6.021J Guide to Report and Proposal Writing

Quantitative Physiology
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Preface

This guide is meant to provide 6.021J students a comprehensive tool for writing proposals and reports in this course. This guide includes information developed by 6.021J technical and writing staff as well as information from *The Mayfield Handbook of Technical Style*.

Writing Resources at MIT

Your 6.021J staff is the best resource you have about writing in 6.021J. If you want help outside of 6.021J, visit the Writing and Communication Center <http://web.mit.edu/writing>.

The Mayfield Handbook of Technical and Scientific Writing and other on-line resources are available at the Writing Program homepage. Note that the Mayfield Handbook is a GENERAL GUIDE and not tailored to the expectations of 6.021J.

1.0 Effective Technical Communication

"The fundamental purpose of scientific discourse is not the mere presentation of information and thought but rather its actual communication. It does not matter how pleased an author might be to have converted all the right data into sentences and paragraphs; it matters only whether a large majority of the reading audience accurately perceives what the author had in mind"
- George Gopen and Judith Swan, "The Science of Scientific Writing"

1.1 Accuracy, Clarity, Conciseness, and Coherence

Good technical communication is accurate, clear, concise, coherent, and appropriate.

Accuracy, which is the careful conforming to truth or fact, has three main aspects:

1. *Document accuracy* refers to the proper coverage of your topics in appropriate detail. Document accuracy is generally cultivated by a clear problem statement and by a preliminary outline.
2. *Stylistic accuracy* concerns the careful use of language to express meaning. Accurate language requires the careful use of paragraph and sentence structure and word choice to describe and analyze your topics effectively. Stylistic accuracy is also a matter of using words precisely.
3. *Technical accuracy* depends on the writer's conceptual mastery of the subject and its vocabulary, as well as on his or her ability to analyze and shape data with a minimum of distortion.

Clarity, which refers to ease of understanding, is a special problem in science and technology writing. Increase the clarity of your material in several ways:

1. *Structural clarity* makes it easy for the reader to get the large picture. Tables of contents, problem statements, and even strategic repetition also promote structural clarity. Graphs and tables, effectively worded headings guide readers and help keep the large picture in focus.
2. *Stylistic clarity* is promoted by simple, direct language. Word choice is a factor in stylistic clarity: use simple language wherever possible to counteract the abstract, highly specialized terms of science and technology.
3. *Contextual clarity*, in which the importance, authorization, and implications of your work are made available, also contributes to ease of understanding. All work has a context, and your readers want to understand what the context of your document is. What prompts you to write? What is your purpose? Whose work precedes or has influenced yours? What is the organizational and intellectual context of your problem? Answer those questions in introductions and problem statements and in your citations and other references.

Conciseness, which refers to the expressing a great deal in few words has a special value in technical fields. Writers are often tempted to include everything that could be relevant to their subject, rather than merely what is focused, relevant material for their report. The concise document is a piece of writing that conveys only the needed material. Increase conciseness by:

1. *Narrow the document scope* to a manageable problem and response.
2. Prepare a clear *introduction* and *develop a detailed outline*. These are two strategies that give you control over document length and scope.
3. *Identify and eliminate material* that is not necessary to support your claims. Look for sections, including appendixes, that are not essential to your work.

Graphics are powerful aids to conciseness because they cut down on the amount of prose necessary to describe objects and processes, summarize data, and demonstrate relationships.

Coherence is the quality of hanging together, of providing the reader an easily followed path. Writers promote coherence by making their material logically and stylistically consistent, and by organizing and expressing their ideas in specific patterns. Coherence can dramatically improve the reader's ability to understand your material by promoting its flow or readability. Coherence is especially valued in science and technology because of the inherent complexity of the subjects.

1. *Give readers a road map* to help them anticipate the content of your work.
2. *Use expected organization.* Divide your report into standard sections and place information in the appropriate section.
3. *Develop paragraphs logically*. By organizing material into a topic sentence and supporting sentences, paragraphs pull together material and emphasize various forms of conceptual development.
4. *Transitional devices* also operate at the paragraph level to provide links between sentences and between paragraphs.

1.2 Audience

Determine your audience's needs by assessing their expertise and their purpose in reading the document. Effective technical writing recognizes several types of readers, reflecting different levels of expertise:

experts
technicians
managers
laypersons

In 6.021J, you can assume that your primary readers are *general experts* as each report is written for a "peer audience" (not your professor). *General experts* possess extensive knowledge about a field in general, but they might be unfamiliar with particular technical terms, specific equipment, or recent advances in your document's subject matter. Specific experts, on the other hand, share or surpass your knowledge about a document's subject matter.

1.3 Point of View

<u>Point of View refers to how you tell the story of your experiment</u>. There are certain conventions in report and proposal writing that readers expect and that lend your writing more credibility.

1.3.1 Active voice versus passive voice

Most of your 6.021J work should be written in passive voice. Passive voice in technical writing keeps the emphasis on the experiment, not the researcher. Passive voice also lends a professional tone to your writing as overuse of active voice seems childlike. For example,

> *Simplistic sounding - Over-use of Active Voice*
> I dissected the frog according to the guidelines in the lab manual. Then, I placed the sciatic nerve in the nerve chamber. I placed the recording electrodes at R7 and R8.
>
> *More professional-sounding - Passive Voice*
> The frog was dissected according to the guidelines in the lab manual. The sciatic nerve was then placed in the nerve chamber.

Careful use of active voice is quite effective, however, in a report to add resonance to the writing. Active voice is usually most effective in the Discussion section of a report. Why? In the Discussion you can foreground your own ideas about why you achieved the results of your experiment

Second person is not acceptable in 6.021J report writing (Second person = "you")

1.3.2 Verb Tense

In proposals and reports you will find it necessary to alternate verb tenses, depending on which section of the document you are writing.

Proposals: Present and future tense

- What you know is written in present tense
- What you will do is written in future tense.

Reports: Combination of present, past, and future tense

- Abstract - Past tense (although an introductory sentence may be written in present tense)
- Introduction - Present tense for rationale. Purpose statement may be written in past tense.
- Methods - Past Tense
- Results - Past Tense, although in certain instances present tense is appropriate
- Discussion - Your choice of tense
- Conclusion (optional) - Your choice of tense

1.4 Organizing Information

Organization is the arrangement of elements into a structure, a whole. Organization is essential in making your document coherent to your audience. A predictable and logical structure helps readers understand the information presented in your document.

Organization is a specific approach to document planning. The key instrument of document organization is the outline. Outlines help you work out both the general structure of your document and specific sections and topics. An outline will force you to partition material, develop a point of view, establish the scope of your document, sequence your topics, and develop a writing strategy.

1.5 Avoiding Common Style Problems in 6.021J

1. Keep it together. Don't separate the noun and verb of a sentence with lengthy phrases. Readers look for syntactic resolution --i.e. what is the subject of the sentence doing?
2. Logic: Follow reader expectations that the topic comes first in a sentence and the resolution comes at the end of the sentence.
   For example these two sentences have different meanings because of the reversed topic-resolution order: "Bees disperse pollen" versus "Pollen is dispersed by bees"
3. Link old ideas to new ones Use transitions or common vocabulary to create cognitive coherency and fill logical gaps.
4. Avoid jargon. Jargon is convoluted prose. Technical terms are concise and aid reader comprehension.
5. Avoid vague pronoun references:
   - "This." The antecedent "this" needs a noun. This what?
   - "It." The pronoun "it" is not descriptive. Use specific nouns.
6. You do not need to use phrases like "as stated above." In written communication, readers generally don't need such pointers as they remember what they've read previously in short reports. However, do reference figures and graphs: "As shown in Figure 3 . . ." or (Figure 3)
7. Don't be the teacher. Avoid writing as though you were instructing someone. For example, "As you can see, the response changed after 10 ms."
8. Do not write Methods like a cookbook series. For example, "Wash the nerve with Ringer's solution."
9. Do not overuse personal pronouns.
10. Know the correct technical terminology for what you are doing.

11. The word "data" is plural (datum is the singular form). For example, "The data were defined such that . . "
12. Do not use bullets to list Methods or Results. Write your report in paragraph form.
13. Do not begin sentence with numbers.
14. In IEEE style you do not use footnotes.

2.0 Proposals

2.1 General Information about Proposal Writing

Proposals develop a plan of action in response to a specific need or problem. In content, successful proposals demonstrate that you understand the scope of the problem and that you have developed a valid and well-focused approach for reaching proposed objectives. The goal in writing proposals is to effectively communicate a plan of action in concise, specific language.

2.1.1 Purpose. The Proposal:

- Defines the problem or question that the experiment is trying to answer
- Develops an appropriate experimental approach with variables and controls to test the hypothesis
- Specifies the methods that will be used to carry out the experiment
- Outlines the expected results

2.1.2 Quick Tips

- Think through your research project before writing. Exactly what are you testing? Why? How?
- Avoid universal words like "all" and "every" as well as vague words like "some" and "a few."
- Also, understand the technical meaning of words like "control" before suggesting that an initial measurement will be your "control." (If you are unsure about usage of the term "control" see the frog lab handout provided in class for a technical definition.)
- A good rule of thumb when writing a proposal is the "peer test" -- i.e. based on your written proposal, can your colleague, friend, or roommate understand exactly what you are doing? Can they restate your research project in one sentence?

2.1.3 Format

- Single-spaced
- One page

2.1.4 Organization

For your 6.021J proposal, you do not need to submit a proposal with all the elements of a professional proposal. However, your proposal does need to include certain basic elements:

- *Title:* Specific and meaningful
- *Authors:* Include the names and e-mail addresses of all group members
- *Hypothesis*: The hypothesis states -- in one sentence -- exactly what you are testing. That statement should be answerable with "yes" or "no"
- *Background*: The background statement explains the motivating problem or rationale for pursuing a research project. The background statement should clearly articulate the reasoning behind your hypothesis.
- *Procedure*: The procedure presents your method for reaching your stated hypothesis. What kind of data will you collect? How will that data be analyzed? Even the most promising research will fall flat if you cannot design a scientifically valid way to investigate it.

2.2 Frog Proposals

2.3 Hodgkin-Huxley Proposals

This theoretical project is intended to provide an opportunity to learn about the complex behaviors that can be exhibited by the Hodgkin-Huxley model and to compare behaviors of the model with behaviors of electrically excitable cells. We have two simulations. The first models a space-clamped axon. That model generates MEMBRANE action potentials. The second models an axon without space-clamp (although the second model can simulate a space clamp since the longitudinal resistances can be set to zero). The second model can produce PROPAGATED action potentials. The second model can be used to explore a wider range of phenomena than the first. The first model is faster and simpler than the second. Thus both models are useful, and your project can use either or both of the models.

Beginning with the proposal and extending through the project, you should keep clearly in mind that you ARE NOT investigating nerve membrane in these exercises. You ARE investigating the Hodgkin-Huxley model for nerve membrane. Your explanations of all phenomena must be in terms of the primitive concepts of this model --- the ionic conductances, ionic concentrations, ionic currents, the capacitance, and the variables m, n, and h. Explanations in terms of molecular channel mechanisms or electrodiffusion of ions in the membrane are irrelevant in so far as they are not contained in the Hodgkin-Huxley model!

2.3.1 Proposal Submission

Partners should submit a single proposal and a single report which identifies both members of the team and gives both email addresses. Proposals should be submitted using the proposal submission form on our home page.

2.3.2 Practical considerations in the choice of a topic

Projects can involve almost any of the properties of the Hodgkin-Huxley model. However, to avoid projects whose aims are vague (e.g., ``I would like to understand how the Hodgkin-Huxley model works'') the proposed project should be in the form of a specific and testable hypothesis. Projects that involve months of computation should obviously be avoided. The amount of computation time should be explicitly taken into account in planning a project. For example, any project that involves measuring the threshold of occurrence of an action potential for many different parameter values is bound to be very time consuming because determining the threshold for a single set of parameters itself involves many computations. The task is to choose a physiological property of the excitation of the action potential that is of interest, and then to define a specific, feasible project.

2.3.3 Choice of topics

Note: The demonstration project performed in lecture on the effect of temperature cannot be the basis of a student project.

Topics can involve comparing predictions of the Hodgkin-Huxley model with measurements on cells. For example, the text contains data on the effects of many external parameters (e.g., ionic concentrations, cell type) on action potentials. A project might involve reading the original papers that describe such measurements (some were made before the Hodgkin-Huxley model was formulated), and testing the hypothesis that these measurements are (or are not) consistent with the Hodgkin-Huxley model. Similarly, a project might involve examining the effect of some pharmacological substance on measurements of the action potential and testing the hypothesis that the substance produces its effect by changing one or another parameter of the model. These projects will require some reading of original literature which is often difficult and usually time consuming. However, such a project can lead to a very rewarding educational experience. Alternatively, the project might involve a purely theoretical topic in which some property of the model is explained in terms of its underlying structure. This type of project does not necessarily involve reading the original literature.

2.3.4 Examples of hypotheses

Any of these (or other) hypotheses can be the starting point for a project. Most of the hypotheses given above are simplistic, and a careful investigation will reveal their shortcomings. The Hodgkin-Huxley model is sufficiently complex that investigation of any of the hypotheses will most likely lead to unexpected results. You should pursue these unexpected results and try to understand their bases. For example, you may find that in pursuing some hypothesis you choose to change some parameter of the model that you expect to result in some change in action potential waveform. The resulting computation might reveal, much to your surprise and chagrin, that no action potential has occurred. Determine why no action potential occurred. The explanation will usually be instructive. Your aim should be not simply to reject or accept the hypothesis but to delve into the topic in sufficient depth so as to a deepen your understanding of the model. One outcome of the project might be to restate your original hypothesis in a new and more sophisticated form.

Hypothesis --- The effect of temperature on the conduction velocity of the squid giant axon can be fit by the Hodgkin-Huxley model.
Articles in the literature should be consulted for this project:

- Chapman, R. A. (1967). Dependence on temperature of the conduction velocity of the action potential of the squid giant axon. J. Physiol. 213:1143-1144.
- Easton, D. M. and Swenberg, C. E. (1975). Temperature and impulse velocity in giant axon of squid loligo pealei. Am. J. Physiol. 229:1249-1253.

Hypothesis --- When two action potentials are elicited, one just after another, the velocity of the second is slower than the velocity of the first action potential. This phenomenon is predicted by the Hodgkin-Huxley model.
Articles in the literature should be consulted for this project:

- George, S. A., Mastronarde, D. N., and Dubin, M. W. (1984). Prior activity influences the velocity of impulses in frog and cat optic nerve fibers. Brain Res. 304:121-126.

Hypothesis --- The threshold current for eliciting an action potential with an intracellular electrode is higher for a space-clamped than for an unclamped model of an axon.

Hypothesis --- Increasing the membrane capacitance will decrease the conduction velocity.

Hypothesis --- Increasing the membrane conductance (by scaling all the ionic conductances) will increase the conduction velocity.

Hypothesis --- Increasing the external concentration of sodium will increase the conduction velocity.

Hypothesis --- Increasing the external concentration of potassium will increase the conduction velocity.

Hypothesis --- Increasing the external concentration of calcium will increase the conduction velocity.

Hypothesis --- Increasing the temperature will increase the conduction velocity.

Hypothesis --- The difference in waveform of the action potential of a frog node of Ranvier and of a squid giant axon (Figure 1.9 in volume 2 of the text) can be reproduced by the Hodgkin-Huxley model of a squid giant axon by a change in temperature.

Hypothesis --- The membrane capacitance determines the time course of the rising phase of the action potential. Increasing the membrane capacitance decreases the rate of increase of the rising phase of the action potential.

Hypothesis --- The falling phase of the action potential (repolarization) can occur in the absence of a change in potassium conductance.

Hypothesis --- Increasing the temperature sufficiently blocks the occurrence of the action potential because the membrane time constant limits the rate at which the membrane variables can change and prevents the difference in time course of the sodium and potassium activation which is responsible for initiation of the action potential.

Hypothesis --- The initiation of the action potential is independent of the potassium conductance.

Hypothesis --- The prolonged plateau of the cardiac muscle action potential can be accounted for by the Hodgkin-Huxley model with a potassium conductance that has a slow activation.

Hypothesis --- The effect of tetraethylammonium chloride (TEA) on the action potential of the squid giant axon can be modelled with the Hodgkin Huxley model by decreasing K_n and increasing K_h.

Articles in the literature should be consulted for this project:

- Armstrong, C. M. (1966). Time course of TEA-induced anamalous rectification in squid giant axons. J. Gen. Physiol. 50:491-503.
- Armstrong, C. M. and Binstock, L. (1965). Anomalous rectification in the squid giant axon injected with tetraethylammonium chloride. J. Gen. Physiol. 48:859-872.
- Tasaki, I. and Hagiwara, S. (1957). Demonstration of two stable potential states in the squid giant axon under tetraethylammonium chloride. J. Gen. Physiol. 40:859-885.

Hypothesis --- The shape of the action potential in the presence of tetraethylammonium chloride (TEA) can be accounted for by the Hodgkin-Huxley model with a reduced maximum value of the potassium conductance.

Articles in the literature should be consulted for this project:

- Armstrong, C. M. (1966). Time course of TEA-induced anamalous rectification in squid giant axons. J. Gen. Physiol. 50:491-503.
- Armstrong, C. M. and Binstock, L. (1965). Anomalous rectification in the squid giant axon injected with tetraethylammonium chloride. J. Gen. Physiol. 48:859-872.
- Tasaki, I. and Hagiwara, S. (1957). Demonstration of two stable potential states in the squid giant axon under tetraethylammonium chloride. J. Gen. Physiol. 40:859-885.

Hypothesis --- Increasing the external calcium concentration will block the occurrence of the action potential because this will reduce the difference in the time constant of sodium and potassium activation which is responsible for the initiation of the action potential.

Hypothesis --- Increasing the external concentration of potassium will decrease the refractory period; decreasing this concentration will lengthen the refractory period.

Hypothesis --- Increasing the external concentration of sodium will decrease the refractory period; decreasing this concentration will lengthen the refractory period.

Hypothesis --- Absolute and relative refractory periods are decreased by increasing the rate constants for sodium inactivation and for potassium activation.

Hypothesis --- Repolarization cannot occur if the potassium activation rate constant is zero.

Hypothesis --- The threshold of the action potential to a brief pulse of current decreases as the external potassium current is increased.

The Hodgkin-Huxley model with default parameters does not exhibit accommodation. Hypothesis --- Accommodation occurs if the leakage conductance is increased.

The Hodgkin-Huxley model with default parameters does not exhibit accommodation. Hypothesis --- Accommodation occurs if the potassium conductance is increased.

Hypothesis --- Increasing the eakage equilibrium potential will block the action potential.

Hypothesis --- The effect of the changes in concentration of sodium ions on the action potential of the giant axon of the squid can be accounted for by the Hodgkin-Huxley model.
Articles in the literature should be consulted for this project:

- Hodgkin A. L. and Katz, B. (1949). The effect of sodium ions on the electrical activity of the giant axon of the squid. J. Physiol. 108:37-77.
- Baker, P. F., Hodgkin, A. L., and Shaw, T. I. (1961). Replacement of the protoplasm of a giant nerve fibre with artificial solutions. Nature 190:885-887.

Hypothesis --- In response to rectangular pulses of current, the rheobase of the strength-duration relation increases as temperature increases.

Hypothesis --- An increase in temperature results in a decrease in the duration of the refractory period.

Hypothesis --- The threshold membrane potential at which the Hodgkin-Huxley model produces an action potential in response to a brief pulse of current is equal to the membrane potential for which the linearized Hodgkin-Huxley equations have unstable eigenvalues.

Application of a long-duration constant current to the Hodgkin-Huxley model produces a train of action potentials. Hypothesis --- The frequency of the action potentials increases with increasing current amplitude.

Application of a long-duration constant current to the Hodgkin-Huxley model produces a train of action potentials. Hypothesis --- The frequency of action potential increases as the parameter K_n is increased.

Application of a long-duration constant current to the Hodgkin-Huxley model produces a train of action potentials. Hypothesis --- The frequency of action potential increases as the temperature is increased.

Hypothesis --- An increase in the external concentration of potassium increases the threshold potential at which an action potential is elicited.

Hypothesis --- Increasing K_h will result in an increase in the steepness of the repolarization phase of the action potential.

3.0 Reports

In 6.021J you will write two reports--frog lab report and Hodgin-Huxley report. Both reports follow a standard format for a technical report.

3.1 Elements of a technical report

A report should tell a story. The story is your lab project and its implications. Scientific reports follow a general organization that includes the following sections:

Table 1: Elements of a 6.021J Report

Front Matter	**Body**	**End Matter**
Cover Page (Title + Abstract) Table of Contents	Introduction Methods Results Discussion Conclusion (optional)	References Appendix

6.021J reports also usually follow the following conventions:

- Use standard font; 10 or 12 point
- Double space drafts (for comments). Single-space final reports.
- Number pages, beginning with Introduction.
- Each section of the body of the report and report end matter is numbered

3.1.1 Title

The purpose of the report title is to be informative, specific, understandable at a glance.

- Avoid "cute" titles
- The title is on a Cover Page
- All nouns are capitalized in the title
- The title is centered on the page
- Your names and date appear below the title
- Do not use abbreviations in the Title

3.1.2 Abstract

The abstract is a one paragraph summary of the report. The abstract of a scientific paper is the most important section, because it usually determines whether someone will read your paper or not. You should write the abstract last. The abstract should include a rationale for the study, your experimental approach, results, and conclusion. Generally, each of these topics should be handled in a sentence or two.

- The abstract is the shortest (150-200 words) and generally most challenging part of your report to write.
- Do not include figures, figure references, or extraneous information--i.e., information not found in the report--in your abstract.

3.1.3 Table of Contents

The Table of Contents helps readers quickly find the information they need from your report and provides a guide to the report content.

- List the headings and subheadings exactly as they appear in your report
- Through formatting show the hierarchy of heading and subheadings.
  For example:

3.1.4 Introduction

The introduction provides the motivation for conducting the study. You should briefly summarize what is known (appropriate literature citations are encouraged) and indicate what new knowledge you hope to discover. Include only relevant background, including key terms, then state the problem that is being addressed. In your Introduction, you do not need to state everything that you have ever learned which is in any way relevant to the topic. Just summarize the relevant facts. While the implications of what you may discover are relevant, you need not state that your findings will be of cosmological importance.

- DO NOT include findings or methods in your Introduction
- Introductions usually follow a *funnel* style, starting broadly with general ideas and then narrowing to your hypothesis.
- You should specifically state the hypothesis you tested
- When you first use a term that you abbreviate later, use the full name at first usage. After it, put the abbreviation in parenthesis. For example, "The compound action potential (CAP) . . ." In following instances, you may use "CAP" in place of compound action potential.

3.1.5 Methods

The Methods section describes the process you undertook to complete the research. Methods describes the FINAL APPROACH that you took to your experiment, which may not be the approach that you initially intended. Describe the experimental methods as well as any mathematical or statistical methods you used to analyze the data. Include Methods for all results presented in your report. <u>By definition any experimental measurements or experimental data you collected are not reported here. They are reported under the Results section.</u> Provide sufficient detail to enable another investigator to exactly reproduce your experiments and, hopefully, obtain the same results. The essence of scientific research is the ability to reproduce results.

- Only include methods for data and results presented in your report.
- Methods are not written like a cookbook (a series of orders) or a numbered series of steps. Write Methods in paragraph form, divided into subsections by topic.
- Distinguish between preliminary measurements/studies and your main experiment.
- Describe your Methods in past tense since you have already completed the experiment.
- Data processing (e.g. statistics, using ANOVA) is a Method and needs to be described.

3.1.6 Results

The Results section DESCRIBES but DOES NOT INTERPRET the major findings of your experiment. Organize Results logically with subsections to emphasize order. <u>Results should correlate organizationally to the Methods</u>. *Collaborative Writer's Tip: If you write the Methods of the report, also write the Results so you know that the two sections are organized respectively.*

Present the data using graphs and tables to reveal any trends that you found. Do not tabulate/graph raw data. Each table or graph should document one of your findings. This will most likely involve synthesizing your raw data into an appropriate format before graphing them.

Simply presenting tables and figures is not acceptable. Coherent prose is necessary to introduce and explain tabular and graphical material. Often each grouping of information in Results is organized as follows:

1. Paragraph explaining a figure following the paragraph. The paragraph description describes in words what is shown in the figure.
2. Figure showing visual representation of data.
3. Figure caption (below the figure) that explains what is shown in the figure.

A key issue in Results is to determine whether the effects you measured are a result of the intervention you studied or rather just reflect random variations in the data or a drift of experimental parameters over time. Well-designed control experiments and statistical analysis of your data should be used to resolve this question.

- Avoid presenting raw data (e.g. showing ten superimposed waveforms to demonstrate a trend of decreasing amplitude) and instead use synthesis graphs (e.g. a plot of amplitude vs. concentration) which explicitly show the trends you are trying to prove
- Figures should appear in the order which they are referenced in the text of the paper.
- Each figure should be a standalone entity, and the caption should be clear, specific and detailed enough to describe what is shown without reading the whole text.
- Avoid captions that begin with "A graph of …" Just state what is shown.
- Make sure the legend is specified and easy to read

3.1.7 Discussion

The Discussion offers your interpretations and conclusions about your findings. At the beginning of the Discussion, return to the main point of your study -- Did you answer your hypothesis? How do your Results relate to the goals of the study, as stated in your introduction? How do they relate to the results that might have been expected from background information obtained in lectures, textbooks, or outside reading? How do you explain deviations in your findings? Were there limitations to your study? What might be useful for future investigations?

The Discussion is your chance to demonstrate your ability to synthesize, analyze, evaluate, interpret, and reason effectively. Draw generalizations from your results or conclusions about theoretical/practical implications. Use evidence to support these claims. Do not include new findings in your Discussion. You do NOT need to bring in theories to explain your ideas beyond what you have learned in class. Your readers are looking for well-supported explanations, not for leaps of fancy or mere repetitions of your findings.

- Do not repeat the visuals shown in the Results section (although some authors choose to add additional visuals to clarify their discussion). Include textual references to figures if you need for readers to reference a figure (For example, "As shown in Figure 3: title . . .").

3.1.8 Conclusion (Optional)

Some writers like to end their reports with a short conclusion that summarizes the main "jist" of their research and includes recommendations for future study.

3.1.9 References - IEEE style

If you reference an outside source in your report, you should cite where you found that source. You should also cite sources that your reader, a fellow student, may be unfamiliar with. The appropriate style for citing sources in this report is IEEE style. Cite only material that you have actually read. See Section 4.3 for guidelines on citing sources in IEEE style.

3.1.10 Appendices

Appendices include the original data taken during the laboratory session. Appendices should be numbered A, B, C, etc. Appendices are useful for additional data and mathematical analyses that are important reference material for the study but which would interrupt the flow of the presentation in the main body of the report.

3.2 Graphics: Presenting Information in Tables, Figures, and Equations

Graphics in reports are invaluable aids to your audience because they condense text, clarify relationships, and highlight patterns. Good graphics display the significance of your data and allow the reader to follow your discussion.

- Use graphics to *condense complicated textual content* for your audience.
  "The nerve was placed on the nerve chamber with the proximal end on the stimulating electrode, as shown in Figure 1."
- Use graphics to *clarify relationships* between results.
  "Although conduction velocity increased with temperature, this relationship is not linear, as can be seen in Figure 2."
- Use graphics to *highlight patterns* in your data that are not immediately evident in your text.
  "Figure 3 displays the effects of exercise on heartbeat in an experiment to study energy expenditure in a partial gravity environment, such as an orbiting space station."

3.2.1 Tables

- Each table must contain a title and a caption.
- Tables are numbered, and they appear in the order they are referenced in the text.

3.2.2 Figures

- Each figure must have a title and a caption beneath the figure
- Figures are numbered, and they appear in the order they are referenced in the text
- Axes are labeled at bottom and side of graph
- For graphs with multiple plots, provide a legend
- Units of measure are visible. Each visual does not extend across more than one page.

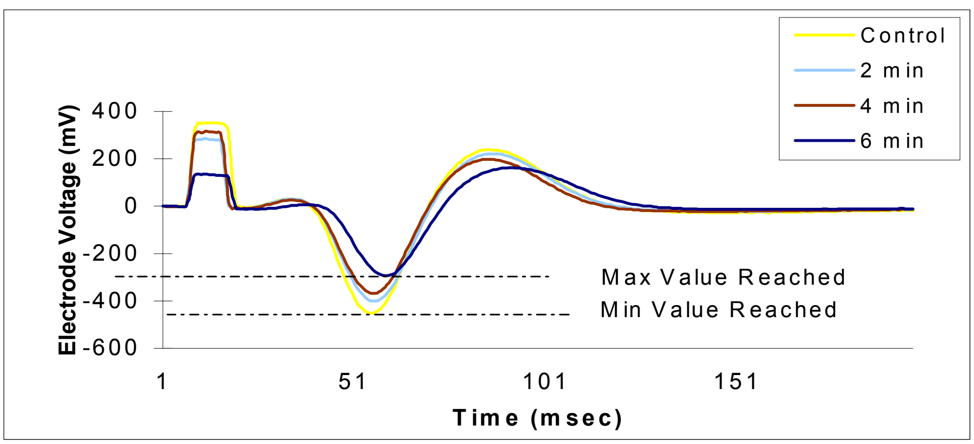

Figure 3: *The stimulus response from an addition of 0.06% alcohol. The maximum value reached is a decrease in the absolute magnitude of the peak and occurs after the alcohol is allowed to settle for 6 minutes. The offset was added in order to center the resting potential at 0.*

3.2.3 Equations

- Equations are numbered.
- Use mathematical symbols.

- Decimal quantities include a zero before the decimal point.
- Add a space before the equation and after the equation to separate from the text

$$G_{Na} = \overline{G_{Na}} m^3 (V_m, t) h(V_m, t) \quad \text{(Eq. 1)}$$

3.3 IEEE Style

The Institute of Electrical and Electronics Engineers (IEEE), one of the largest professional organizations in the world, oversees numerous journals and regularly publishes its own Letters, Transactions, and Proceedings of the technical conferences it sponsors.

IEEE style uses a single sequentially ordered note number to cite all references to each source mentioned in the text. The IEEE reference listis arranged by the order of citation in the text, not in alphabetical order. IEEE style also prohibits the use of content notes, preferring instead that supplementary explanations and examples be included in the text (often in parentheses).

3.3.1 Two parts to IEEE style: (1) in-text citation and (2) references page

Example of IEEE citation in the body of a report:

> *The oncogene jun has presently become one of the best-known oncogenes because of its ability to act as a transcription factor [1]. One study [2] examined the mRNA levels of jun C, jun B and jun D in various mouse tissues and concluded that each of these genes is expressed independently in different tissues and that they may play a role in growth, development and cellular differentiation.*

Example of the above report's References page

> *[1] F. Cavalieri, T. Ruscio, R. Tinoco, S. Benedict, C. Davis, and P. K. Vogt, "Isolation of three new avian sarcoma viruses: ASV9, ASV17, and ASV 25," Virology, vol. 143, pp. 680-683, 1985.*
>
> *[2] S. I. Hirai, R. P. Ryseck, F. Mechta, R. Bravo, M. Yaniv, "Characterization of jun D: a new member of the jun protooncogene family," Embo Journ., vol. 8, pp. 1433-1438, 1989.*
>
> *--Taniya Sarkar, Wei Zhao, and Nurul H. Sarkar, "Expression of Jun Oncogene in Rodent and Human Breast Tumors," World Wide Web Journal of Biology*

3.3.2 Examples of IEEE References for Reference page of report

Books

Book by One Author

[1] A. Lightman, Ancient Light: Our Changing View of the Universe. Cambridge, MA: Harvard University Press, 1991.

Edited Book or Anthology

[1] J. L. Spudich and B. H. Satir, Eds.,Sensory Receptors and Signal Transduction. New York: Wiley-Liss, 1991.

Selection in an Edited Book

[1] E. D. Lipson and B. D. Horwitz, "Photosensory Reception and Transduction," in Sensory Receptors and Signal Transduction, J. L. Spudich and B. H. Satir, Eds. New York: Wiley-Liss, 1991, pp. 1-64.

Book by an Institutional or Organizational Author

[1] Council of Biology Editors, Scientific Style and Format: The CBE Manual for Authors, Editors, and Publishers, 6th ed., Chicago: Cambridge University Press, 1994.

Technical Report

[1] C. F. Heohan, M. C. Liepins, C. A. Meuse, M. M. Wolfson, "Summary of triple Doppler data, Orlando, 1991," MIT Lincoln Laboratory, Lexington, MA. Tech. Rep. ATC-186 (DOT/FAA/NR-92-2), 7 Apr. 1992.

Government Publication

[1] National Aeronautics and Space Administration, NASA Pocket Statistics. Washington, DC: Office of Headquarters Operations, 1991.

Journal Articles

Article in a Journal Paginated by Annual Volume

[1] K. A. Nelson, R. J. Dwayne Miller, D. R. Lutz, and M. D. Fayer, "Optical generation of tunable ultrasonic waves," Journal of Applied Physics, vol. 53, no. 2, Feb., pp. 1144-1149, 1982.

Article in a Professional Journal Paginated by Issue

[1] J. Allemang, "Social studies in gibberish," Quarterly Review of Doublespeak, vol. 20, no. 1, pp. 9-10, 1993.

Article in a Popular Monthly or Bimonthly Periodical

If the journal is a monthly or bimonthly periodical, use the month and year of publication instead of the volume number.

[1] J. Fallows, "Networking technology," Atlantic Monthly, Jul., p. 34-36, 1994.

Article in a Daily, Weekly, or Biweekly Magazine or Newspaper

Include the year, month, and day.

[1] B. Metcalfe, "The numbers show how slowly the Internet runs today," Infoworld, 30 Sep., p. 34, 1996.

Websites

[1] T. Land, "Web extension to American Psychological Association style (WEAPAS)," [Online document], 1996 Mar 31 (Rev. 1.2.4), [cited 1996 Sep 14], Available HTTP: http://www.nyu.edu/pages/psychology/WEAPAS/

3.4 Frog Report Specifics

3.4.1 Commonly Misunderstood Concepts

- Differences between Compound Action Potential (which is being measured in this lab) and an Action Potential.
- Why a diphasic response is seen.
- What is a control.

3.4.2 The Report: Common Issues

Introduction

- Since you do not have much background knowledge at this point, your background research may be sparse. However, make sure you explain to readers why you chose to study you did.
- Do not spend a lot of time and space defining CAP and terms that peer readers understand.

Methods

- Do not repeat the frog dissection process described in the lab manual. You only need to describe your specific experimental method.
- Cite the lab manual
- Methods are not just procedures, but also your method(s) for taking measurements.
- Explain exactly how amplitude was defined and measured.
- Explain the controls you took.
- Detail how many trials and at what levels.

Results

- Results are more than just graphs. Explain in words what is shown in each figure.
- Separate your Basic Observations from your Experimental Results using subheadings
- Do not spend too much time explaining basic observations.
- Organize results to show trends or comparisons in the data.

3.5 Hodgin-Huxley Report Specifics

The Hodgin-Huxley report comes late in the semester when students are tired. Leave yourself enough time to write your report and run your simulations.

3.5.1 Commonly Misunderstood Concepts

- The Frog Lab is an experimentally-based project. The HH lab is based on simulation.
- Time controls are not necessary for simulations. There can be controls performed for other variables, such as the numerical method used by the software.
- The HH software models the responses of the giant squid axon, a single, very specific cell
- Well-defined procedures for measuring various properties are necessary. (e.g., In determining threshold current amplitude, how will you determine whether a given response is an action potential or not?)

3.5.2 The Report: Common Issues

Methods

- This lab does not have procedural methods.
- The methods will mainly be explanations of how and why data was gathered
- The notion of control is different than the frog experiment. In the HH experiment there is no need to control for time.

Results

- Explain results in terms of the model. What did the model predict? Compare those predictions with experimental findings.
- Explain results in terms of the variables of the model

Discussion

- Be careful about drawing conclusions. If you use a definition and then change a definition and get a different result, how robust is your finding really?

4.0 Tips on Collaborating

One of the most useful education experiences in this course is learning to work with others. Most scientific writers collaborate on projects and through the experience of working collaboratively researchers develop techniques for working with others so that the work is evenly distributed.

4.1 Ways to make collaborating easier

1. Work together to select your project. Decide which specific issue to study, and outline your proposal report.
2. Create a work plan that clearly defines which partner is responsible for each of the duties to be performed.
3. Divide the work load fairly, using each person's strengths. For example, if you are good at MATLAB, take responsibility for producing the graphs for your report.
4. Get contact information so you can find your partner out of the lab.
5. Set due dates. Stick to those dates.
6. Agree on word processing program so it is easier to merge your work.
7. Each write different sections of the report. If you write the Methods, you should also write the Results since Methods and Results should correlate.
8. Synthesize your efforts in advance. Do not wait until the day your report is due (or the night before!!) to combine your work.
9. Always keep only one master draft.
10. Work in parallel on different sections, then in series (one person at a time) on the whole draft.
11. Edit. Edit. Edit.
12. Proofread. Proofread. Proofread.

4.2 Tips for collaborative editing

When writing collaboratively, stay professional and focused on your task. Try using a two-part editing process for editing your work. First, edit for content. Second, edit for style.

4.3 Edit for Content

Read through your draft, stopping at the end of each section, and ask yourself the following questions:

- ⇒ Is the information accurate? Are there any incorrect data entries? Are all outside sources documented? Is all information from outside sources either paraphrased or quoted exactly and enclosed in quotation marks? Are any graphics misleading?
- ⇒ Is the information complete? Have you omitted any facts, concepts, equations or processes necessary for the document's aim and for the audience type and the audience's purpose? Are there any steps missing from instructions, procedures, or descriptions of processes?
- ⇒ Is the information comprehensible to your audience? Are all technical terms that need to be defined for your audience clearly defined? Are all acronyms explained when first used?
- ⇒ Does the report tell a story? Does it bring up the important points you are trying to make? Are the methods and results clearly and precisely described? Are the discussion points relevant to your results? Is each result discussed and properly documented?

4.4 Edit for Style

⇒ If you have not already done so, divide your document into sections and subsections by inserting headings and subheadings into your document.
⇒ Does each section and subsection follow logically from the preceding one?
⇒ Early in the text, is there a clear road map of the entire document? Does the document follow that road map?
⇒ Review the graphics in the order presented in your document. Do they present the key information to the reader in a logical order?
⇒ Read a printed copy of the report aloud to find typographical errors and page break errors.

5.0 Tips on Editor's Comments

5.1 Writing Meaningful comments on other reports

By far some of the most helpful comments on 6.021J reports come from other students! Yes, it is true. Often tech readers and the writing instructor do not offer "the complete picture." Only another student can tell you if your report is really clear and wll organized because peer-readers are the primary audience for your reports.

Observe the following general strategies in reviewing a colleague's document.

1. Take the time to review it right. Spend an hour on your review out of courtesy to the other writers.
2. Read the report at least twice -- first time for surface coherence and obvious errors; second time for deep editing issues (logic, coherence between sections). You will probably need to skip back and forth in the report to do a thorough editing job.
3. Start by praising what the document does well.
4. Spend much of your time responding to the author's specific requests. (That assumes that the writer left you questions.)
5. Avoid performing an editorial review, unless asked to by the author. You do not need to mark every comma error in the report. Mark a few and the author should understand the problem from a few examples.
6. Do not just criticize harshly (i.e. "This sucks.") no matter how poor the draft. Make suggestions on how to solve the problems you notice in the document.
7. Ask questions if you do not understand a part of the report.
8. If something is "vague" or "unclear" explain why.
9. If a sentence is difficult to read or unclear, underline it and write in the margin your note.
10. Write an end note in which you summarize the main problems with the report in order of importance.
11. Sign your review with your name and email address.

5.2 Making sense of editor's comments

For both the frog report and the Hodgin-Huxley report, you will receive comments on your first draft from three readers -- peer readers, a technical reader, and a writing reader. All professional writers must manage multiple edits from multiple editors, so 6.021J is good practice. As the writer you get the final word on whether you change your report or not. Editor's comments are only SUGGESTIONS. Use your own judgment in choosing how to revise your report. Feel free to add a cover letter on your final report if you feel strongly about rejecting a comment. In the end, editor's comments are meant to HELP YOU. Take their advice as help, not as personal criticism.

Tips for making sense of edits:

- If editor's suggest similar edits. It's probably a good hint that something really is wrong with a part of your report if multiple editor's comment on it.
- If editor's comments are contradictory. Try to understand why the editor's were commenting contradictorily on a point. Did one misread? Are they saying the same thing in different ways? Was there another problem elsewhere in the report that led to this disagreement?
- If editor's simply make poor comments -- maybe they were confused about a point, maybe they missed a point. Do not think your editor does not know what he or she is doing. Editor's are human. Sometimes they make mistakes.
- If you do not understand a comment or cannot decipher your editor's handwriting, ask your editor to explain. All 6.021J readers are willing to answer questions in person and via email.