

A Sample Article Using IEEEtran.cls for IEEE Journals and Transactions

IEEE Publication Technology, Staff, IEEE,

Abstract—This document describes the most common article elements and how to use the IEEEtran class with LATEX to produce files that are suitable for submission to the IEEE. IEEEtran can produce conference, journal, and technical note (correspondence) papers with a suitable choice of class options.

Index Terms—Article submission, IEEE, IEEEtran, journal, LATEX, paper, template, typesetting.

1 INTRODUCTION

THIS file is intended to serve as a “sample article file” for IEEE journal papers produced under LATEX using IEEEtran.cls version 1.8b and later. The most common elements are covered in the simplified and updated instructions in “New_IEEEtran_how-to.pdf”. For less common elements you can refer back to the original “IEEEtran_HOWTO.pdf”. It is assumed that the reader has a basic working knowledge of LATEX. Those who are new to LATEX are encouraged to read Tobias Oetiker’s “The Not So Short Introduction to LATEX,” available at: <http://tug.ctan.org/info/lshort/english/lshort.pdf> which provides an overview of working with LATEX.

2 THE DESIGN, INTENT, AND LIMITATIONS OF THE TEMPLATES

The templates are intended to **approximate the final look and page length of the articles/papers**. They are **NOT intended to be the final produced work that is displayed in print or on IEEEXplore®**. They will help to give the authors an approximation of the number of pages that will be in the final version. The structure of the LATEX files, as designed, enable easy conversion to XML for the composition systems used by the IEEE. The XML files are used to produce the final print/IEEEXplore pdf and then converted to HTML for IEEEXplore.

3 WHERE TO GET LATEX HELP — USER GROUPS

The following online groups are helpful to beginning and experienced LATEX users. A search through their archives can provide many answers to common questions.

<http://www.latex-community.org/>

<https://tex.stackexchange.com/>

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4 OTHER RESOURCES

See [1]–[5] for resources on formatting math into text and additional help in working with LATEX.

5 TEXT

For some of the remainder of this sample we will use dummy text to fill out paragraphs rather than use live text that may violate a copyright.

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$$x = \sum_{i=0}^n 2iQ. \quad (1)$$

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6 SOME COMMON ELEMENTS

6.1 Sections and Subsections

Enumeration of section headings is desirable, but not required. When numbered, please be consistent throughout the article, that is, all headings and all levels of section headings in the article should be enumerated. Primary headings are designated with Roman numerals, secondary with capital letters, tertiary with Arabic numbers; and quaternary with lowercase letters. Reference and Acknowledgment headings are unlike all other section headings in text. They are never enumerated. They are simply primary headings without labels, regardless of whether the other headings in the article are enumerated.

6.2 Citations to the Bibliography

The coding for the citations is made with the LATEX \cite command. This will display as: see [1].

For multiple citations code as follows: \cite{ref1, ref2, ref3} which will produce [1]–[3]. For reference ranges that are not consecutive code as \cite{ref1, ref2, ref3, ref9} which will produce [1]–[3], [9]

6.3 Lists

In this section, we will consider three types of lists: simple unnumbered, numbered, and bulleted. There have been many options added to IEEEtran to enhance the creation of lists. If your lists are more complex than those shown below, please refer to the original “IEEEtran_HOWTO.pdf” for additional options.

A plain unnumbered list

bare_jrnl.tex
bare_conf.tex
bare_jrnl_compsoc.tex
bare_conf_compsoc.tex
bare_jrnl_comsoc.tex



Fig. 1. Simulation results for the network.

A simple numbered list

- 1) bare_jrnl.tex
- 2) bare_conf.tex
- 3) bare_jrnl_compsoc.tex
- 4) bare_conf_compsoc.tex
- 5) bare_jrnl_comsoc.tex

A simple bulleted list

- bare_jrnl.tex
- bare_conf.tex
- bare_jrnl_compsoc.tex
- bare_conf_compsoc.tex
- bare_jrnl_comsoc.tex

6.4 Figures

Fig. 1 is an example of a floating figure using the graphicx package. Note that \label must occur AFTER (or within) \caption. For figures, \caption should occur after the \includegraphics.

Fig. 2(a) and 2(b) is an example of a double column floating figure using two subfigures. (The subfig.sty package must be loaded for this to work.) The subfigure \label commands are set within each subfloat command, and the \label for the overall figure must come after \caption. \hfil is used as a separator to get equal spacing. The combined width of all the parts of the figure should do not exceed the text width or a line break will occur.

Note that often IEEE papers with multi-part figures do not place the labels within the image itself (using the optional argument to \subfloat[]), but instead will reference/describe all of them (a), (b), etc., within the main caption. Be aware that for subfig.sty to generate the (a), (b), etc., subfigure labels, the optional argument to \subfloat must be present. If a subcaption is not desired, leave its contents blank, e.g., \subfloat[].

7 TABLES

Note that, for IEEE-style tables, the \caption command should come BEFORE the table. Table captions use title case. Articles (a, an, the), coordinating conjunctions (and, but, for, or, nor), and most short prepositions are lowercase



Fig. 2. Dae. Ad quatur autat ut porepel itemoles dolor autem fuga. Bus quia con nessunti as remo di quatus non perum que nimus. (a) Case I. (b) Case II.

TABLE 1
An Example of a Table

One	Two
Three	Four

unless they are the first or last word. Table text will default to `\footnotesize` as the IEEE normally uses this smaller font for tables. The `\label` must come after `\caption` as always.

8 ALGORITHMS

Algorithms should be numbered and include a short title. They are set off from the text with rules above and below the title and after the last line.

Algorithm 1 Weighted Tanimoto ELM.

```
TRAIN(XT)
  select randomly W ⊂ X
  Nt ← |{i : ti = t}| for t = -1, +1
  Bi ← √MAX(N-1, N+1)/Nti for i = 1, ..., N
  Ĥ ← B · (XTW)/(||X + ||W - XTW)
  β ← (I/C + ĤTĤ)-1 (ĤTB · T)
  return W, β
```

```
PREDICT(X)
  H ← (XTW)/(||X + ||W - XTW)
  return SIGN(Hβ)
```

Que sunt eum lam eos si dic to estist, culluptium quid qui nestrum nobis reiumquiatur minimus minctem. Ro moluptat fuga. Itatquiam ut laborpo rersped exeres vollandi repudaerem. Ulparci sunt, qui doluptaquis sumquia ndestiu sapient iorepella sunti veribus. Ro moluptat fuga. Itatquiam ut laborpo rersped exeres vollandi repudaerem.

9 MATHEMATICAL TYPOGRAPHY AND WHY IT MATTERS

Typographical conventions for mathematical formulas have been developed to provide uniformity and clarity of presentation across mathematical texts. This enables the readers of those texts to both understand the author's ideas and to grasp new concepts quickly. While software such as LATEX and MathType® can produce aesthetically pleasing math when used properly, it is also very easy to misuse the software, potentially resulting in incorrect math display.

IEEE aims to provide authors with the proper guidance on mathematical typesetting style and assist them in writing the best possible article. As such, IEEE has assembled a set of examples of good and bad mathematical typesetting [1]–[5].

Further examples can be found at <http://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE-Math-Typesetting-Guide-for-LaTeX-Users.pdf>

9.1 Display Equations

The simple display equation example shown below uses the “equation” environment. To number the equations, use the `\label` macro to create an identifier for the equation. LaTe_X will automatically number the equation for you.

$$x = \sum_{i=0}^n 2iQ. \quad (2)$$

is coded as follows:

```
\begin{equation}
\label{deqn_ex1}
x = \sum_{i=0}^n 2iQ.
\end{equation}
```

To reference this equation in the text use the `\ref` macro. Please see (2)

is coded as follows:

```
Please see (\ref{deqn_ex1})
```


A matrix with single verticals

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

is coded as:

```
\begin{equation}
\begin{vmatrix} a & b \\
c & d \end{vmatrix}
\end{equation}
```

A matrix with double verticals

$$\begin{Vmatrix} i & 0 \\ 0 & -i \end{Vmatrix}$$

is coded as:

```
\begin{equation}
\begin{Vmatrix} i & 0 \\
0 & -i \end{Vmatrix}
\end{equation}
```

9.6 Arrays

The `array` environment allows you some options for matrix-like equations. You will have to manually key the fences, but there are other options for alignment of the columns and for setting horizontal and vertical rules. The argument to `array` controls alignment and placement of vertical rules.

A simple array

$$\left(\begin{array}{cccc} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 134 \end{array} \right) \quad (15)$$

is coded as:

```
\begin{equation}
\left( \begin{array}{cccc} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 134 \end{array} \right)
\end{equation}
```

A slight variation on this to better align the numbers in the last column

$$\left(\begin{array}{cccc} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 134 \end{array} \right) \quad (16)$$

is coded as:

```
\begin{equation}
\left( \begin{array}{ccccc} a+b+c & uv & x-y & 27 & \\ a+b & u+v & z & 134 & \end{array} \right)
\end{equation}
```

An array with vertical and horizontal rules

$$\left(\begin{array}{c|c|c|c} a+b+c & uv & x-y & 27 \\ \hline a+b & u+v & z & 134 \end{array} \right) \quad (17)$$

is coded as:

```
\begin{equation}
```

```
\left( \begin{array}{ccc|c} a & b & c & r \\ \hline a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 134 \end{array} \right)
\end{equation}
```

Note the argument now has the pipe "`|`" included to indicate the placement of the vertical rules.

9.7 Cases Structures

Many times cases can be miscoded using the wrong environment, i.e., `array`. Using the `cases` environment will save keystrokes (from not having to type the `\left.\right|`) and automatically provide the correct column alignment.

$$z_m(t) = \begin{cases} 1, & \text{if } \beta_m(t) \\ 0, & \text{otherwise.} \end{cases}$$

is coded as follows:

```
\begin{equation*}
\{z_m(t)\} =
\begin{cases} 1, & \text{\text{if }} \beta_m(t), \\ 0, & \text{\text{otherwise.}} \end{cases}
\end{equation*}
```

Note that the "`&`" is used to mark the tabular alignment. This is important to get proper column alignment. Do not use `\quad` or other fixed spaces to try and align the columns. Also, note the use of the `\text` macro for text elements such as "if" and "otherwise."

9.8 Function Formatting in Equations

Often, there is an easy way to properly format most common functions. Use of the `\` in front of the function name will in most cases, provide the correct formatting. When this does not work, the following example provides a solution using the `\text` macro:

$$d_R^{KM} = \arg \min_{d_l^{KM}} \{d_1^{KM}, \dots, d_6^{KM}\}.$$

is coded as follows:

```
\begin{equation*}
d_{\{R\}}^{\{KM\}} = \underset{d_{\{l\}}^{\{KM\}}}{\arg \min} \{d_{\{1\}}^{\{KM\}}, \dots, d_{\{6\}}^{\{KM\}}\}.
\end{equation*}
```

9.9 Text Acronyms Inside Equations

This example shows where the acronym "MSE" is coded using `\text{}` to match how it appears in the text.

$$\text{MSE} = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2$$

```
\begin{equation*}
\text{MSE} = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2
\end{equation*}
```

10 CONCLUSION

The conclusion goes here.

ACKNOWLEDGMENTS

This should be a simple paragraph before the References to thank those individuals and institutions who have supported your work on this article.

APPENDIX

PROOF OF THE ZONKLAR EQUATIONS

Use `\appendix` if you have a single appendix: Do not use `\section` anymore after `\appendix`, only `\section*`. If you have multiple appendixes use `\appendices` then use `\section` to start each appendix. You must declare a `\section` before using any `\subsection` or using `\label` (`\appendices` by itself starts a section numbered zero.)

REFERENCES SECTION

You can use a bibliography generated by BibTeX as a .bb file. BibTeX documentation can be easily obtained at: <http://mirror.ctan.org/biblio/bibtex/contrib/doc/> The IEEEtran BibTeX style support page is: <http://www.michaelshell.org/tex/ieetran/bibtex/>

SIMPLE REFERENCES

You can manually copy in the resultant .bb file and set second argument of `\begin` to the number of references (used to reserve space for the reference number labels box).

REFERENCES

- [1] *Mathematics Into Type*. American Mathematical Society. [Online]. Available: <https://www.ams.org/arc/styleguide/mit-2.pdf>
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- [5] M. Letourneau and J. W. Sharp, *AMS-StyleGuide-online.pdf*, American Mathematical Society, Providence, RI, USA, [Online]. Available: <http://www.ams.org/arc/styleguide/index.html>
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- [8] M. Fließ, C. Join, and H. Sira-Ramirez, "Non-linear estimation is easy," *Int. J. Model. Ident. Control*, vol. 4, no. 1, pp. 12–27, 2008.
- [9] R. Ortega, A. Astolfi, G. Bastin, and H. Rodriguez, "Stabilization of food-chain systems using a port-controlled Hamiltonian description," in *Proc. Amer. Control Conf.*, Chicago, IL, USA, 2000, pp. 2245–2249.

BIOGRAPHY SECTION

If you have an EPS/PDF photo (graphicx package needed), extra braces are needed around the contents of the optional argument to biography to prevent the LaTeX parser from getting confused when it sees the complicated `\includegraphics` command within an optional argument. (You can create your own custom macro containing the `\includegraphics` command to make things simpler here.)

If you include a photo:



Michael Shell Use `\begin{IEEEbiography}` and then for the 1st argument use `\includegraphics` to declare and link the author photo. Use the author name as the 3rd argument followed by the biography text.

If you will not include a photo:

John Doe Use `\begin{IEEEbiographynophoto}` and the author name as the argument followed by the biography text.