Preparing Effective and Efficient Lab Reports

***Abstract*—This document provides a guide for preparing lab reports based on the style guide for IEEE Transactions, Journals, and Letters.**

I. What? I became an engineer so I wouldn't have to write…

One of the most valuable skills you will develop as an engineer is the ability to communicate your work to others. Engineers and related STEM professionals communicate through code, technical drawings, models, presentations, videos, informal verbal discussions, and yes, writing—including published journal and conference articles, technical reports, and documentation. The purpose of writing engineering reports *in this class* is to practice and/or hone your skills in:

- preparing and presenting data through graphical formats (plots, photographs, etc.)
- analyzing data and technical findings
- explaining data and conclusions using technical English writing
- using specific professional norms in preparing reports and documents (in this case, the IEEE style guides)

This document is a guide to formatting; The *IEEE Editorial Style Manual for Authors* is available at https://journals.ieeeauthorcenter.ieee.org/create-your-ieee-journal-article/create-the-text-of-your-article/ieee-editorial-style-manual/. This document contains a formal subset of editorial guidelines for IEEE Transactions, Journals, and Letters, modified as it makes sense for an academic context. We present these guidelines as a reference to you while writing your reports.

Please communicate your work clearly. While you will not be directly graded on grammar, spelling, neatness, professionalism, or following these guidelines *exactly*, your writing should be clear enough to prevent technical errors or misunderstandings. **You will not earn full credit for your work if your writing causes technical confusion, has technical errors, or is otherwise incorrect or ambiguous.**

You are encouraged to get help with writing! The use of writing tools such as Microsoft Word's spelling and grammar checker, Grammarly, and other electronic tools may be useful, but please make sure any suggestions are aligned with what you are trying to write; you should not accept the software's suggestions without care. The same recommendations go for using a thesaurus to substitute words. Even better than software checking is having a friend or colleague read over your report and note areas which are not clear. Best would be a visit to Northeastern's writing center: https://cssh.northeastern.edu/writingcenter/ for additional support. Almost *everyone* can use more suggestions to improve their writing—please consider a visit to the writing center to help you learn to write more clearly and efficiently.

Why are writing and data presentation important skills to learn? Check out a few of these examples of success and failure:

Richard Feynman's report on the Space Shuttle Challenger disaster

Reddit thread on what technical documentation should include (Warning: it's Reddit, so there's strong language)

Why should you comment your code

The engineer's guide to writing code comments

American Society of Engineering Education (ASEE) paper on The importance of writing skill to the engineering student

II. Guidelines For Report Preparation

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text. Abbreviations such as IEEE, SI, ac, and dc do not have to be defined. Abbreviations that incorporate periods should not have spaces: write "C.N.R.S.," not "C. N. R. S." Do not use abbreviations in the title unless they are unavoidable (for example, "IEEE" in the title of this article).

B. Use of dashes

The en dash represents the words "to," "through," or "and." Use it between page numbers (e.g., pp. 5–10), reference numbers (e.g., [5]–[10]), figure citations, (e.g., Figs. 2–4), academic years (e.g., 1996–1999), proper nouns (Bose–Einstein theory), a range of values (e.g., 10–20 cm), or for opposites (e.g., in–out). Also use the en dash in chemical abbreviations such as Ni–Al–Si. When using the en dash to represent a range, if the word "from" is used, the word "to" must be used rather than an en dash (e.g., from 5 to 50 times). The em dash is used to highlight a parenthetical phrase in a sentence (e.g., "An FIB modifies a surface by sputtering with energetic ions—usually Ga for technical reasons— in a beam with half-width of the order of 10 nm.").

C. Grammar and IEEE principles of style

The principles of style given below aim to concentrate on the fundamentals of modern usage. Particular emphasis is given to the rules most commonly violated.

1) Form the possessive singular of nouns by adding **'s**.
2) In a series of three or more terms, use a comma after each term except the last.
3) Enclose parenthetic expressions between commas.
4) Use the semicolon, not the comma, to separate two complete sentences which form a compound sentence.
5) Use a colon after an independent clause to introduce a list.
6) Punctuation always goes inside the quotation mark, except for the colon and semicolon.
7) Do not use double parentheses in text expression, but keep them in math.
8) All acronyms and numerical plurals do not use apostrophes.
9) Compound nouns made from a one-syllable verb and a short adverb are one word when found that way in the dictionary.
10) A pair of words, modifying a third word separately, does not get a hyphen.
11) A hyphen is not used after the comparative or the superlative.
12) Do not use commas between adjectives.
13) Do not hyphenate predicate adjectives.
14) Compound verbs are generally hyphenated.

D. Font

The report format may specify, otherwise single-column, single-spaced, 12 pt Times New Roman is a good choice

E. Report sections

Report sections should be governed by the information you need to convey. Generally, an information/background section which introduces relevant engineering concepts and related work, a methods (or modeling) section that explains how you got your results, a results section that presents your data, and a discussion section that explains your data, conclusions, sources of error, and mismatch between model and measured data will be adequate. An (optional) conclusion may review the main points of the article and elaborate on the importance of the work or suggest applications and extensions (e.g., future work).

III. MATH PRESENTATION AND NUMBERING

Use either the Microsoft Equation Editor or the MathType plugin, which can be obtained from https://store.wiris.com/en/products/mathtype/download. For help with formatting and placing equations, refer to the *IEEE Editing Math Guide* at http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/Editing-Mathematics.pdf and the *IEEE MathType Tutorial for Microsoft Word Users* at http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE-Math-Typesetting-Guide-for-MS-Word-Users.pdf.

A. Equations

Number equations consecutively with equation numbers in parentheses flush with the right margin of the column, as in (1). First use the equation editor to create the equation. Then select the "Equation" markup style. Press the tab key and write the equation number in parentheses. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Use parentheses to avoid ambiguities in denominators. Punctuate equations when they are part of a sentence, as in

$$B_p + H_2 = 40. \qquad (1)$$

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (*T* might refer to temperature, but T is the unit tesla). When referring to an equation or formula, use simply "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is ... ."

B. Numbering

1) Variables are set in italic; vectors and matrices are usually boldface italic.
2) Remove commas around variables in text.
3) Always add a zero before decimals, but do not add after (e.g., 0.25).
4) Spell out units in text without quantities (e.g., where the noise is given in decibels).
5) Numbers and units used as compound adjectives should be hyphenated only if needed for clarity (e.g., 10-kV voltage; 5-in-thick glass).
6) Use thin spaces (instead of a comma) between numbers in tens or hundreds of thousands (e.g., 60 000, 100 000, but 4000).
7) Use zeroth, first, *n*th, (*k*+1)th, not 0^{th}, 1^{st}, 2^{nd}, 99^{th}, n^{th}, $(k+1)$st.
8) Use the word "equation" at the start of a sentence only, but in text just use the number [e.g., in (1)], unless describing an equation, e.g., see "Darlington equation (1)."
9) The slash is used in place of the word "per" when it leads to the clarity of the sentence (e.g., the ratio of 16 samples/s to 35 samples/s as compared to…).
10) Use "indices" instead of "indexes" when referring to subscripts.
11) Plural variables have an "'s".

IV. Guidelines for Graphics, Figures, and Tables

A. Figure preparation

You should include figures such as photographs, plots, and diagrams to demonstrate your experimental setup, present your findings, and support the conclusions you make in your lab. A figure (e.g., Fig. 1) includes an image and a figure caption below written in 10 pt. font. Figure captions should briefly explain (in fewer than 50 words) what the referenced image is as well as your interpretation of the image(s). The figure image should be clear (not blurry or low resolution) and be large enough for readers to absorb important detail. All axes should be labeled with quantities and units. Figures should be labeled sequentially throughout the report.

1) **Figure Axis Labels**
   a) Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity "Magnetization" or "Magnetization *M*," not just "*M*." Put units in parentheses. Do not label axes only with units. For example, write "Magnetization (A/m)" or "Magnetization ($A \cdot m^{-1}$)," not just "A/m." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."
   b) Multipliers can be especially confusing. Write "Magnetization (kA/m)" or "Magnetization (10^3 A/m)." Do not write "Magnetization (A/m) × 1000" because the reader would not know whether the top axis label means 16000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8- to 10-point type.

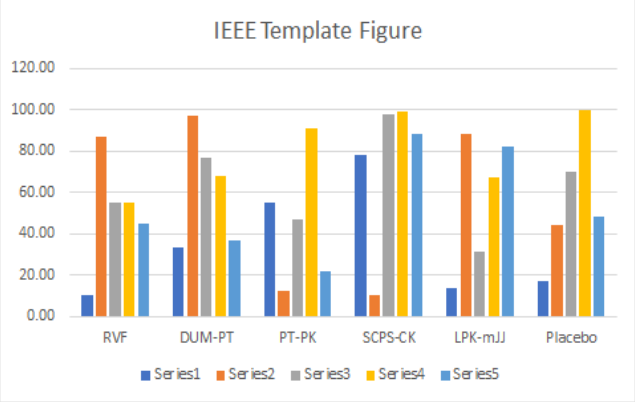

Fig. 1. A bar chart which depicts the percentage of scientists who had heard of the process. Each series was undertaken sequentially from the months of January (series1) through May (series5). (*Note: the sample image is a bad example because the Y axis is unlabeled*)

B. Multipart Figures

Multipart figures (Fig. 2) are figures compiled of more than one sub-figure presented side-by-side or stacked. Multipart figures should be combined and labeled before final submission. Labels should appear centered below each subfigure in 8-point Times New Roman font in the format of (a) (b) (c).

(a)

(b)

Fig. 2. Various depictions of huskies, including a photograph of two huskies on a sled dog team (a) and a vector art drawing of a husky mascot for Northeastern University (b). Distinguishing husky features include prominent, pointy ears, a long snout, and a thick coat of fur.

C. Resolution and font size

The proper resolution of your figures will depend on the type of figure it is as defined in the "Types of Figures" section. Images should be at least 150 dpi (dots per inch) to avoid low resolution issues if possible. When preparing your graphics, IEEE suggests that you use one of the following Open Type fonts: Times New Roman, Helvetica, Arial, Cambria, or Symbol.

D. Referencing a Figure or Table Within Your Article

When referencing your figures and tables within your article, use the abbreviation "Fig." even at the beginning of a sentence. Do not abbreviate "Table." Tables should be numbered with Roman numerals. You should reference your figures in the text, and if you find yourself including figures but having no place to reference them, that is a signal that you are not discussing the references in enough detail.

E. Tables

Tables should be used sparingly to present comparisons between things. For the purposes of EECE 5554, a plot will be likely to be a more appropriate way to present data because it allows readers to see trends in data as a variable is changed. As with figures, the table should use units in the header and explain the quantities presented in the table.

TABLE I

THE NUMBER OF PARTICIPANTS IN EACH SERIES (1-5) FOR THE EXAMINED PROTOCOLS (NOTE: THE HEADER SHOULD HAVE INCLUDED SERIES NUMBER IN THE HEADING FOR CLARITY)

Name	#1	#2	#3	#4	#5
RVF	10	87	55	55	45
DUM-PT	33	97	77	68	37
PT-PK	55	12	47	91	22
SCPS-CK	78	10	98	99	88
LPK-mJJ	14	88	31	67	82
Placebo	17	44	70	100	48

APPENDIX

Appendixes, if needed, appear after the conclusion.

REFERENCES

If you use outside references (other papers, websites, packages, someone else's photographs or images) you should reference them in the text. They appear on the line, in square brackets, inside the punctuation. Multiple references are each numbered with separate brackets. When citing a section in a book, please give the relevant page numbers. In text, refer simply to the reference number. Do not use "Ref." or "reference" except at the beginning of a sentence: "Reference [3] shows ... ." Please do not use automatic endnotes in *Word*, rather, type the reference list at the end of the paper using the "References" style.

For a complete discussion of references and their formats, see the *IEEE Editorial Style Manual for Authors* at https://journals.ieeeauthorcenter.ieee.org/create-your-ieee-journal-article/create-the-text-of-your-article/ieee-editorial-style-manual/.

Basic format for magazines:

J. K. Author, "Name of paper," *Abbrev. Title of Periodical*, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year, doi: 10.1109.XXX.1234567.

Basic format for books:

J. K. Author, "Title of chapter in the book," in *Title of Published Book, x*th ed. City of Publisher, (only U.S. State), Country: Abbrev. of Publisher, year, ch. x, sec. *x*, pp. xxx–xxx.

Examples:

[2] Philip B. Kurland and Ralph Lerner, eds., *The Founders' Constitution.* Chicago, IL, USA: Univ. of Chicago Press, 1987, Accessed on: Feb. 28, 2010, [Online]. Available: http://press-pubs.uchicago.edu/founders/

Basic format for handbooks:

Name of Manual/Handbook, x ed., Abbrev. Name of Co., City of Co., Abbrev. State, Country, year, pp. xxx-xxx.

Examples:

[3] R. J. Hijmans and J. van Etten, "Raster: Geographic analysis and modeling with raster data," R Package Version 2.0-12, Jan. 12, 2012. [Online]. Available: http://CRAN.R-project.org/package=raster

Basic format for reports:

J. K. Author, "Title of report," Abbrev. Name of Co., City of Co., Abbrev. State, Country, Rep. xxx, year.

Example:

[4] E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the earth's atmosphere," Aerospace Corp., Los Angeles, CA, USA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.

Basic format for conference proceedings:

J. K. Author, "Title of paper," in *Abbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), Country, year, pp. xxxxxx.

Examples:

[5] D. B. Payne and J. R. Stern, "Wavelength-switched passively coupled single-mode optical network," in *Proc. IOOC-ECOC,* Boston, MA, USA, 1985, pp. 585–590.

Basic format for electronic documents (when available online):

Issuing Organization. (year, month day). *Title*. [Type of medium]. Available: site/path/file

Example:

[6] U.S. House. 102nd Congress, 1st Session. (1991, Jan. 11). *H. Con. Res. 1, Sense of the Congress on Approval of Military Action*. [Online]. Available: LEXIS Library: GENFED File: BILLS

Basic format for patents:

J. K. Author, "Title of patent," U.S. Patent *x xxx xxx,* Abbrev. Month, day, year.

Example:

[7] G. Brandli and M. Dick, "Alternating current fed power supply," U.S. Patent 4 084 217, Nov. 4, 1978.

Basic format for theses (M.S.) and dissertations (Ph.D.):

J. K. Author, "Title of thesis," M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

J. K. Author, "Title of dissertation," Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

Examples:

[8] J. O. Williams, "Narrow-band analyzer," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, USA, 1993.

[9] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

Basic format for the most common types of unpublished references:

J. K. Author, private communication, Abbrev. Month, year.

J. K. Author, "Title of paper," unpublished.

J. K. Author, "Title of paper," to be published.

Examples:

[10] A. Harrison, private communication, May 1995.

[11] B. Smith, "An approach to graphs of linear forms," 2014, *arXiv:2105.02824*.

[12] A. Brahms, "Representation error for real numbers in binary computer arithmetic," IEEE Computer Group Repository, Paper R-67-85.

Basic formats for standards:

a) *Title of Standard*, Standard number, date.

b) *Title of Standard*, Standard number, Corporate author, location, date.

Examples:

[13] IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.

[14] Letter Symbols for Quantities, ANSI Standard Y10.5-1968.