0.025."

Rewritten

"One liter of 0.1 M ($\pm$0.025) solution of potassium thiocyanate (KSCN) was prepared and titrated against a silver nitrate ($AgNO_3$)

standard in an acidic medium with ferric ammonium sulfate indicator. To determine the endpoint, $AgNO_3$ was added until the red-brown color was permanent for 1 minute. The pH was adjusted with concentrated nitric acid."

Note that the rewritten versions are shorter and actually give *more* information. The reader will assume the weighing steps from the body of text. The reader will also assume the placing of metal in the crucible, and the dissolution of KSCN in water. The reader should also know standard titration techniques (if not, refer the reader to an appendix which goes through step-by-step instructions). Furthermore, neither example hides what is being done (preparation of an ingot, determination of a solution concentration).

B4. REFERENCES:

Statements of fact as well as descriptions of past work should be referenced so that the reader can, if she/he wishes, check these. This is done by inserting a number in the text at the appropriate place. The number corresponds to the number of the reference in a separate reference section. The number may be in (1) or [2] or it may be superscripted[3], but placed in the text where it will be clear to the reader what statement is being referenced. The numbers of the reference should be sequential, (1) referring to the first citation in the text, (2) to the second, etc. An alternative style is to have the authors and date in parentheses in the text of the report following the information that has been cited rather than using numbers for each citation.

In the reference section, the authors, the source, the date, and the pages should be given. Only those references specifically cited in the text should be listed. Below is an example of a portion of text and the corresponding reference section.

Research report excerpt:

"In a recent study, Nesbitt *et al.* (1) investigated the effect of thiourea as a sulfide donor in the removal of metal contaminants from water by precipitation as sulfides. The results of this investigation were the development of two processes that have direct industrial application. The study showed that copper, zinc, lead, cadmium, and mercury would be removed as metal sulfides. The results give credence to Pearson's Hard-Soft Acid-Base Theory (2) which predicts that each of these metals would combine with sulfur over any other species.

Many analytical procedures were used in this study. The atomic absorption spectrophotometer (see Ref. 3 for details of the analytical technique and flame conditions) was used for metal ion determination. Electron microscopic techniques (4) were employed for determining precipitate composition and structure."

References

1. C.C. Nesbitt, J.L. Hendrix, and J.H. Nelson, "Use of Thiourea for Precipitation of Heavy Metals in Metallurgical Operations Effluent", Extraction Metallurgy '85, Institute of Mining and Metallurgy, London, 1985.

2. R.G. Pearson, "Hard and Soft Acids and Bases", Journal of the American Chemical Society, 85(22), 1963, pg. 3533.

3. D. A. Skoog, and D.M. West, "Fundamentals of Analytical Chemistry", 3rd Ed., pp. 268-273, Holt, Rhinehart and Winston, New York, 1976.

4. M. Von Heimdahl, "Electron Microscopy of Materials", Academic Press, New York, 1980.

Table 1. Reference format of AIME (other periodicals differ slightly)

Journal:	J.B. Tucker, "Biotechnology Goes to Sea", High Technology, 5(2), (1985) pg. 34.
Book:	A.F. Taggert, "Handbook of Mineral Dressing", pg. 12-32, John Wiley & Sons, Inc., New York, 1940.
Paper in an anthology:	B.L. Bramfitt, A.R. Marder, and R.J. Dotton, "Continuous Deformation of Austenite to Develop Tough High-strength Steels", pp. 537-555 in The Hot Deformation of Austenite, John Ballance, ed., AIME New York, 1977.
Paper at a meeting:	J.J.C. Jansz, "Thermodynamics of Aqueous Chloride Solutions: Calculations of Ionic Activities and Distribution Data for Chloro Complexes", Presented at the Winter AIME conference, Los Angeles, February, 1985.
Private conversation:	Private communication, J.L. Hendrix, University of Nevada—Reno, January, 1985.

A reference to a book should include the publisher, city, and pages referenced (unless it is the whole book), e.g.,

20. R.B. Fischer and D.G. Peters, A Brief Introduction to Quantitative Chemical Analysis, W.B. Saunders Company, Philadelphia, 1969, pp. 135-137.

If the reference is to an article in a conference proceedings or book which is a compendium, the editors should also be cited, e.g.

30. D.M. Muir and A.J. Parker, in "Hydrometallurgy: Research and Development and Plant Practice", Eds. J.D. Miller and K. Osseo-Assare, pp. 341-356, AIME, New York, 1983.

If the author is unknown, the citation should start with the title of the work, e.g.

1. ASM Metals Handbook, Vol. 8, 8th ed., 1973, p. 259, A.S.M., Metals Park, Ohio.

A reference may be cited several times. It should not appear more than once in the list of references. All citations should be to the same number.

B5. FIGURES:

Figures include photographs, graphs, schematic drawings and other visual material. A Table is not a Figure! Figures should be numbered in the order to which they are referred in the text. They should appear either at the end of the paper (in a Figures section) or as soon after they are cited as convenient (preferable). All figures should be cited somewhere in the text.

Every figure should have a caption written **below** the figure, which is a title and as much of a description as can be concisely given. (A little redundancy with the text does not hurt.) As a general rule, one should put enough information in the title and description so that if the figure is viewed without the report it can be understood. In other words, it should be able to stand on its own. For a graph, one should try to avoid using the axes labels in the description. For example rather than to give a plot of pH versus concentration the title "Concentration as a Function of pH for Silver Nitrate", it would be better to use "Titration Curve of Silver Nitrate".

With the software that is readily available to all of us there is little excuse for producing anything but high quality graphs and figures. Some simple rules include:

- Axes must be clearly labeled as to the parameter and the units of measurement of that parameter;
- Data points (i.e., the actual measured values) should be clearly visible and not obscured by lines;
- Data points should **NOT** be connected by lines unless there is a specific reason for doing so;
- Regression lines should be clearly labeled as such;
- The type size and style (font) should be easily readable, not fancy;
- For photographs, some measure of scale or magnification should be given.

B6. TABLES:

Frequently the best way to present data is in the form of a table. As are figures, tables should be sequentially numbered (usually with Roman numerals) in the order that they are used in the text, and titles should be given above the table. Tables should appear at the end of the paper or as soon after the reference to them as is convenient.

B7. SUMMARY:

Reports should be written with the reader in mind. The writing should be concise, but unambiguous and complete. A summary is a useful way to put important information together in one spot.