UNIVERSITY OF HOUSTON

ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

Formal Laboratory Report Format

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**1 The Formal Report**

**1.1 What is the Formal Report?**

Effective and accurate communication of technical information is an important part of the professional engineer's job. Whether such information has been obtained in the course of engineering research or as part of a routine analysis of an engineering project, good communications skills avoid confusion and costly errors. Therefore the formal report is graded for technical accuracy, spelling, grammar, and proper format including the use of neat, informative figures and graphs. These characteristics affect the clarity of the report, and clarity is the most important issue in technical writing.

Several laboratory courses in the UH undergraduate Electrical and Computer Engineering curriculum require the writing of a formal report. In this document we present guidelines for writing the formal report in ECE 2100. These guidelines are based on a report organization typically used for the reporting of research in professional journals and engineering analyses by engineering firms. Other courses may require something a bit different, but most will follow this format to one extent or another.

The formal report consists of the following sections, each of which is discussed in this document.

**-** Title Pagewith Abstract

**-** Introduction

- Research Question

**-** Background

**-** Methods

**-** Results

**-** Discussion

**-** Conclusions

**-** References

**-** Acknowledgment

**-** Appendices

**1.2 What Should I Assume About My Reader?**

Write your report so that a knowledgeable reader could reproduce your experiment or project. Assume that your reader is an engineering student at your level who knows how to use standard laboratory equipment. You may want to remind your reader of topics such as measurement techniques or circuit analysis, but don’t teach these topics as would be done in a textbook. Instead, use brief summaries and give at least one good reference where further information may be found.

**1.3 Tone, Tense, Person, and Voice**

The formal report is a description of something you did. It is neither a textbook nor an article in a popular magazine. In general, the use of past tense is preferred through most of the report, except for statements that are always true.

You may use either the first or third person in your writing, but do so consistently. When using the first person, do not use “I”; use “we”, even if you are the only person who did the experiment. You may use the active or passive voice as long as you are consistent. You should try to use the same person and voice throughout your paper; nevertheless, there may be instances in which a change of tense or voice is justified. However, do not change the tense or voice within a given section of the paper.

Your writing should be clear and succinct. Avoid the use of long, flowery sentences. Be efficient in your writing. It is the content of your report and the quality and logic in its organization that is important in this exercise. There are often strict limits placed on authors by editors of journals and digests. Similarly, company reports are often limited to a small number of pages. Succinctness in technical writing is an important attribute. Evaluate each sentence to see how much information it contains.

**1.4 Presentation, Length, and the Use of Computers**

You are required to use a computer to prepare your report. It is expected that all text, figures, and equations will be prepared on a computer. Choose a font that is clear, but no smaller than Times New Roman 12 point. Use “1.5” line spacing and 1” margins on all sides.

The body of your formal report (that is, excluding front matter and back matter) should not exceed 8 pages. Your writing should be concise but complete and accurate so that you should not require more than this. Often the shortest reports earn the highest grades.

**2 Formal Report Organization**

 **2.1 Title Page and Abstract Page**

The title should be short but descriptive of the project. It is centered at the top of the first page. Put your name, and the name of your lab partner, on this page.

The *Abstract* begins on a separate page. The heading, *Abstract*, should appear directly above the abstract and separated by two blank lines. The abstract is only one paragraph and does not contain references, figures, or equations.

The word "abstract" in the present context means to remove or separate. It is a brief, concise summary of all the sections of the report. It should take no more than half a page using a line spacing of 1.5. The abstract should stand on its own in telling the reader what is contained in the report. Most importantly, it should be very specific about conveying the results of the experiment or project. Remember that your abstract is not an introduction to the rest of your report. Many people who read your abstract will never read the rest of your report. The abstract is essentially a short version of your entire report.

 **2.2 Introduction**

An introductory section, in which the objectives of the laboratory exercise are explained, starts on the second page of the report. The *Introduction* should accomplish precisely what its name implies; the reader is here introduced to the project and informed of its objectives. The *Introduction* should provide the motivation for doing the project. In addition, an overview of the approach used to meet the objectives should be given. To this end, it may be useful to briefly summarize the results of the project here.

**2.3 Research Question**

Succinctly state your purpose in doing the experiment by casting it in the form of a research question: what is the question you are trying to answer by doing this experiment? Ideally there is one research question, but more than one is acceptable.

You will of course want to make sure that the research question you pose is answered somewhere in your report. This can be done in the *Conclusion*, but it could also be discussed as part of the *Discussion* section.

**2.4 Background**

In many laboratory exercises there are certain theoretical considerations that can be made; in others a certain design approach is used. Your project or experiment will involve one of these. Thus your report should include a discussion of the theoretical basis for the measurements you are performing or a description of your design approach, whichever is appropriate. For example, it is possible to predict the response of a simple circuit to a square wave input using basic circuit analysis techniques. Thus in a report describing an experiment on this topic, your *Background* should include a description of the theoretical circuit response. If as part of a project you designed a circuit to perform a particular function, you would include your design approach in this section.

You may use outside references to obtain the background needed for your theoretical considerations or your design approach. However, do not write this section as a textbook is written. That is, do not give complete, step-by-step derivations necessary to teach the reader a concept from scratch. Instead, summarize the important points and refer the reader to an appropriate text or other source of information. The goals here are to provide the information necessary to understand and appreciate the results of the project or experiment, and to allow the reader to reproduce any calculations or theoretical results you may present.

**2.5 Methods**

In this section you will explain the procedure used in setting up and executing your experiment or project. Good figures or diagrams are useful here. Write in paragraph form using complete sentences, and use the past tense. Remember you are giving a report, not a set of lab instructions. Explain what you did; do not tell the reader what to do.

An important goal here is to make it possible for the reader to go into the lab and reproduce your experiment or project. It may be useful to describe the lab equipment, but avoid giving unnecessary detail. You will need to use your judgement here. The reader may need to know which oscilloscope you used, especially if your scope has some special features important to your results. The reader most likely does not need to know how long the leads on your resistors were, or what color wire you used for ground connections.

Your methods should include a description of the data you took, as well as how it was taken. It should also include the method of analysis used to interpret the data. If you used statistical analysis of some sort, explain that. If you decided to plot a voltage as a function of time, explain why you did that and what the reader should be able to learn from it.

**2.6 Results**

The results of your project (the data) are presented in this section in a concise and easily interpreted form, but the *Results* section is not merely a compilation of data. The data should be integrated with prose describing the results. If appropriate, point out how the instrumentation or measurement method might have affected your results, and point out trends or surprising aspects of the data. Lead your reader through your data so that it is clear what the results were.

You will need to use your judgment in deciding how to use graphs, tables, or other figures to present your data. Data that relates one continuous parameter to another, such as a voltage to a current, is often best presented in a graphical form. In that case it is helpful to the reader if a smooth curve is fitted to the results. The measured data points should be clearly indicated with a symbol, for example, small squares or circles.

In some cases it is preferable to present data in a table as a simple list of numbers. If you are reporting very few (say, no more than 3) data points, you might simply incorporate the results into a sentence instead of having a table with 3 data points. Generally, you should not report any piece of data in more than one form; that is, do not present both a table and a graph of the same data.

To ease the burden on the reader, it is not usually desirable to list every last scrap of data that has been taken. However, there should be sufficient data to convincingly support your conclusions. In any case, professional integrity demands that you never deliberately "bias" the data by selecting only results you believe are correct. Some judgment must be exercised here; if you have one data point which is inconsistent with a large collection of points following a smooth trend, it is reasonable to infer that such a point is the result of measurement error and can be eliminated. However, if a large portion of the data is contradictory to expectations but you are sure the measurements have been performed correctly, the data should be presented. Comment on such inconsistencies and attempt to present reasonable hypotheses to explain them.

In the *Results* section you will generally present "reduced" data. Reduced data have been derived by computation from the "raw", that is, directly measured, results. For example, a listing of the measured resistance of ten 2.2 k resistors represents raw data, while the average of these ten values and their standard deviation represent reduced data. Although at the professional level it is common practice to present only the reduced data, since these are educational exercises you should include both raw and reduced data for the purpose of these reports.

If it is possible to theoretically predict the results that should be obtained, such predicted results should be included in this section. For example, the theoretical response of an RC circuit to a square wave input could be interpreted as a result and plotted along with measured data obtained from an oscilloscope. In the case of a design project, the final design is the result of the project and should be presented in this section. In addition, the final circuit schematic and the measurements that were made to verify its performance are also results of a design project.

 **2.7 Discussion**

This section is the proper place to explain why you think the results came out as they did. Describe and discuss any discrepancies between what you found and what you expected. You may wish to comment on the accuracy of the equipment or on whether the experimental method you used was appropriate. Suggestions as to how the procedure should be modified to improve the accuracy or efficiency could be included here. If you plan to compare your results with what other researchers have obtained, the *Discussion* section is a good place to do it.

 **2.8 Conclusions**

In this section, you should concisely summarize the objectives and results of the experiment or project. This is also a good place to remind the reader of the *Research Question* and explicitly answer that question. The relationship between the objectives of the laboratory exercise and the actual experience you have documented in the previous sections can be included here. This section should parallel the introduction in its topics. Never include any new material in this section. You should be summarizing things that have already been presented to the reader.

 **2.9 References**

Texts, technical papers, laboratory exercise documents, project handouts, and other sources used in writing the report must be included here. Reference all sources whether copyrighted or not. The intent of this section is to allow the interested reader to follow up on your sources for further information or to check on how accurately you presented the information you obtained.

Sources should be listed in the order in which they first appear in the text of your report. When documentation is required, the source should be indicated by some clear and unambiguous method. It is recommended that you use a reference number in square brackets, [2], typically including page information, [2, page 57]. Documentation concerning the source will then appear in the References section, in this example as the second reference. You may use the same reference more than once in your text without repeating the reference; that is, you may use the same reference number more than once.

Many sources are long, consisting of many pages. If so, you must indicate which pages were used for that reference.

Some examples of proper referencing follow.

 1. When the information was obtained from the reference as a whole, i.e., no direct quotes were used but one or more ideas were adapted, only a simple reference number is needed.

Some promising methods have been described which allow ultrasonic images to be made using a piezoelectric opto-acoustic transducer. [2, pages 45-50]

 2. If the reference is to a direct quote, the page information is required. Note that the words 'present' and 'discuss' are modified in this example so that they will be grammatically correct in this sentence.

The paper by Wang and Wade "present(s) and discuss(es) two schemes for implementing the PST approach." [2, page 2l3]

 3. Even in the absence of a direct quote, page information is often helpful.

The power level after attenuation by 20 cm. of tissue in the SRI system was 8 x l0-7 Watt/cm2. [2, pages 2l6-2l7]

 Proper formats for various types of reference are given below.

For reference to a book:

 [1] W. Strunk, Jr. and E.B. White, The Elements of Style, Third Edition, New York: MacMillan Publishing Co., l979, pp. 1-33.

For reference to a book chapter: (Page numbers are those of the particular chapter.)

 [2] K. Wang and G. Wade, "A Scanning Focused Beam System for Real-Time Diagnostic Imaging," in Acoustical Holography, Vol. 6, N. Booth, Ed. New York: Plenum Press, l975, pp. 213-228.

For reference to a journal article:

 [3] B. Noorbehesht, "Modified Equivalent Circuit for Optoacoustic Transducers," IEEE Transactions on Sonics and Ultrasonics, Vol. SU-29, No. 6, Nov. l982, pp. 377-381.

 For a laboratory exercise or a project handout, enough information must be included to be able to identify the source. List the authors if known:

 [4] ELEE 2300 Experiment III, "Thevenin and Norton Equivalent Circuits," produced by the Electrical Engineering Department of the University of Houston, p. 5.

 **2.10 Acknowledgment**

An acknowledgment of assistance should be provided in which you state what help you received in gathering your data and in preparing your report. It would be appropriate to acknowledge the assistance of a lab partner in this section.

 **2.11 Appendix**

In many technical reports, details that would interfere with the essence of the paper are often placed in the Appendix. For example, detailed computations performed to reduce data or to make theoretical predictions should be placed in an appendix. Generally speaking, the rule is that an appendix is the place to put material that will be read by some readers, but not by all readers.

The Appendix must not be just a collection of data or equations; it must be written with explanations of what is contained within it. The appendix must follow all the rules for the rest of the report, including margins and page numbers. You may have more than one appendix, in which case they should be enumerated with the letters of the alphabet (e.g., Appendix A. Computation of Theoretical Standing Wave Pattern, and Appendix B. Calculations of Standing Wave Ratios).

Note that it is not necessary to have an appendix in your report, unless your assignment specifically requires you to do so. Include one only to contain material that is lengthy or awkward to present and which would otherwise interrupt the smooth flow of the report. If you have no such material, do not include an appendix. Do not include results in the Appendix, except perhaps in the case that you have a very long list of raw data to present and you do not wish to interrupt the results section with it.

**3 Guidelines for Preparing Your Report**

**3.1 Figures, Tables, and Equations**

**3.1.1 Figures**

Figures may be used to illustrate an experimental set-up or to clarify a written passage that may be otherwise difficult to understand. Good use of figures can make the difference between a good report and a mediocre one. Figures must be numbered consecutively beginning with number 1. If you wish, you may re-start the numbering at 1 in each section, but in that case use a notation to distinguish among sections; for example, Figure 1.1 may be the first figure of the Introduction while Figure 2.1 is the first figure of the Experimental Procedure section.

Present your figures as soon as possible after they are referenced in the text. Some word processors allow mixing of text with figures created in other software applications on the same page. This is a nice touch but is not necessary. Make sure that all figures are referenced somewhere in the text. That is, tell the reader when it is appropriate to view the figure, by writing something like, “See Figure 4.” Do not present a figure without first explaining it and introducing in the test.

Figures are always accompanied by captions, which appear at the bottom of the figure after the figure number. The intention is to identify the figure, give a concise description of what is contained in the figure, and to explain what the reader should notice in the figure. In addition, you are encouraged to include one or more sentences that will act as a title for the figure. A figure caption with number, title, and description might read *Figure 3. Current-Voltage Characteristics for the Diode. This plot of current vs. voltage for the device used in this experiment shows its nonlinear character. Note that a threshold appears to occur near 0.7V.*

**3.1.2 Tables**

Tables must be numbered consecutively beginning with number 1. As with figures, you may begin numbering from 1 in each section provided the numbering scheme makes a distinction among sections, e.g. Table 1.1 and Table 2.1 for the *Introduction* and *Methods*. Tables, like figures, must appear as soon as possible after they are referenced in the text.

Tables are always accompanied by a table caption, which appears at the top of the table (unlike a figure caption that appears at the bottom of the figure). The table caption includes the table number followed by a short phrase for the title. It can also include a brief sentence or two describing what is contained in the table.

**3.1.3 Equations**

Equations appear on separate lines and are incorporated into the text so that the resulting sentences are grammatically correct. All equations must have an equation number, which is right justified (i.e. placed against the right-hand margin). Punctuate the equations as needed to make the sentence they are in grammatically correct.

Use an equation writer to create equations. Do not use the keyboard to indicate mathematical operators (\* and /, for example). Do not use “E” to indicate exponentiation; use superscripts to do this.

**3.2 Specific Points Regarding Report Format**

Your report grade will suffer if there are spelling or grammar errors. Use a spelling checker. If you are unsure of your grammar skills, get someone to proofread your paper.

When figures, tables, or equations are referred to in the text, they should be capitalized, just as any other title is capitalized. For example, "Equation (3)", and "Figure 2" refer to a specific equation and figure and are capitalized.

Avoid using mathematical symbols that could be spelled out. For example, do not write "the two dipoles were || to each other." Write "the two dipoles were parallel to each other." On the other hand, you may use symbols that represent variables. For example, you can write that "The function (x) is related to 0 by Equation (5)".

 Do not begin a sentence with a mathematical symbol. The following sentence is considered to be in poor form: "*v* is the voltage across the resistor." Instead, revise the sentence. "The voltage across the resistor is *v*."

 Explain nonstandard abbreviations the first time they are used. For example, you may choose to refer to the Formal Laboratory Report Format as FLRF. The first time in the text that you use the phrase you should write it out, with the abbreviation in parentheses following it.

**3.3 Academic Honesty Policy**

We operate under the University of Houston Academic Honesty Policy. We aggressively pursue violations of this policy in the Electrical and Computer Engineering Department. In this section we discuss the implications of the Academic Honesty Policy for formal report writing.

 The most common violation of the academic honesty policy as far as the formal report is concerned is plagiarism. According to the UH Academic Honesty Policy, plagiarism is defined as "representing as one's own the work of another without acknowledging the source." Accordingly, any indication that the work or words in the report have been copied from any source without acknowledging that source will be treated as a violation.

***But I have the same data as my lab partner !***

Lab partners may have identical raw data in a given experiment or project, but report writing and data reduction are to be done individually. The preparation of figures, tables, plots, graphs, and other parts of your report are part of the writing of these reports. **Therefore, you and your lab partner may not have the same figures, tables, plots, and graphs.** **If you and your lab partner have identical figures, tables, plots, or graphs, it will be considered as a possible violation of the academic honesty policy.** This does not mean that you cannot discuss your work with your lab partner or with others. However, such discussions are limited to helping each other understand the experiment or project.

***When Must I Reference a Source?***

There are two general cases in which you must reference a source: any time you have taken words in part or in whole from another person's writing, and any time you give an idea or specific factual information which you did not discover, derive, or otherwise arrive at yourself. Stated another way, if you consulted a text or other source during the actual writing of your report, you should reference that source.

When you use words taken from another person's writing, you must enclose those words in quotes and give a reference. For example, the following paragraph is taken from a lab exercise on Thevenin Equivalents.

*This laboratory exercise, while specifically about Thevenin and Norton Equivalents, is in general a study of equivalent circuits. Equivalent circuits are common throughout circuits and electronics, and are always used in the same way. An equivalent circuit is used to replace another circuit, and is in some way simpler or easier to analyze. The behavior outside the equivalent circuit is the same as the behavior would be when the circuit it replaces is in the same position. It is equivalent in no other sense, and the behavior within the equivalent circuit may be unrelated to the circuit it replaces.*

If you wanted to include these words in your report, you might do something like the following.

*"This laboratory exercise ... is in general a study of equivalent circuits." [5, p. 1] The terminal properties of the equivalent circuit are identical to those of the circuit it replaces. The circuits are "equivalent in no other sense, and the behavior within the equivalent circuit may be unrelated" to the original circuit. [5, p. 1]*

 However, such extensive use of direct quotes is undesirable and suggests laziness on the part of the writer. It would be better to rewrite the paragraph, for example as follows.

*In this laboratory exercise, Thevenin and Norton equivalent circuits are tested in order to reinforce the concepts of equivalent circuits. The terminal properties of the equivalent circuit are identical to those of the circuit it replaces. The circuits are equivalent for all external considerations, although they may well differ substantially in their internal structure. [5, p. 1]*

 Note that quotation marks are not needed for minor sentence fragments like *this laboratory exercise*.

You must be careful not to transfer someone else's writing into your report with simple changes of wording and punctuation. For example, consider the first two sentences in the laboratory handout on Thevenin Equivalents. These could be rewritten with minor changes as follows.

*This laboratory exercise is about Thevenin and Norton Equivalents, but is in general a study of circuits that are equivalent. Equivalent circuits are often found in circuits and electronics, and are always used in similar ways.*

Whether a rewrite such as this is considered plagiarism may not be clear in a given instance, but at the very least such writing indicates that the writer has done little of his or her own work and deserves a low grade. If such writing is found in a report, the report may be rejected. Therefore you should write on your own as much as possible. When you wish to paraphrase an idea from a text, for example, make sure you understand the idea. Then close the book and write it in your own words. Make sure that you give a reference number to indicate the source. In most instances this will not result in the need for quotation marks, since it is difficult to remember large sections of text, word for word. If, finally, there is no clear way to express the idea without using the same words as the source, then you must use quotation marks to show which words were taken from the source.

If you take an idea or factual information from a source and include it in your report, quotation marks are not needed but you must reference it to indicate where you found it. An exception is factual information which is "common knowledge", which need not be referenced. When in doubt, use a reference. As an example, consider the idea that in Houston in July the weather is hot and humid. This information is common knowledge, at least to anyone who has visited Houston in July. In any event, it is clear that you are not the original source of this information, so a reference is not necessary. However, if you go further and state an average temperature and humidity level, you must give the source of the information unless you have made the measurements yourself. In general, if you did not consult a source during the writing of your report, you may assume that the knowledge you had is common knowledge.

If you take an equation from a source, it does not need to be in quotation marks, but it must be referenced. If a figure is copied from a source, then a reference number must be included to indicate the source. Commonly, this reference is given in the caption of the figure.

The bottom line is this: Prepare and write your own report by yourself, with no one around, alone.