

WRITING THE ECE-498B TECHNICAL REPORT

TEAM MEMBERS: J. O'Hanlon (editor)
S. Infinitive
D. Signer
Y. Work

TEAM NUMBER: 01

SUBMITTED TO: Prof. X. Pert
Dr. Clair Voyant
Mr. Venture Capitalist

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ECE-498B
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
UNIVERSITY OF ARIZONA, TUCSON, AZ



Two team members from Project 01: Left, team typist; right, third-generation team leader. Photograph © Paul O’Hanlon. This frontispiece is included to illustrate the proper location for a group mug shot, or photo of the team’s project. The photo belongs here, not on the document cover!

ABSTRACT:

This document describes how to prepare the ECE-498B final technical report. It was written in response to questions asked by students in prior years. The document presents concepts with printed images and sometimes jaundiced writing. The completed nineteen-page document explains the content of each section, notes some commonly observed grammar errors, and provides detailed formatting instructions.

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I. INTRODUCTION

A. Overview

The purpose of a technical report is to explain fully and document carefully your knowledge of the design problem, criteria, procedures, methods, materials, results, and conclusions drawn from the Capstone design project. Here, the audience will be your instructors and peers. In the “real world,” the audience will be your supervisor, project manager, development director, other engineers, and perhaps a customer. Some of these individuals may have a significant influence on your career path, promotion and salary. The wise engineer values clear and concise written communication skills.

B. Contents Outline

The report structure adopted for ECE-498B is similar to the classic “scientific method,” [1] and consists of the following components. Please view the “forest” before examining the “trees.”

- Title Page
 - Abstract
 - Table of Contents
 - List of Figures
 - List of Tables
 - Introduction
 - Design Criteria and Specifications
 - Design and Results
 - Conclusions
 - Acknowledgement
 - Symbols / Glossary (optional)
 - References
 - Appendix
-
- The diagram uses curly braces to group the list items into three categories: 'Front Matter' (Title Page, Abstract, Table of Contents, List of Figures, List of Tables), 'Body' (Introduction, Design Criteria and Specifications, Design and Results, Conclusions, Acknowledgement), and 'Back Matter' (Symbols / Glossary (optional), References, Appendix).

Technical reports are divided into sections, which are ordered in a logical progression: front matter, body, and back matter. The detailed descriptions of each section are provided here.

C. Front Matter

The front matter is intended to outline the document and provide the reader with a view of its contents.

1) *Title page:* The title needs to state clearly the subject of the report. Chose as brief a title as possible. Long-winded titles are often unclear. Other information required on the title page include the names of the team members (identify the editor), the faculty and mentors to whom the report will be submitted, the date, the course number, department, and university. The date shown on the report will be the date on which it will be submitted.

2) *Frontispiece:* Occasionally, the front matter may include a frontispiece, (usually a photograph), which faces, or in this single-sided document, follows the title page. This is the

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appropriate location for inclusion of a team mug shot, or a photo of the team's prize lunar lander. **Do not** include photographs on the title page of the report! You are writing a technical report, not an advertisement for dish soap.

4) *Abstract*: The abstract is one of the most important parts of the front matter. It is the abstract that is published in on-line journal abstracting services. It is the abstract that the department director first reads. If the abstract is vague or nondescript, the reader will soon lose interest. This is your window to the world, your advertisement! If the reader (read: boss) loses interest half way through the abstract ... Ah yes. We mentioned your boss approves raises.

Many abstract-writing procedures this author has seen are convoluted, or unduly complex. An abstract is really quite easy to write; however, there is one catch—it must be written after the report is finished. There are 4, count them four, and only four parts to an abstract. No part needs to be more than one sentence. Most journals limit the length of the abstract to the order of 40-to-75 words. The abstract to this report is 56 words long. The four parts are: (1) **What**, (2) **Why**, (3) **How**, and (4) **Result**. Figure 1 illustrates a useful abstract, whereas Fig. 2 depicts an abstract that will not get you nominated for the Pulitzer Prize.

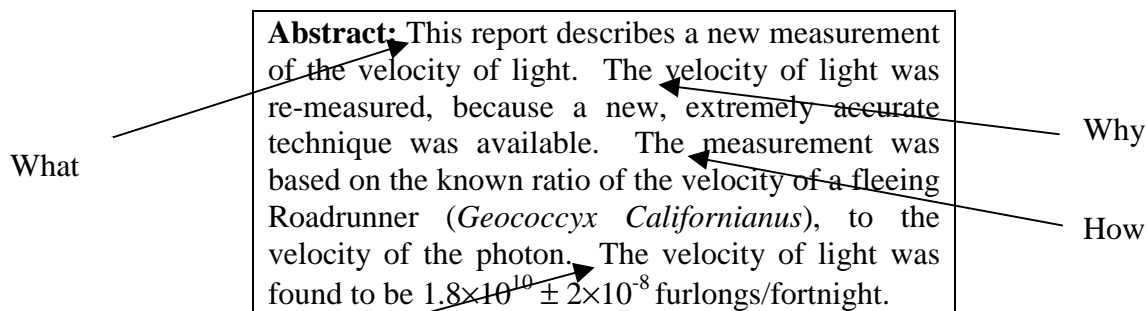
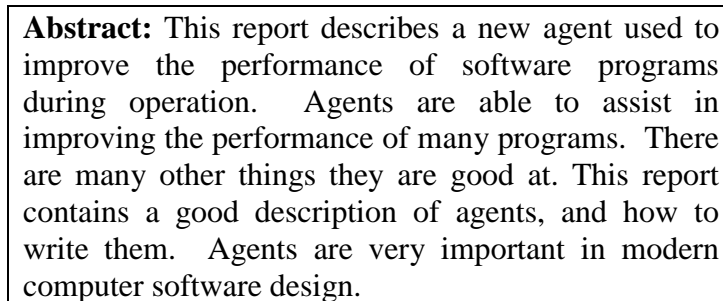


Figure 1. A descriptive abstract

Result



Abstract: This report describes a new agent used to improve the performance of software programs during operation. Agents are able to assist in improving the performance of many programs. There are many other things they are good at. This report contains a good description of agents, and how to write them. Agents are very important in modern computer software design.

Figure 2. A useless abstract

There is no information in the second abstract. It does not tell what the team did, why they did it, or how it was accomplished. Most importantly, it does not include any team results. One is tempted, when reading abstracts like this one, to conclude that the team did not finish its

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assignment! This conclusion was verified after reading myriad reports that were submitted to this grader during the last semester.

5) *List of Figures and Tables*: Not much to these sections, just a grocery list of legends and page numbers. Please place them on separate pages.

6) *Table of Contents*: Usually this is the last item in the front matter. The Table of Contents can consist of only major section headings, or include as many as two levels of sub-headings. This document has one subheading level. Try to limit the Table of Contents to one page.

D. Body

The body of the report is the heart and soul of your work. Write it carefully and concisely; make each word count. Always begin with an outline; review the outline carefully with your team members and perhaps with one of your instructors before writing the first word.

1) *Introduction*: The first section of the report body is redundantly entitled “Introduction.” The IEEE seems to like that title. This writer considers that an insult to the reader’s intelligence. However, the object here is to follow IEEE format. The Introduction describes the “what” and “why” of the report, and contains the following three sub-sections.

a) *Problem statement*: The problem statement was written for ECE-498A. It can be used in the final report, after including any corrections suggested by the technical writing instructor.

b) *Problem objective*: This sub-section provides the team’s objectives for solving the problem. Please, one paragraph; two paragraphs at most.

c) *Background*: All technical reports begin by providing a brief history of the problem, with a discussion of solutions attempted by other researchers. It is in this section, that your solution is placed in the context of prior works. References must be cited! The background should be complete, but remember, the reader wants to see what your team accomplished. It is not necessary to write a text-book-length dissertation! Please, quality before quantity. This reviewer has seen six-page background sections! Consider a typical journal publication of four-to-six double column pages in length; the background might be as long as one column. Please, do not try to make up for lack of real project data by including a tedious, long, detailed background discussion. Two pages should be enough, perhaps three at the most.

The introduction section should conclude with a statement that describes the scope of the report. This will tell the reader how broad or narrow the treatment will be, and will serve as a lead-in to the next section. It is not necessary to be verbose; the best writing is clear and concise. Be aware that it takes more time to write concisely, than it does to prattle on endlessly.

2) *Design Criteria and Specifications*: This section begins with a list of the design criteria and specifications for the team’s project. This can be a simple unnumbered (or bullet) list, giving all relevant data.

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3) *Design and Results*: The details of what the team accomplished, how it was done, and the results achieved belong here. This will be the longest and most detailed section of the report.

Here one explains all procedures, materials, and methods, and logical reasons for the choices made. This could be organized in a number of ways, perhaps a software section, and then a hardware section. Alternatively, one could have a theory section followed by design, construction, implementation, testing, and results sections. The organization and flow of this material will be determined by the nature of the technical topic. Spend some time planning this section; consult with an instructor, should you have any questions. Certain details belong in an Appendix.

4) *Conclusions and Recommendations*: Technical reports are not valuable unless they contain conclusions. The conclusions are the inferences drawn from the work, and must be supported by the data. The conclusion or summary of the work needs to be concise. The conclusion should never introduce new material.

It is appropriate to include a paragraph detailing recommendations for future work. These recommendations demonstrate your physical and intuitive understanding of the project. They show where it could benefit from further work. Recommendations, of course, do not need to be supported by data.

5) *Acknowledgement*: It is important to acknowledge the help provided by companies and individuals in the performance of your Senior Project. This is the appropriate place.

F. Back Matter

Material that is not required to read the report is placed in this section. It will consist of references and appendixes; it may possibly be preceded by a List of Symbols, and possibly a Glossary of Terms. Symbol lists are not as common in reports as they might be, but many of 498B reports last semester did include glossaries within the text that most properly belonged in an appendix. Their placement distracted from understanding the material.

1) *References*: This page includes references to all the sources used in the preparation of your report. Please include sources from which you have obtained equations, figures, quotes, or ideas that you have summarized or paraphrased. Sources include books, technical reports, on-line publications, periodicals, conference proceedings, theses, dissertations, standards, and patents.

Be careful when using the citation "personal communication." Citations exist to provide written clarification or proof. A personal communication has no written element! Such a citation is used only when it is necessary to give credit for an idea suggested by another engineer.

2) *Appendix*: The appendix usually contains detailed information that would interfere with the flow of the document. Typical examples are detailed calculations, computer code, experimental process recipes, equipment operating procedures, raw data, and component specifications. Like humans with appendicitis, reports with many appendixes and little text can be painful. One editor suggested to this writer a good way of reducing the size of a book: suggest to the author that many items be moved to the appendix, and then, as the book goes to press, delete the appendixes!

II. WRITING STYLE

Writing styles are personal. Regardless of your style, it must communicate information clearly to the reader. Below are a few writing guidelines that you may find useful. These comments, summarized from another source [2], were included after spending hours painfully reading reports.

A. Punctuation

Comma use varies. Some writers used the closed form, where a comma is placed before the conjunction [a, b, and c], whereas other writers use the open form [a, b and c]. In general, one uses commas before the conjunction, when joining two parts of a compound sentence, but avoids excessive use elsewhere. Do not use a comma to set off a mathematical variable in a sentence [The speed of light C is given in units of m/s.], unless it would be its normal place.

B. Hyphens

Hyphens need not be used excessively. Hyphens are not necessary in technical noun combinations [z axis, dc voltage], although some electronic grammar editors, such as Word 97 may disagree [z -axis]. Hyphen use changes with time (hyphen \rightarrow two words \rightarrow merged words), so it is best to consult a modern dictionary for current usage. Note how *trademark* has become one word, whereas *service mark* is two words. Hyphens in trademarks and service marks should be retained. [Windows-98] Modifying words should be hyphenated where helpful [twenty-second exposure].

C. Capitalization

- Capitalize trademarks and service marks.
- It is good form to include the generic immediately after the trademark and use the trademark or copyright symbol at first use [Windows-98[®] operating system].
- Generic words that were formerly trademarks [aspirin, escalator] are not capitalized.
- Do not capitalize *ac*, *dc*, or *rf*.
- Capitalize the first letter of an abbreviation when used at the beginning of a sentence. [*Rf voltages are more dangerous than dc voltages...*]

Within titles and headings one should:

- Capitalize the second word in hyphenated expressions. [*High-Speed Roadrunner*]
- Prepositions, conjunctions, and articles are not capitalized, unless they follow a colon, a dash, or are part of a hyphenated expression. [*Dust in the Air: A Long-Term Study*]
- Capitalize acronyms in titles and headings. [*DC Voltage Converter*]
- Capitalize the word following a symbol that begins a sentence [(*100*) *Silicon ...*]

D. Units of Measure

Technical publishers use System International (SI) exclusively in all works. This reviewer notes three common errors relating to the use of units in prior Capstone final reports. First, the

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Angstrom [\AA] is no longer used. Please use the nanometer [$1 \text{ nm} = 10 \text{\AA}$]. Second, with the exception of percent %, inches ", and degrees °, a space is used between the numeral and unit. [*10 oz, 6 V dc, 100%, 59°C, 64 MB, 12", 60 Hz*]. The dollar sign precedes the numeral with no space. Third, use the shilling mark with care when expressing compound units. The unit $\text{Pa}/(\text{m}^2\text{-s})$ can be misinterpreted when written as $\text{Pa}/\text{m}^2\text{-s}$. The parentheses remove all doubt! Alternatively, one may use the exponential form: $\text{Pa}\cdot\text{m}^{-2}\text{-s}^{-1}$.

E. Cross-Referencing Tables, Figures, and Equations

All tables, figures, and equations will be numbered. Cross-references to tables use their Roman numeral [*Table XX*]. Cross-references to Figures use their Arabic number. "Figure" is spelled out when beginning a sentence, but abbreviated within a sentence. [*Figure 4 illustrates the fleeing roadrunner, whereas Fig. 5 illustrates the coyote in full pursuit.*]

Ditto for "equation," except that lower case is usually used within a sentence. [*In eq. (4.2)...*]

III. CLEAR AND UNCLEAR USAGE OF GRAMMAR

We speak and write with different vocabulary, sentence construction, and logical sequences. One common technical report writing mistake that has been observed by this writer is the practice of writing in the spoken voice. This style does not make for a good technical report! The style in which you present your oral report to your class will be much different than used in a good technical report. Below are listed some common problems observed by this technical writing. Some of this material was summarized from another source [3].

A. *Needless Words and Phrases*

Space-filling words are useful in speaking—they provide a pause, or allow for a change in direction—but do not add to a written document. Filler statements (see below) serve no purpose.

- *As everyone knows ...*
- *4 x 8 feet in size*
- *The ball is yellow in color*
- *In the field of engineering ...*
- *Stainless steel is the type of material that ...*
- *It is interesting to observe...*
- *With respect to the project at hand ...*
- *In this context it may be said that ...*
- *After careful consideration it was concluded that...*

Simplify these statements, and eliminate useless words. The following meanings are clear.

- *It was observed...*
- *The panel is 4 x 8 feet...*
- *In engineering...*

B. *Fluffy Fillers*

Never use a pretentious phrase when a simple phrase would suffice. (This does not mean the same as writing with a third-grade vocabulary!) Try to avoid phrases such as shown here:

- *The classical underpinnings of computer science...*
- *It is the opinion of our esteemed colleague...*
- *The semiconductor industry has witnessed the birth of a new technology*
- *The significant contributions of this author...*
- *The computer revolution is controlling our destiny...*
- *Particle control is an integral part of any serious effort...*

C. *Unnecessary Prepositions*

The use of unnecessary prepositions makes sentences stutter. Try to avoid phrases like:

- *The team counted up all the resistors on the board.*
- *When all the data have been analyzed, the team will decide as to whether...*
- *The cables enter into the robot...*
- *The team faced up to its failure...*

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D. Fowler's Rule

Proper use of the words *that* and *which* will make your writing clear.

- *That* introduces a clause that restricts the meaning of the noun. No comma before *that*!
[*It is necessary to remove contamination that causes defects.*]
- *Which* adds meaning to the sentence without restricting the meaning of the noun.
[*Airborne particle counters, which were invented in 1980, are used to improve chip yield.*]

E. Time and Place

Time and place are often confused in technical writing. *While* and *when* connote time. Grammarians will allow *while* to mean both *at the same time*, and *although*. *Since* can have three meanings [4]:

- *In the time period*
[*Prof. O has never spoken to me, since last year.*]
- *Ever since*
[*Since the invention of the particle counter, chip yields have improved.*]
- *Because of*
[*Since Prof. O's explanation, the students were able to do the problem.*]

Technical editors often limit the use of *while* and *since* to their temporal meanings, and in this manner, remove any ambiguity in their use.

Correct:

- [*The voltage across the resistor increased, while the current decreased.*]
- [*Electrons are small, whereas ions are large.*]

Incorrect:

- [*The half-watt resistor was brown, while the one-watt resistor was blue.*]
The writer meant *but* the one-watt..., or *whereas* the one-watt...
- [*Where faculty do not schedule exit interviews, meeting seniors takes two weeks instead of three days.*]
The writer meant: *If* faculty do not... or *When* faculty do not ...

Confusing:

- [*Since Team 21 was restructured, the workload has been uniformly distributed.*]
The writer meant: *Ever since* Team ...
- [*Since the robot's success, other teams have entered the competition.*]
The writer meant: *Because of* the robot's success...

F. Where's the Preposition at?

In English, the emphasis comes at or near the end of the sentence; therefore, we do not end a sentence with an unnecessary preposition or adverb. There are rare instances where one can end a sentence with a preposition, but not in technical writing. A very famous comment was made by Sir

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Winston Churchill that addressed this issue. After receiving a Minute issued by a priggish civil servant, objecting to the ending of a sentence with a preposition and the use of a dangling participle in official documents, Churchill red-pencilled in the margin [5]:

“This is the sort of pedantry up with which I will not put.”

Asking your advisor “where the satellite is at” is not one of those rare instances!

G. *The Suicidal Participle*

The dangling participle can make the meaning of the sentence ambiguous. Consider the following two sentences:

- [After examining several materials of construction, the robot was covered with Lucite.] Examining is the participle, and it is hanging way out on its own! The sentence can be made quite clear by giving the participle a noun or pronoun anchor. Anchor it like so...
- [After examining several materials of construction, Team 21 covered the robot with Lucite.]

H. *To Incorrectly Split the Infinitive*

The sign of the infinitive goes next to the infinitive: [to solder, to compute...] It’s OK for Hemmingway to artistically split the infinitive, but this writer will not give you that freedom!

I. *Writingwise*

The suffix *-wise* has become overused to the point of becoming a fad. Clear technical writing does not substitute vague words for precise words. Please! Avoid the indiscriminate use of constructions like: *engineeringwise, computerwise, powerwise, frequencywise, voltagewise, energywise, timewise, managementwise, contractwise*, and so forth.

J. *Jargon*

Technical writing is full of jargon, acronyms, and other techniques for obscuring clarity. Always write out the full meaning of a phrase, followed by enclosing the acronym in parentheses at its first use. After first use, the acronym will suffice. The Abstract does not qualify for first use. If you define an acronym in the Abstract, do it again the first time it is used in the body.

Substituting correct engineering department titles, or function descriptions with jargon makes for tacky writing. Sentences like:

- [Reliability says that the devices are no good.]
- [Without the widgetron, test will have to push assembly.]

do not make for clear writing. In a similar manner, avoid using nouns as verbs

Come on folks, you are college seniors; these are things you should have learned in freshman English!

IV. FORMATTING A TECHNICAL REPORT

Wherever one goes, one will have to write reports or perhaps archival papers. Camera-ready copy is now commonplace. Employers, grant agencies and publishing houses have established styles or formats within which material must be organized. The ECE-498B Senior Capstone Project will use a modified IEEE format. The IEEE Transactions and Journals are published in a two-column, double-sided format. This report will be formatted in one column, and printed on one side of letter-sized 8 1/2"×11" paper. The same font styles will be used; however, font sizes will be increased, and the Running Header, Running Footer, page margins, and Title Page text will be different from an IEEE Transaction.

A. Document Layout

Set page margins to 1" on all four sides. Set Running Headers and Running Footers at 0.6". Many ink jet printers can only print to within 0.5" of the Header or Footer boundary; therefore, setting these margins to 0.6" will ensure that all of the Running Footer text line will be printed. The page layout is illustrated in Fig. 3. These parameters are easily set in any word processing software.

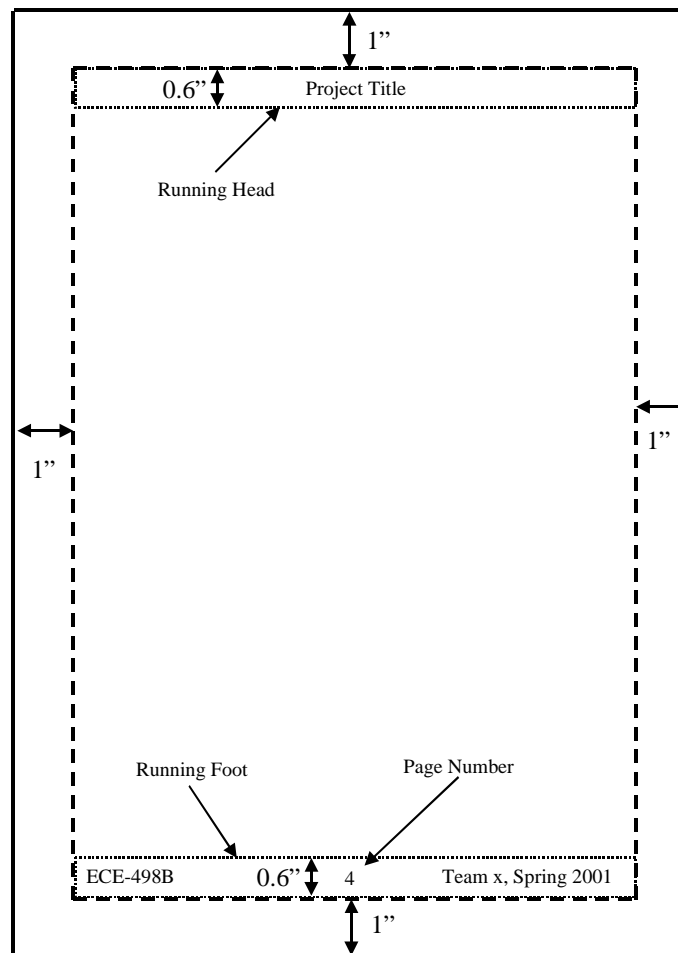


Figure 3. Page layout, showing margins, running headers, and footers.

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2) *Section Breaks:* The Running Header and Footer information will differ in the Front Matter, Body and in the Appendix portion of the Back Matter. The easiest way to deal with this problem is to use the word processor's ability to insert electronic "section breaks." By this device, the content of the Running Header and Running Footer can be changed as appropriate. The content of the Header and Footer will be defined in each (electronic) section. The Running Header either will be empty or will contain the report title. The Running Footer will contain only the page number (centered), or the course number (left justified), the page number (centered), and the Team number, semester and year (right justified.)

The body of the report will be enumerated in Arabic numerals, beginning with 1, whereas the front matter will be enumerated in Roman Numerals, beginning with i. The Title Page is not numbered. See the front matter in this document for clarification. All word processing software can divide material into sections. Within each section, commands such as pagination style, or first page numbering can be set to the desired report format.

3) *Font Selection:* The most pleasingly formatted documents use few fonts. One font is used for text and either the same or a minor variant is used for major headings. A simply composed document can be most attractive and easy to read. One should choose an easily read serif font for text, such as the Times Roman[®] typeface. (Press Times[®], Times New Roman[®], etc. are similar variable-pitch typefaces). Some document formats use sans-serif heading fonts. The use of sans-serif for body text can result in eyestrain. Serifs (the little points at the corners of characters) increase the character's high spatial frequency content, allowing the eye to read the character with less distortion, and from a greater distance. (In an analogous fashion, sound systems compensate for the reduced high frequency response of the human ear by amplifying these frequencies.) Use the following fonts for this report.

TABLE I. FONT SELECTION
FOR THE ECE-498B REPORT

Item	Times New Roman Font				Small Cap
	Points	Normal	Bold	Italic	
Text	12	×			
No 1 Heading	18		×		×
No 2 Heading	12			×	
No 3 Heading	12			×	
No 4 Heading	12			×	
Figure Legends	11	×			
Table Legends	11	×			×
Table Text	11	×			
Citations below tables	10	×			
Running Head/Foot	12	×			

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Italic and bold are used only for emphasis. One may use italic to set off software commands, or for quotations, etc. By limiting their use, they retain their ability to emphasize.

B. Front Matter

1) *Covers*: The front cover may be either a sheet of clear plastic in front of the Title Page, or card stock on which the Title Page information is printed. Place a blank sheet of card stock after the last page, and staple. No need to spend hard-earned money on fancy covers.

2) *Running Header and Footer*: No text is placed in the Running Header of the Front Matter, and only the page number is placed in its Running Footer. Pages will be numbered in 12-pt. lower case (Times Roman) Roman numerals, with no page number printed on the report cover. (The page following is numbered “ii.”) See this report Front Matter.

3) *Title Page*: Format exactly as shown on this title page. Please use exactly the same vertical spacing as shown on this title page. Use Times Roman 24-pt cap and small cap font for the report title. Use Times Roman 12-pt cap and small cap for remainder. All remainder in bold, except for names and date. See this report Title Page.

4) *Frontispiece*: New page, caption below, center, if one or two lines, justify if three lines or more are needed. Credit all photos or material taken from other sources. See this report frontispiece.

5) *Abstract*: New page, title: 18-pt. Cap and small cap, centered. Skip 1 line, begin text. Text begins with 0.25” indent. See this report Abstract.

5) *List of Figures*: New page, title: 18-pt Cap and small cap, centered. Skip 1 line, begin figure list. Indent descriptions 1in. Reference page numbers. See this report List of Figures.

6) *List of Tables*: New page, title: 18-pt Cap and small cap, centered. Skip 1 line, begin table list. Indent descriptions 1in. Reference page numbers. See this report List of Tables.

7) *Table of Contents*: Format as shown in this report. New page, title: 18-pt cap and small caps, centered, skip one line, 12-pt. bold, skip 1 line, begin outline list in 12-pt. normal. Right justify page number entries. Page numbers are given only for No 1 headings. (The beginning of each major section.) See this report Table of Contents.

C. Body

1) *Running Header and Footer*: The Running Header will contain the report title in 12-pt normal cap and lower case (clc). The Running Footer will contain 3 items: Left justify the phrase “ECE-498B.” Center the page number. Pages will be numbered in 12-pt. lower case (Times Roman) Arabic numerals, beginning with “1.” See page 1 of this report. Right justify the phrase “Team [number], [semester] [year],” see this Running Footer.

2) *Section Headings*: Please follow section-heading styles described below; use fonts described in Table I. Examples of section headings can be found throughout in this report. For example, the heading immediately above is a No 2 heading.

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a) *No 1 Heading*: Begin new page. 18-pt bold. Center heading. Number with Roman numerals; heading title in cap and small caps. Skip 1 line; begin text. Note: IEEE two-column format does not begin a new page with each new No. 1. heading. This would result in much wasted paper. However, in a 12-point, 6 1/2"×9" single-column report, a page break improves reading clarity. See "I: Writing the ECE-498B Technical Report" heading on page 1 of this report.

b) *No 2 Heading*: No new page. Number with capital Arabic letters, 12-pt, italic, no indent. Skip one line; begin text. See for example "*C. Body*" on previous page.

c) *No 3 Heading*: No new page, Number with Arabic numbers, 12-pt, italic, indent heading and first line 0.25", colon, followed by text. See for example "2) *Section Headings*:" on previous page.

d) *No 4 Heading*: (**IF** needed.) No new page. Number with lower case Arabic letters, 12-pt, italic, indent heading 0.5", colon, followed by text. This paragraph begins with a No 4 Heading.

3) *Tables*: Tables and table legends are horizontally centered on the page. If the legend requires more than one line, center all lines, as illustrated in the table below. Table legends are set above the table, with a line-space between table and legend. See for example, Table II. Skip 2 lines between the table and the text that follows, space permitting. Set tables at the top and/or bottom of pages, but not in the middle of a page with text surrounding. The page is easy to read when type set in this fashion. (In IEEE two-column format, it will be done differently.) Please cite data in tables, if taken from another source. See below. Units: The easiest way to deal with units in a table is to include them in the line just below the variable. In this manner, they will only have to be stated one time in the table. See for example, the unit formatting in the Table II, below.

TABLE II. BACKSTREAMING RATES VS TYPE OF BAFFLE
INSTALLED AT ENTRANCE TO DIFFUSION PUMP

Conditions	Duration of Test (hr)	Backstreaming Rate ^A (mg-cm ⁻² -min ⁻¹)
Without Baffle	165	1.6×10 ⁻³
Without LN ₂ Trap	170	5.6×10 ⁻⁶
+ Creep Barrier	240	8.7×10 ⁻⁸

^A Reproduced with permission from [*Book Title*] or [Article] and [complete citation]

4) *Figures*: Figures, and figure legends of one or two lines are centered. Legends of longer than two lines are justified, as noted in recent Proceedings and Transactions. Figure legends are set below the corresponding figure, See Fig.'s 1-3. Skip one line between the top of the figure and the text above. Skip one line between the bottom of the figure and its legend. Skip 2 lines after the legend space permitting. Type set figures at the top and/or bottom of pages, but not in the middle of a page with text surrounding. (This is not done in IEEE two-column format. In a

one-column full-page format, a central block of text is easier to read, than two blocks of text—one below each figure.) Please cite data used in figures, if taken from another source. **Label axes in figures!** Provide the variable name **and its units!** An example is shown in Fig. 4, on the next page. Do not use colors to distinguish parameters on a figure. They will not photocopy. Use symbols, and provide a key to the symbols in the figure legend. See Fig. 4. Ever hear of “error bars?” If you have not, you might consider including them in graphical presentations of your experimental data. Your boss will not think much of you, should you not be able to put a value on the accuracy of each data point. IEEE format does not permit boxes around figures.

Suggestion: Import your graphical data into PowerPoint, and then format the legends, etc.

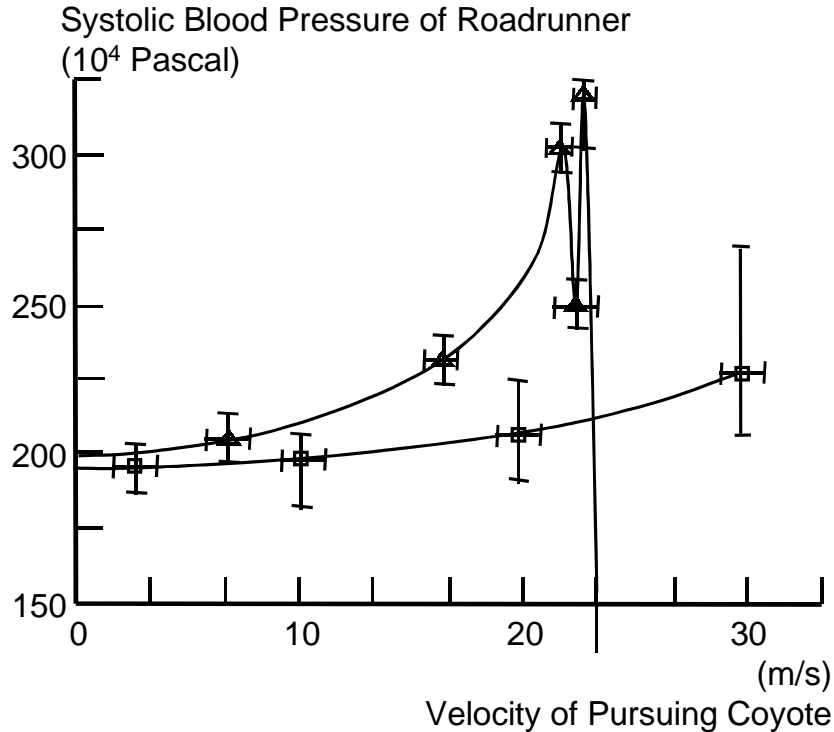


Fig. 4. Roadrunner heart failure vs. velocity of the pursuing coyote:
 □—□—□ Hot summer day; △—△—△ cold winter day.

5) *Paragraphs:* Justify paragraphs. Indent first line of all paragraphs 0.25”. No line space between paragraphs. Please do not write in first person. Please do not begin a discussion by saying “First, we have... and then never have a “second” or third!” Be consistent! Please express ranges as 45–99 mV using the “en-dash,” and not the short dash. Please remember that *data* is plural, and *datum* is singular. Center equations; right justify equation numbers, like so.

$$L = \frac{\mu}{\mu_0} \frac{\delta}{2} \frac{\partial L_0}{\partial x} \quad (1)$$

6) *Trailing Fragment:* A trailing fragment is a short bit of a line, at the end of a paragraph that will not fit on the end of the page. It looks dumb when a line fragment is set on the top of the

next page.

This example of a trailing fragment shows how it detracts from the page layout and ease of reading. There are at least four ways to remove these little bits of type: (1) Re-write the material in a shorter form. (2) Use the word processors font kerning to shrink the spaces between words in a paragraph. (3) Manually reduce any blank lines 12 pt. to 10 pt. several places on the offending page, (4) or for short paragraphs, use a page break to move the entire paragraph to the following page.

Most word processors will automatically move the last two lines of a paragraph to the top of the next page, and avoid this irritation. However, this results in a wasted line at the end of the prior page. Best to shorten the paragraph.

7) *Acknowledgement*: New page, 18-pt. cap and small cap, centered, no Roman numeral. Skip 1 line, begin text with 0.25" indent.

D. Back Matter

1) *Running Headers and Footers*: These will contain the same text in the Header and Footer, with the exception that the appendix is repaginated, beginning with page number A1. Use the word processor's "section break" command, to create a new "electronic section) at the beginning of the Appendix. In this way, one can alter the pagination style without affecting the pagination within the body.

2) *References*: New page, 18-pt. cap and small cap, centered, no Roman numeral. Skip one line, begin list. Please use "end-note" style (references at the end of the document), rather than footnote style (references at the bottom of each page). Use the in-line numbering style - the number is enclosed in brackets after the material, as shown later in this paragraph. Please use IEEE reference format. This information is available on the IEEE Internet Home Page [6]. This Adobe Acrobat[®] page definition file describes precisely how to cite any publication from old book to Internet address. When citing a reference at a later point in the report, simply use the same number. Do not use the *ibid.* (the page just cited), or *op cit.* (in the work cited).

Appendix references are treated somewhat differently, because the appendixes follow the reference list. Format those references at the end of the appendixes, in the form shown on page A1 of this report.

3) *Appendixes*: Begin each appendix on a new page. Use 18-pt bold, cap and small cap center on top of page. First line: APPENDIX I (Roman numeral numbering) Second line: TITLE, then skip one line and begin text with 0.25-in indent. Repaginate as described in 1), above.

V: EDITING THE REPORT

It is extremely important that one team member be appointed editor of the document. Although individual team members will write portions of the material, one person must edit the final document for consistency, form, style, and English usage. That individual should be identified and be listed as the lead author on the Title Page.

This author has learned a great deal from publishing-house editors, since writing and composing several books. Here are some hints that can be applied to technical paper writing. First write a section, then put it away for a few days. Then and only then, re-read it for style and flow. Your mind needs some time before it will forget what you wrote, and see it anew.

Second, ask a team member to read your writing—another person will spot detailed problems or errors your mind has been “programmed” to ignore.

Third, verify any original manuscript or section that was hand written or typed, prior to word processing. Typeset text must be compared with its hand-written original. This is done most accurately by two people: one person reads the original aloud, while the other person listens, and compares the spoken word to the typeset text.

Forth, when assembled, edit the document for only one item at a time. For example, start at the beginning and check the formatting of all headings (No’s 1–4). Make a list on a separate sheet of paper, A, 1) 2), B 1), 2) 3), C, etc. It is easy to confuse sub-headings. Start again at the beginning and check all paragraph indents. Start again at the beginning and check all table legends. Start again at the beginning and check all figure captions. Start at the beginning, crosscheck all references, and so on. One is doomed to failure, if one attempts to verify myriad formatting details all in one “pass.” There are simply too many items to remember.

Fifth, check spelling with a computer spell checker and visually! Spell checking involves pattern recognition and context as well. Repeated word errors are not easily spotted by eye, if a line break appears in between. Stop. Did you catch that one? For example, a word containing a double “el” may not be easily recognized when misspelled with a single “el.” However, a word with a double ascender (ll, tt, dh) that had a “short” letter mistyped in between will be easily visible to the eye, because the word’s shape has been significantly altered. These are just a few advantages of a spell checker. However, don’t forget the obvious; spell checkers do not detect errors that generate different, correctly spelled words! [*break, beak; meet, meat.*]

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APPENDIX I: LANGUAGE DIFFERENCES

Engineers whose second or third language is English sometimes have trouble writing in English. This is not true in general. Some of the very best writers I have ever known learned English as their second, third or fourth language. Since English has its roots across the Atlantic, it is often easier for students from these countries to master English than it is for students from the Pacific, but not always. Chinese speakers face difficulties due to the large structural differences between the two languages. To come from Chinese to English is indeed, a very great jump. The comments that follow were penned by a Chinese scientist to help others understand these differences [1].

Chinese is a character language, not a phonetic language. A Chinese writer's own language does not consist of an alphabet made of a finite number of letters. It has a seemingly infinite number of different characters. Chinese students have a well-developed memory, because mastering Chinese is far more difficult than mastering English. One of the greatest grammatical differences between Chinese and English is the lack of verb tenses in Chinese. A verb in Chinese is very much like a noun in English. Its doesn't change according to time or noun subject. Verb agreement and correct verb tenses are two issues that make English difficult for Chinese writers.

Sentence length is another adaptation that must be made by Chinese writers. In their language, a sentence can be any length at all. "Pearls on a string," they have been called. In English, these are called "run-on" sentences. Because it is a character-based language, Chinese words do not have as many forms as English words. Articles are not used in Chinese, so it is not easy for a new English writer to know when they should be used. Neither verbs nor nouns change form. The same character represents the singular and plural forms, so it is difficult for the new writer to know when to use plurals. In technical documents, this sometimes results in awkward English expressions such as "many equipments." Comparatives also present problems to non-native speakers of all backgrounds. In particular, whether to use [*-er, -est*], or [*more, most*]. The two forms found their way into English from different routes- German and romance languages, respectively, and there is no easy solution.

1. Unpublished Note, "What Particular Problems do Chinese Speakers have with English and Why?" Attributed to Jim Su, Member Technical Staff, AT&T, Bell Labs. Circa 1988.